When is Globalization Good for Long-run Growth? Trade Reforms, Coordination Failures and some Alternative Futures for the New NICs

Chaiyuth ***PUNYASAVATSUT*** *Thammasat University*
Ian ***COXHEAD*** *University of Wisconsin-Madison*

Abstract

In a small open economy, interactions between externalities from human capital accumulation and new technological opportunities embodied in imported intermediate goods create the possibility of "take-off", or sustained industrial growth. Industrialization can thus be triggered by trade reforms that reduce the prices of intermediate goods— in contrast with the protection policies indicated in "infant-industry" arguments. However, an interdependence between the growth of technologically advanced domestic industries and the supply of human capital suggests a role for government in coordinating expectations between firms and institutions that supply higher education. Such coordination is a public good; its provision should cause growth to accelerate, while coordination failure could lead to a development trap in which the economy remains on the lower rungs of the technological ladder. Thus multiple equilibria are possible for a small open economy at a low initial level of industrialization.

We illustrate these alternative outcomes in a simple general equilibrium model capturing the stylized facts of a developing economy. If the externalities and interdependences we posit are important, then the model provides one explanation for the widely-observed but seldom explained phenomenon that "outward-oriented economies really do grow faster".

1. Introduction

Among developing economies, the extent of divergence of per capita incomes since about 1960 is quite remarkable. Part of this trend is easily attributed to differences in endowments and to exogenous events such as; another part is due to massive policy mistakes such as the autarkic growth policies of North Korea, or Burma since 1962. However, divergence can also be observed even among groups of developing countries that are otherwise broadly similar in terms of initial resource endowments, historical experience and broad development policy strategy. While it would be futile to search for a single explanation for such divergent experiences, many comparisons seem to indicate that the compounded effects of policy differences – even relatively small ones – are important (e.g., Hill and Jayasuriya 1985). Theory suggests that the effects of policy differences are likely to be greater in the presence of externalities or other distortions, since these can magnify the intersectoral and intertemporal effects that policies exert.

Recent contributions to the theory of economic growth (and particularly industrialization) have emphasized a variety of externalities: knowledge accumulation, (Romer 1986, 1990), human capital accumulation (Lucas 1988, 1993; Azariadis and Drazen 1990), and increases in aggregate demand through investment coordination (Murphy et al. 1989). Theoretically, only a single source of these externalities is sufficient to explain why some but not other countries can industrialize and become prosperous. However, it is entirely possible that several may co-exist. There is ample evidence, for example, of the existence of more than one kind of Marshallian externality associated with trade (Punyasavatsut 1998).

As a result of externalities, there may be multiple equilibria in the growth experiences of market economies. It will often happen that the greater the resources committed to production in sectors with external economies, the higher are returns to those resources. Thus, committing resources to such sectors may be desirable and may lead to a higher-income equilibrium. This idea has been used to explain industrialization in initially poor countries (specifically, the process that Hirschman once labelled the "take-off into sustained growth"), and in particular the rapid growth of some East Asian economies (Murphy et al 1989; Stokey 1991; Lucas 1988; Matsuyama 1991).

In this paper we explore alternative long-run industrialization outcomes when there are multiple sources of external economies. The paper has two goals. First, we propose a model that highlights the roles played by foreign intermediate goods, human capital accumulation, and inter-industry linkages. We want to show that interactions between externalities arising from these three elements may generate multiple equilibria, and that relative magnitudes of these externalities may determine the nature of equilibria and the ways in which policies affect an equilibrium outcome. In particular, we will show that trade policy reform, by reducing the prices of intermediate goods, may help a country with both a relatively low human capital endowment and an initially small industrial sector to take off— a result that contradicts the predictions of many existing models, and yet in many respects provides a better fit with experience. As a second goal we consider the broad applicability of this model. In particular, we provide numerical illustrations that stylize the Thai experience, and address questions relevant to the Thai case.

The arguments in the paper are based on three empirical observations about industrialization in market-oriented developing economies. *First*, domestic and foreign intermediate inputs are not perfect substitutes. New or more productive technologies may be embodied in machinery and equipment imported from abroad. To establish high-technology industries, a developing country needs to import these inputs. Casual observation from the Thai case suggests that through trade and capital liberalization, imported intermediate and capital goods have been closely associated with the growth of specific manufacturing sectors.[1] Empirical studies support this observation by showing

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1 The rapid growth of the Thai automobile and parts industries, and the shift of the industry from net importer to net exporter in less thana decade after 1988, was preceded by reforms that cut tariffs both on inputs and finished goods, and reduced local content requirements.

a positive relationship between imported inputs and total factor productivity growth (Punyasavatsut 1998), a finding consistent with studies of industrialization in other countries (Temple and Voth 1996; Lee 1995; Jones 1994; De Long and Summers 1991; Findlay 1978).

Second, human capital, or the educational attainment of the labor force, is an essential input in the production of high-end products (Schultz 1964; Nelson and Phelps 1966).[2] In addition to direct effects, there may be spillovers—technological externalities— either from human capital accumulation (Azariadis and Drazen 1990), or from learning by doing (Lucas 1988, 1993). Human capital externalities find strong empirical support. Using cross-country data, Benhabib and Spiegel (1994), for example, found that human capital *stocks* determine the growth *rate* of total factor productivity. In East Asia, education, along with trade liberalization, has been credited with making the critical contribution to industrialization (Pack 1992; Young 1995).

Third, when industries are linked through backward (demand) and forward (cost) linkages, there may be pecuniary externalities between industries. Externalities through demand linkages occur when an increase in the scale of operation of the downstream industry benefits upstream firms, and cost linkages occur when expansion of the upstream industry leads to lower input prices to downstream industries. In the presence of pecuniary externalities, simultaneous investment across groups of interlinked industries may be profitable, and may be an essential step for takeoff. That pecuniary externalities are conducive to industrialization and growth has been argued by many scholars (Hirschman 1958; Rosenberg 1963; Jacobs 1969; Scherer 1982; Glaeser et al. 1992).

We seek to explore externalities and their interaction in a specific context, that of a small open developing economy. This requires a critical assessment

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[2] In the literature, human capital can be treated as an ordinary input in the production function (for example, Mankiw, Romer, and Weil 1992), or as a factor stimulating and adopting new techniques (for example, Romer 1990). For the debate on whether the economy's growth depends upon the growth rate or the level of human capital, see for example Benhabib and Spiegel 1994. In this paper, we focus on the role of human capital in explaining sectoral growth in industry.

and some extensions to the current theoretical literature. Before presenting the formal model, we set out our assumptions and discuss the structure of the model in heuristic fashion.

Consider an open economy made up of two sectors, agriculture (which is perfectly competitive and employs only unskilled labor), and manufacturing. The latter sector, which we assume is imperfectly competitive, contains upstream and downstream industries, which we combine into one aggregate industry. The manufacturing sector thus produces intermediate goods and uses these as inputs in final goods production. Production requires skilled labor and a composite intermediate combining inputs from domestic and imported sources. All intermediates from all sources are imperfect substitutes by assumption, so each intermediate good firm behaves as in monopolistic competition, pricing its product higher than the marginal cost of production. Free entry and exit guarantee zero profits, and the number of domestic intermediate firms is endogenously determined. By aggregating across industries we capture demand and cost linkages within the manufacturing sector. The strength of inter-industry linkages determines the magnitude of any pecuniary externality.

Pecuniary externalities depend partly on trade. An increase in the availability of foreign intermediate goods reduces the cost of manufacturing production, with the magnitude of this effect depending on how strongly industries are linked. The cost reduction attracts new entrants to domestic manufacturing, and this added competition in the product market forces firms to reduce prices, driving profits to zero. By this reasoning, a change (such as tariff reform) that reduces the cost of imported intermediates can be a spur to industrial growth.

At the same time, however, the expansion of domestic intermediate firms increases the demand for skilled labor, since this is complementary with intermediates. By assumption, the increased use of skilled labor raises its productivity (this is the technological externality) and with firms paying labor the value of its marginal product, skilled labor wages are driven up. This effect increases the mark-up price of each firm, creating a tension between the price-reducing effects of cheaper imported inputs and the price-increasing effects of higher wages for skilled labor. At the early stage of industrial growth, inter-industry linkages are likely weak, so skilled labor accounts for a relatively large share of total production cost. If the supply of human capital does not increase the prices charged by domestic intermediate firms may rise as more firms enter. It is now easy to see that multiple equilibria may arise in the presence of combined pecuniary and technological externalities.

Although many models explaining industrialization take the supply of human capital as exogenous, this is not a satisfactory approach in the economy we have just described. This is because it is not always clear why educational investments should become attractive when a country at a low initial level of industrialization and with a low initial level of human capital undertakes trade liberalization. When a labor-intensive economy becomes open to trade, returns to education might be predicted to fall as comparative advantage drives the country to specialize in production of labor-intensive goods and importation of human capital intensive goods. In a framework where human capital is exogenously determined, a country with a low initial stock of this factor will never experience human capital-intensive growth (Rodrik 1996). In this paper, we allow human capital to grow endogenously, and in so doing, we show that there is a link between human capital accumulation and the supply of foreign capital goods in the process of industrialization. Human capital increases along with industrialization. Reducing the price of foreign intermediates will stimulate industrialization *and* demand for skilled labor. At certain combinations of human capital endowments and numbers of domestic high-tech firms, a country will move onto the path to the higher-level equilibrium. This idea brings together two strands of the growth literature: one holding that increases in varieties of intermediate inputs can facilitate escape from the low-level equilibrium trap (Rodriguez-Clare 1996; Ciccone and Matsuyama 1996); and another attributing growth to the accumulation of human capital, in which spillovers occur when human capital reaches some critical mass (Azariadis and Drazen 1990).

The model as just described also extends earlier trade-oriented models by

Krugman and Venables (1995), and Venables (1996), which highlight the role of industrial linkages in open economies and address the role of trade policy as a potential trigger to industrialization. However, there is only one kind of externality in these models (the pecuniary externality described above) and there is no role for human capital. Since the pecuniary externality operates through inter-industry linkages and is an increasing function of the strength of such linkages, the Krugman-Venables models cannot easily explain industrialization in countries in which such linkages are initially very weak. These characteristics limit the applicability of this class of models in developing country cases.

The major innovation in this paper is to consider industrialization when pecuniary externalities operate jointly with technological (human capital) externalities. In this type of analysis it is immediately clear that the operation of the model depends critically on conditions governing changes in the supply of human capital. A second innovation, therefore, is to explain the human capital accumulation as a function of the overall level of industrialization. These two innovations combine to produce our empirical point, that the effectiveness of trade policy in determining the whether an economy converges on a çgoodé or a çbadé equilibrium depends on the fundamental characteristics of the economy, and especially on the relative magnitudes of pecuniary and human capital externalities.

The remainder of the paper is in four parts. Section 2 sets out the formal model. Section 3 describes instantaneous multiple equilibria, and shows how a change in trade policy helps trigger industrialization. Section 4 offers numerical examples of the effect of policy change on the equilibrium. A final section offers some concluding remarks and suggestions for future research.

2. The Model

We begin with the basic model following Venables (1996). Consider an economy consisting of two sectors, agriculture and manufacturing. A representative consumer receives only labor income, and has Cobb-Douglas preferences between goods produced in agriculture and manufacturing. These preferences can be represented by an expenditure function,

$$e = P_a^{1-\gamma} P_m^{\gamma} V, \qquad (1)$$

in which V is utility, P_a the price of agriculture , and P_m is the price index for manufactures, and γ is the share of manufactures in consumer expenditure.

Technology

We assume that agriculture is perfectly competitive, and uses only unskilled labor with constant returns to scale, so one unit of labor is required to produce a unit of agricultural output. We assume the agricultural price to be fixed at the border and, by choice of units, set $P_a = 1$. At equilibrium, if agricultural output is positive, the equilibrium wage of unskilled labor is also equal to 1.

Manufacturing contains downstream and upstream industries. Downstream industries are characterized by perfect competition, and upstream industries by monopolistic competition. Both upstream and downstream outputs are tradable, and subject to trade policy. Following Krugman and Venables (1995) we combine activities into a single industry which produces both final and intermediate goods and uses the intermediates as inputs in its own production. This aggregation combines the inter-industry linkages and transactions of the input-output table into one industry. We assume that the aggregate industry so created is imperfectly competitive. For simplicity, we employ the Dixit-Stiglitz (1977) method of modeling monopolistic competition, in which products are differentiated. This framework allows us to capture both demand (backward) and cost (forward) linkages between firms within a single industry (from this point we refer to both types simply as "linkages" except where drawing a distinction is necessary). Industrial expansion increases demand for the output of firms in the industry since new entrants demand intermediates from existing firms. As new entrants provide new varieties of differentiated products, this also reduces the costs of existing firms. To maintain our focus on a single economy, we assume that the output of the manufacturing sector is entirely consumed and not exported.

From the demand side, the differentiated products produced in the manufacturing sector can be aggregated into a composite good using a CES sub-utility function. The price index of this manufacturing composite is P_m, , and takes the CES form

$$P = \left[n^{d} (p)^{1-\sigma} \quad + n^{f} (p)^{1-\sigma} \right]^{1-\sigma}, \quad >1, \tag{2}$$

where p is the price of domestically produced varieties, n^d is the number of domestic high-tech firms (= varieties), p^f the price of imported varieties, and σ is the price elasticity of demand between domestic and imported varieties. For $\sigma > 1$ this structure means that no variety is essential. Without loss of generality, the number of foreign industries (= varieties) is set to be constant and equal to unity. The number of domestic industries is an endogenous variable to be determined by free entry and exit.

Firms in manufacturing use skilled labor and a composite manufacturing intermediate good to produce output. We make the major simplifying assumption that the composite intermediate good is the same as the composite consumption good. Thus the price index of intermediate goods is P_m as defined in (2) above. Labor and the intermediate are combined with a Cobb-Douglas technology with intermediate share μ. Each firm produces output χ using α units of the input as a fixed cost and an additional β units per unit of output. In addition (and at this point our analysis departs from the Krugman-Venables framework), there is a technological externality associated with the employment of human capital. We assume that economies of scale associated with human capital are external to the firm but internal to the manufacturing sector. Both marginal cost and average cost are negatively related to the quantity of human capital employed in the sector. For simplicity, assume that the human capital externality can be represented by $A(H)=H$.

Then the total cost of each firm is:

$$C = ([\alpha + \beta\chi] W_H^{1-\mu} P_m^{\mu})/H \tag{3}$$

For $\mu > 0$, there are liage effects. It is worth nothing that there is also a cost reduction in making intermidiate goods extensively used in the manufacturing sector. Therefore, production costs decline with n^d and with the accumulation of skilled labor in manufacturing at a given constant wage.

From (3), the corresponding technology of producing the domestic intermediate good can be recovered as

$$\chi = A(H)[H^{1-\mu} M^{\mu}] - \Phi,$$

$$\text{where } \beta \equiv \left[\frac{1-\mu}{\mu}\right]^{\mu} + \left[\frac{1-\mu}{\mu}\right]^{\mu-1}, \tag{4}$$

$$\text{and} \quad \alpha \equiv \Phi\beta.$$

The technology for producing the composite manufacturing good is:

$$M = \left[\left(\int_0^{n^d} \chi(j)^{\varepsilon} dj\right)\right] + \left[\left(\int_0^{n^f} \chi^f(j)^{\varepsilon} dj\right)\right], \quad 0 < \varepsilon < 1,\ \varepsilon = \tfrac{\sigma-1}{\sigma},\ \sigma > 1 \tag{5}$$

Each firm maximizes operating profits, given by

$$\pi = p(\chi)\chi - C = p(\chi)\chi - ([\alpha + \beta\chi] W_H^{1-\mu} P_M^{1-\mu})/H \tag{6}$$

Profit maximization implies that firms will use a mark-up pricing rule. Price exceeds marginal cost by a constant factor $1/\sigma$. For simplicity, we choose units of measurement such that $\beta = (\sigma-1)$ and thus both terms canceled. Thus the price of domestic intermediate goods is set as:

$$P = \left(W_H^{1-\mu} \; P_m^{\mu}\right) / H \qquad (7)$$

With free entry and exit of firms, industry equilibrium occurs when profits are zero. Since all the inputs are priced equally and enter symmetrically in the production function, all firms operate with the same scale. With price just covering average costs, i.e. $px = C$, a unique size of firm is:

$$\bar{x} = (\sigma - 1)\,\alpha / \beta = \alpha\beta. \qquad (8)$$

The equilibrium output level of each firm $\bar{\chi}$ is unique and determined by the demand elasticity between varieties and the relative magnitude of fixed cost to marginal costs. Hence, any change in the scale of the industries will have to come from a change in the number of firms.

Demand for each industry output (or variety), from both consumer demand and factor demand, is [3]

$$x = p^{-\sigma} P_m^{\sigma-1} E \qquad (9)$$

where E is total expenditure on those industry output. At the equibrilum, $x = \bar{x}$.

Total expenditure on manufacturing goods comes from two sources. First, there is consumersû expenditure on manufactures. With Cobb-Douglas preferences, a fraction γ of income is spent on manufactures. Second there is expenditure generated from intermediates. With the zero profit condition, revenue equals cost. Intermediate expenditure is thus equal to $\mu n \; p\bar{\chi}$. Then, we have:

$$E = \gamma(W_H H + W_L L) + \mu n^d p\bar{\chi} \qquad (10)$$

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[3] Fpr froof, see Grossman and Helpman (1991, pp. 46-47).

We next characterize the labor market. Inverse demand for skilled labor at the industry equilibrium is as

$$\frac{W_H}{p} = H^{1-\mu} M^{\mu} \tag{11}$$

In deriving (11), we use the fact that the industrial productivity is increasing with the number of skilled labor employed. Since the economies of scale are external, firms will pay skilled labor the value of marginal product as perceived by them. The factor market equilibrium requires that demand equal supply for each type of labor. To close the model, we must characterize the market supply for skilled labor. We make the simplifying assumption that supply of skilled labor is adjusted in a costless and timeless manner. We postulate that human capital or skilled labor is endogenously determined by individual schooling decisions. Under this assumption, the equilibrium is instantaneous.

3. Instantaneous Multiple Equilibria

The supply of skilled labor or human capital is a result of individual schooling decisions. By "human capital" we mean a set of specialized skills that an individual can acquire by devoting time to education. The more time that he or she spends in school, the greater is the measure of human capital that he or she acquires. In this model, unskilled and skilled labor perform different tasks. Only skilled labor can be employed in the manufacturing sector. We thus treat these two types of labor as imperfectly substitutable inputs. The quantity of skilled labor and its wage are both endogenous. Accumulated skilled labor directly affects the level of profits of intermediate firms, and thus the number of firms.

We need to establish the time allocation problem faced by each individual. To do so we borrow the framework suggested by Findlay and Kierzkowski (1983) and later adapted by Grossman and Helpman (1991: 125-127). In this framework, there are four equilibrium conditions relating the fraction of the population that chooses to acquire specialized skills, the level of educational attainment, supplies of unskilled and skilled labor, and relative factor returns.

We assume now that the economy is populated with a continuum of agents. Each agent lives for a finite time, T. The age distribution is uniform at any moment in time, with a density of N/T individuals of every age from 0 to T. The total population is constant at N. Let S be the number of years in school. We assume that an individual who spends S years in education receives the measure $h(S)$ of skill, where $h(\_)$ is an increasing and concave function and $h(0) = 0$. Optimality conditions for educational investments are first, that in dividuals are indifferent between acquiring skill and receiving no education at all,

$$\frac{W_H}{W_L} = \frac{1-e^{-rT}}{(e^{-rS}-e^{-rT})h(s)} \; ; \tag{12}$$

and second, that the marginal cost of spending S years in school is equal to its marginal benefit:

$$1-e^{-r(T-S)} = \frac{rh(S)}{h'(S)} \; . \tag{13}$$

Let ω denote the fraction of the population that acquires skills. At any moment in time, a measure $\omega SN/T$ attends school and is out of the labor force. The supply of unskilled labor will thus be:

$$L_0 = (1-\omega)N \; ; \tag{14}$$

and that of skilled labor with $h(S)$ will be:

$$H = \frac{(T-S)}{T} \omega Nh(S). \tag{15}$$

Equations (12)-(15) relate the fraction of the population that chooses to acquire specialized skills, the level of educational attainment of the representative worker, and the supplies of both inputs, to relative factor rewards.

For an economy that is incompletely specialized in production, equations (2), (5), (8)-(11) and (12)-(15) characterize an equilibrium, and can be used to find equibriumvalues of the endogenous variables P_m, W_H, p, n^d, S, ω, L and H with exogenous parameters T, N and r.

The complexity of the system precludesan analytical solution. This is because we need to solve the interdependence among the domestic intermediate goods price, wage differentials, and supplies and demands of skilled and unskilled labor simultaneously. For simplicity, we assume that any moment in time, there is an equibrium in the labor market. The equilibrium wage for skilled labor is increasing in the quantity of human capital employed at the equibrium.

Before identifying multiple equilibria, we describe basic mechanisms in the model. Increases in n^d, the number of intermediate input varieties, affect firms' profitability. There are three channels through which n^d shifts the demand curve of intermediate goods. *First*, an increase in n^d raises product market competition, reducing the price index, thus shifting the demand curve for the output of each firm down. The *second* and *third* channels operate when μ is positive, i.e. manufacturing uses manufactured goods as inputs. An increase in n^d creates extra expenditure on intermediate goods, raising E, and thus raising demand and profits of each firm. This is the demand, or backward linkage between firms. An increase in n^d also reduces the price index, thus lowering total cost and marginal costs, and thereby raising firms' profits. This is the cost, or forward linkage.

To analyze equilibria of the model, we can describe the model solution from equations (2), (5), (9), (10) and (11), and the equilibrium value of H in (11). As in Venables (1996), we construct two relationships between p and n^d. The first relation describes the profit-maximizing price charged by each firm as a function of the number of domestic firms operating in the industry. We refer to this curve as CC. The CC schedule is derived by using (2) and (11) in (7).

$$(CC)\ p = \left[H^{\frac{(1-\mu)^2-1}{\mu}} M^{1-\mu} \right] \left[n^d p^{1-\sigma} + (p)^{1-\sigma} \right]^{1/1-\sigma} \qquad (16)$$

When there is cost linkage between firms, i.e. when $\mu > 0$, an increase in n^d reduces the price index P_m. Firms receiving a cost reduction thus reduce the price they charge: this is the second bracketed term on the R.H.S. of (16). However, an increase in n^d also raises the quantity of skilled labor employed in manufacturing. Since firms will pay more for labor of higher productivity, so the price they charge will need to be raised: this is the first bracketed term on R.H.S. of (16). Given that μ is small, the latter effect will dominate the former, implying an upward slope of the CC curve.

The second relation gives the price which firms charge other domestic firms (and also consumers) at the scale of operation required to break even or make zero profits. We refer to this line as BB. The BB line is obtained by using (2), (10) and (11) in (9) and the operating scale is at the industry equilibrium.

$$(BB)\ \bar{x} = p^{-\sigma} \left[\frac{\mu n^d p \bar{x} + \gamma\,(W_H H + W_L L)}{n^d p^{1-\sigma} + (p^f)^{1-\sigma}} \right]. \qquad (17)$$

When a new firm enters, the demand curve facing each firm will shift downward. A cut in demand causes firms to further reduce prices in order to continue to sell at the break-even level: this is the denominator of (17). An increase in n^d also creates additional expenditure on intermediate goods, raising E. This effect depends on the strength of inter-industry demand linkages, and this is the first term in the numerator. Moreover, an increase in n^d induces a change in consumer expenditures since the price index of manufacturing goods is lower than before. The extent of this expenditure switching depends on the price elasticity of demand for aggregate manufacturing, γ: this is the second term in the numerator. The slope of the BB curve is ambiguous. However, if the first of these effects is less important, the BB curve will be upward sloping, reflecting the impact of entry through the increase in skilled labor wages and thus output prices.

The CC and BB curves are depicted in Figure 1. If there are positive linkages and strong externalities in factor market, the CC curve may be steeper than the BB curve at some range as shown. For an initial level of $n^d > N_u$, profits are positive since the price charged (on CC) is less than the one required to break-even (on BB). At this level, demand is greater than that required to break-even. Positive profits induce entry of new firms. As more firms enter, a new equilibrium is reach at n_H where the profit is zero. At S_H, the equilibrium is stable, and could be called a high-tech equilibrium. For that level of N_u, the equilibrium is unstable. Similarly, if $n^d < N_u$ initially, the price is too high for firms to break even, thus all firms exit due to negative profits. At S_L, the equilibrium is stable, and could be called a low-tech equilibrium or a pre-industrialization state.

The result obtained in Figure 1 is the outcome of the presence of industrial linkages and an externality from human capital accumulation, given instantaneous adjustment in the labor market. The characteristics of the equilibrium solution vary with the strength of linkages, the magnitude of the human capital externality, and the price elasticity of demand for manufactured goods. Varying these parameter values could thus affect the curvatures of the CC and BB curves, yielding only one stable interior solution, but this is a special case of little interest. For example, when μ is low and the human capital externality is strong, the CC curve is steeper than the BB curve, yielding a stable interior equilibrium. Instead, we now explore the questions of whether and how trade policy affect equilibrium outcomes.

Tariff Policy

To analyze the effects of trade policy on development of industry, we consider changes in the price of imported intermediate goods, p^f. Consider, for example, a tariff reduction in imported specialized goods. For simplicity, we assume that there is no recycling of tariffs back into the economy, so that tariff revenue reduction has no distributive impact and thus does not affect the equilibrium. The decrease in p^f affects the domestic high-tech firms in two ways. *First*, a price reduction in imported intermediate varieties lowers the composite price index for manufacturing. This will shift the CC curve downward. *Second*, an increase in import competition switches expenditure to foreign firms, lowering the price that domestic firms charge in order to break even. This will shift the BB curve downward also. However, the curves need not be displaced by the same amount.

To see how tariff reduction can be effective in moving an economy from the low-level equilibrium to the high-level one, we first consider the case of a pre-industrialized economy, with $n^d = 0$. Setting $n^d = 0$ in the definitions of CC and BB gives:

$$(CC)\quad p = \left[H^{\frac{(1-\mu)^2-1}{1-\mu}} \; x^{f^{1-\mu}} \right] (p^f) \qquad (18)$$

$$(BB)\quad p = \left[\frac{\gamma\,(W_H H + W_L L)}{\bar{\chi}} \right]^{1/\sigma} (p^f)^{\sigma-1/\sigma}$$

At $n^d = 0$, there will exist a p^{f*} such that the CC and BB schedules intersect. When p^{f*} is changed through trade policy, the relative magnitudes of the square bracketed term in (CC) and that in (BB) will determine whether the new CC curve lies above or below the new BB curve. From (18), it can be shown, however, that if the bracketed term in (CC) is greater than the bracketed term in (BB) and since $\sigma > 1$ by assumption, the CC schedule will shift by more than the BB schedule. In this situation, industrial linkages are weak and the externality from human capital accumulation is strong.

Let us consider two cases. *First*, we consider the case when a tariff reduction will lead to the high-level equilibrium: a situation when industrial linkages are weak and the externality from human capital accumulation is strong. In Figure 2, the slope of the BB curve is flatter than that of the CC curve. At $n^d = 0$, the equilibrium is stable at S_L, the situation before trade policy reform. Then, a reduction in the price of imported varieties will lead to an expansion of production, shifting the CC curve downward more than the BB curve . Both curves intersects once, at the point S_H with $n^d > 0$. At this level, the new high-level equilibrium is stable. Instead, if we increase the tariff, the CC curve will shift upward by more than the BB curve. In this situation, the entire CC curve lies above the BB curve (not drawn). The new stable equilibrium is the one with the higher domestic price, but without changes in the number of domestic firms, i.e. $n^d = 0$. In this case, a tariff increase makes no further improvement in industrial development.

Second, we consider the situation when linkages are strong and the human capital externality is weak. If the human capital externality is sufficient weak, the slope of the CC curve may be steeper than the BB curve (Figure 3). However, the CC curve will have a downward slope when the first bracketed term in (16) is dominated by the second bracketed term. A reduction in the price of imported intermediate goods will then shift the BB schedule down by less than the CC schedule.

In Figure 3, at $n^d = 0$, the initial equilibrium at U_L is unstable. A decrease in the tariff on imported varieties causes production to expand, reaching a new stable equilibrium at S_H with a lower price charged for domestic industries. This case is similar to Venables (1996), where interindustry linkages are strong.

In both cases, a lower tariff for foreign intermediate goods is associated with an expansion of domestic intermediate firms. However, the resulting price for domestically produced intermediate goods is indeterminate in the first case, and so is the price of the composite manufactured good.

In brief, the essential reason for multiple equilibria is the presence of two externalities: a pecuniary externality operating through industrial linkages between firms, and a technological externality through human capital accumulation. In economies at early stages of industrialization, industrial linkages are weak. In the absence of vertical integration among upstream and downstream firms, a country can become industrialized by liberalizing its foreign trade in intermediate inputs. In our model, foreign intermediate inputs are essential for domestic manufacturing. Through weak industrial linkages but with a strong human capital externality, an increase in these foreign intermediate inputs can stimulate demands for skilled labor and domestic varieties. This analysis shows that there is a possibility that liberalized trade can trigger industrialization by moving resources into the manufacturing sector exhibiting external economies.

Several points should be noted. First, when there is no externality from human capital employed in manufacturing, the CC schedule (the markup pricing condition) will always slope downward, while the slope of the BB schedule (the break even condition) is ambiguous. As shown in Venables (1996), when there are weak industrial linkages, raising protection has a conventional effect: the reduction in competition with imported foreign goods allows domestic firms to reach the production scale needed to break even. This is the opposite policy implication from our conclusion: the difference rests crucially on our assumptions and parameter values. Second, when inter-industry linkages are strong and the human capital externality is weak, we reach the same conclusion as Venables: reducing protection triggers domestic production or industrialization, similar to the second case just described. Third, when both externalities are strong, many possible cases are possible. However, this likely yields an interior stable equilibrium.

4. Numerical Examples

Since analytical study of the equilibrium is algebraically complex, it is useful to present the solution of a numerical exercise in order to see how the model works. We want to demonstrate two points. *First*, we will show that for intuitively reasonable parameter values, we can derive situations in which multiple equilibria described in this paper might be expected to exist. For simplicity, the result is obtained with some scaling in units of measurements of H, n^f, χ^f and $\bar{\chi}$. We do not attempt to replicate or calibrate our parameters from real data; this deserves a separate study. Therefore, policy implications from these results should be very cautiously drawn. *Second*, using the hypothetical solution as the starting point, we next ask by how much the price of foreign intermediate goods should be reduced in order too initiate the transition from a low-level to a high-level equilibrium.

Figure 4 illustrates equilibria of the model when there is no human capital externality and there is only one type of labor employed in both sectors. On the vertical axis of this figure is the price of domestic intermediate goods p. On the horizontal axis is the number of domestic high-tech firms n^d. The BB and CC schedules indicate loci along which domestic firms earn zero profits and set prices according to the markup pricing rule. Numerical values for the parameters are shown in Appendix 1. Figure 4 shows that when there is no externality from human capital accumulation (no skilled labor in the model), both the CC and BB curves will have a downward slope. There are three equilibria: two stable equilibria and one unstable equilibrium in the middle.

Figure 5 is constructed with human capital employed in the manufacturing sector, the situation in which we are most interested. Table 1 reports values of the price of domestic intermediate goods and the number of domestic firms in the high and low-level equilibria in the basic parameterization of the model. By construction, prices in these two equilibria were arbitrarily set at 3.5 and 10 respectively. The corresponding numbers of domestic high-tech firms are 0 and 53. Note that the average firm size is constant in the model and that by our choice of units it is unity. In the high-tech equilibrium, where a large fraction of population choose to become skilled labor and thus there is a higher level of human capital, the wage rate paid for skilled labor is higher at the margin, so the price of the intermediate goods is higher. Eventhough the skilled labor wage is higher, however, a larger number of firms can be sustained because of the positive reinforcing effects that result from both kinds of externality.

The presence of the range of the number of firms between 7 and 53 creates possibilities of welfare-enhancing government policy. In particular, as discussed earlier, a reduction in tariffs on imported intermediate goods can lead the economy to the high-level equilibrium. Table 2 shows the high-level equilibrium when tariffs on imported intermediate goods are reduced by 5, 10, and 25 per cent, and all other parameters held constant. The simulation results show that reducing the tariff by 25 per cent could eliminate the low-level equilibrium. At the new high-level equilibrium, the price is increased by almost 210%, and the number of domestic high-tech firms is increased by 135 per cent. Cheaper imported intermediate goods could trigger industrialization, given a labor market that adjusts efficiently.[4]

5. Concluding Remarks

We have presented a simple general equilibrium model in which industrialization in a small open economy can be triggered by a reduction in the price of intermediate goods. Interactions between externalities that result from human capital accumulation and industrial linkages under imperfect competition create the possibility of take-off. Industrialization occurs along with human capital accumulation. The underdevelopment trap is in part due to a coordination failure, since these externalities cannot be fully internalized, and thus there is insufficient demand for skilled labor.

Some policy implications can be drawn from this model. *First*, in a small

[4] Although this numerical exercise is intended to show only a hypothetical case, the results that a tariff reduction stimulates industrial development of the high-tech industries is appealing. Thai land did experience rapid growth in automobile industries after reducing tariffs on parts and components and domestic content requirements. Of course, other factors also helped contribute to the success of automobile manufacturing in Thailand–especially tax exemptions and other investment incentives.

open economy with imperfect substitution between domestic and foreign intermediate goods, domestic demand is not irrelevant. The interesting implication of this finding is that the expansion of domestic industry is necessary as a stimulant to human capital accumulation. And therefore, there is a possibility of increases in human capital stock as the economy opens more to trade. *Second*, an alternative (and first-best) policy to stimulate industrialization is to use pricing policy. Tax and subsidy policies on the domestic intermediate goods could do the same task. However, if the foreign intermediate and capital goods embody more advanced technology, there is a limitation to using the first-best policy. *Third*, interdependence between supplies of intermediate goods and the accumulation of human capital suggests a role for government in coordinating expectations between firms and institutions that supply higher education. Past experiences of skilled labor shortages in Thailand, for example during the early 1990s, suggests an existing coordination failure and slow adjustment in the market for high skilled labor. Moreover, if there is evidence of a human capital externality, a government subsidy for educational investments will be welfare-improving.

There are obviously many ways in which this analysis could be extended. *First*, if we allow for more complex labor market dynamics, the set of possible equilibria could be even richer. In deriving the equilibrium outcome in this paper we rely on naive Marshallian dynamics and the absence of adjustment costs in the reallocation of labor from agriculture into manufacturing. A dynamic model might yield more interesting insights into the selection of equilibria. As shown in Matsuyama (1991) and Krugman (1991), when labor reallocation incurs a cost and occurs slowly, this movement should be considered as an investment decision. When such an investment decision depends on the current and expected future wage (which depends in turn on the actions of other agents), this complementarity will lead to expectational indeterminacy in the perfect foresight model. In this situation, expectations and history can play an important role in determining the equilibrium outcome. Also, there is a potential role for government policy in coordinating expectations.

Second, it is obviously interesting to extend the model and to test it with some real numbers. Because of the simplifying assumptions that we have made, we do not believe that our model can be taken directly to the data. Calibration and testing with empirical parameters can be a next step to test the plausibility of the model.

Third, our model excludes capital accumulation and mobility. Introducing capital as another ordinary input in the model is obviously a way toward the real world. However, it is not clear that this will change the outcome. As argued by Rodriguez-Clare (1996), if capital accumulation is associated with a low number of varieties or a low division of labor, returns to capital are also low. So capital does not flow to countries with little division of labor. Government interventions to raise capital accumulation might help to take the country out of the underdevelopment trap.

Table 1. Numerical Values of the Price of Domestic Intermediate Goods and the Number of Domestic Firms in the High and Low-level Equilibriums.

	prices of domestic intermediate goods	the number of domestic firms
Low-tech equilibrium	3.5	0
High-tech equilibrium	10	53

Table 2. Effects of Tariff Changes on the Price of Domestic Intermediate Goods and the Number of Domestic Firms.

percentage change in	Change in tariff by per cent		
	5%	10%	25%
price of intermediate goods	130	160	210
the number of firms	32	60	135

Notes: See also Figures 6-8.

Figure 1. Multiple Equilibria

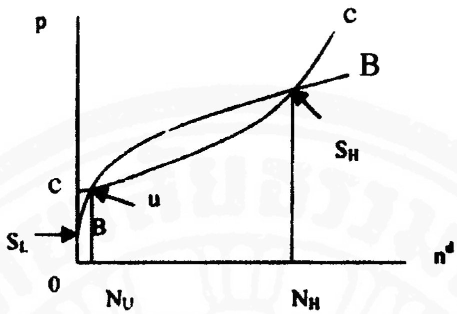


Figure 2. A Tariff Reduction Triggers Industrialization when Human Capital Externality is Strong.

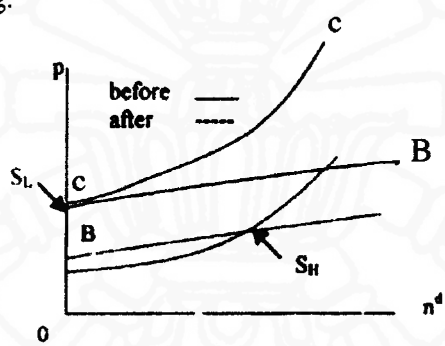


Figure 3. A Tariff Reduction Triggers Industrialization when there is no human Capital Externality.

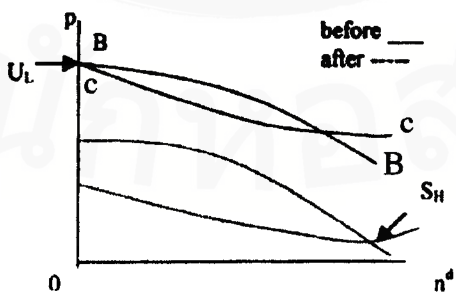
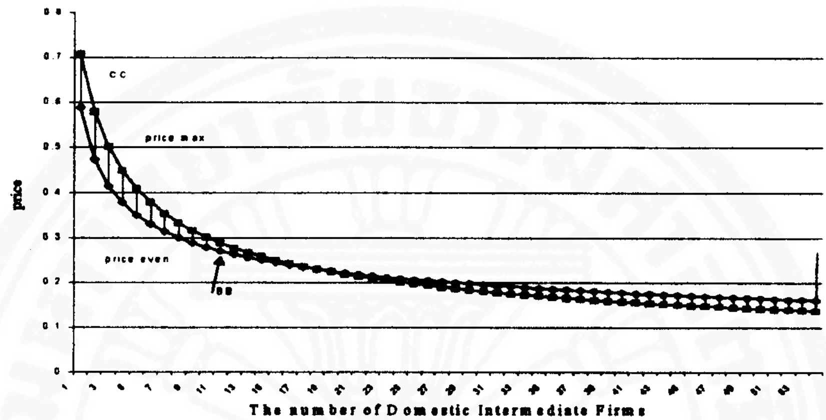


Figure 4. Numerical Equilibria when There Is No Human Capital Externality



Note: See parameter values in Appendix A.

Figure 5. Numerical Equilibria when There Is Human Capital Externality

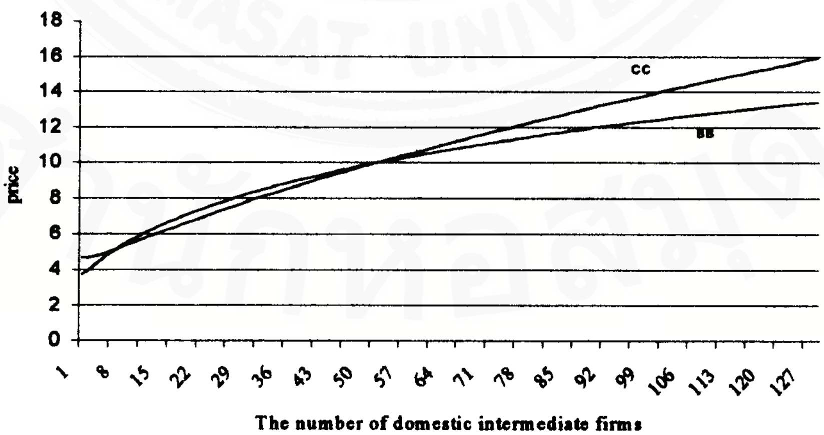


Figure 6. A 5 per cent Tariff Reduction in the Price of Intermediate Goods.

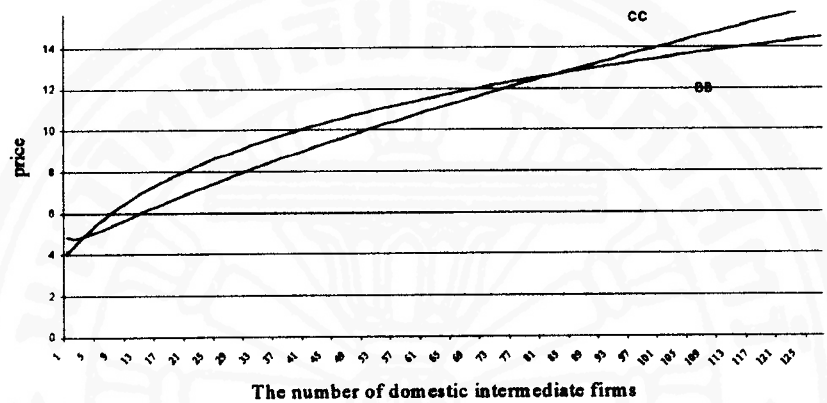


Figure 7. A 10 per cent Tariff Reduction in the Price of Intermediate Goods.

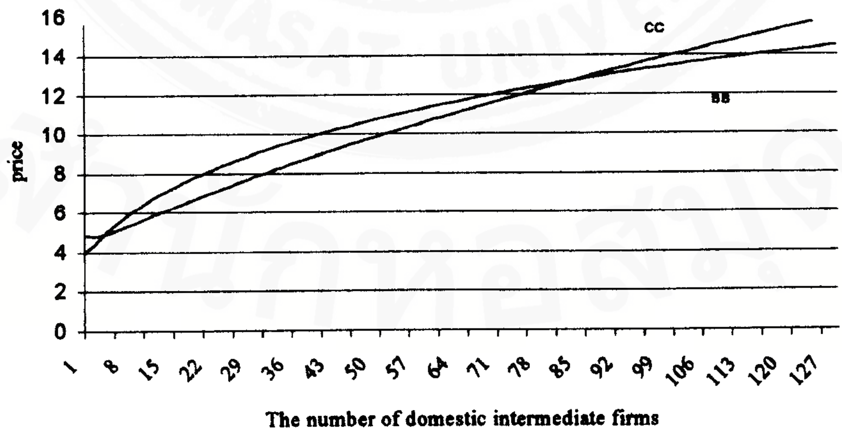
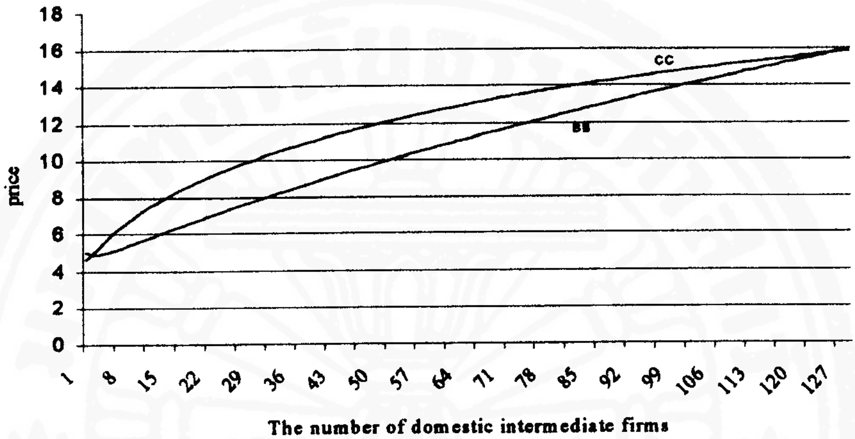


Figure 8. A 25 per cent Tariff Reduction in the Price of Intermediate Goods.



Appendix A. Parameter Values for Numerical Exercises

The simulation of Figure 4 sets μ=0.5, σ=3, χ^f=1, n^f=1, p^f=1, W_H=1, $\bar{\chi}$=1. For Figure 4, the number of human capital is irrelevant and assumed to be constant. In Figure 5, we set μ=0.45, γ=0.7, σ=4, χ^f=1, n^f=1, H = $(n^d)^{1-2}$, $\bar{\chi}$=1, p^f=1. . The amount of skilled labor employed is increasing as more firms enter the domestic intermediate industries. Without solving the labor market equilibrium for skilled and unskilled labor, we assume for simplicity that human capital is increasing in n^d at a certain rate. Similarly, in Figures 6-8, we reduced p^f by 5, 10 and 25 per cent, respectively.

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