THE DYNAMICS OF
EXPORT-PROCESSING ZONES

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CONTENTS

THE DYNAMICS OF EXPORT-PROCESSING ZONES

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Using a monopolistic pricing model as benchmark, this paper develops a dynamic framework within which issues concerning the role of export-processing zones in promoting economic openness and transition is assessed. Technological learning and adaptation contribute profoundly to economic development in LDCs; multinational activities tend to generate an externality that facilitates the process of technology transfer and learning. The model signifies these critical factors. The study suggests, among other things, that the concept of export-processing zones may serve as an effective policy means, when implemented properly, in achieving greater economic openness and growth. In this gradual evolving development process, countries that operate export-processing zones may follow a different transitional path and sequence from the one that is often cited in literature.

Introduction

As a policy means of achieving greater economic openness and growth, the concept of export-processing zones (EPZ) has gained noticeable significance during the past three decades. According to a recent count, there are well over 850 zones of various sorts operating around the world, compared with just a handful in the 1960s (ILO, 1998). Most of the latecomer zones are established in less-developed countries (LDCs) and economies in transition. To break away from an inward-looking growth path, to facilitate international flows of trade, capital and technology, and to hasten the pace of economic development and structural transformation, the opening of the EPZs has been taken as the first, albeit partial, step in that direction.

Conceptually, an EPZ may be characterized as a geographic area within the territory of a country where economic activities of certain kinds are promoted by a set of policy instruments that are not generally applicable to the rest of the country. In practice, the types of zone activities vary from bonded warehouse, export processing and assembling, border or port trade, and high-tech R&D, to trade-related transportation or financial services. Despite these variations, export-oriented manufacturing activities have been the main focus of most zones, where production tends to be dominated by foreign invested firms.[1] To attract foreign and, very

[1] According to the types of activities that are most emphasized, the zones have been given various names, ranging from free-trade zones, duty-free zones, free-export zones, free-investment zones, free-

often, multinational firms into the zones, various policy incentives have been offered by the host countries: common elements in these incentive packages are: duty-free status; tax holidays, exemption and reduction; simplified administrative procedures and fewer regulations; improved infrastructure and facilities; and advantageous geographic location. From the standpoint of foreign invested firms, these incentives can all be translated into a lower production costs in the zones and, all else being equal, higher potential profits from the EPZ operation. In return, the host countries may expect to benefit from job creation, improved capability of foreign exchange earnings, trade expansion, transfer of more advanced foreign technologies and resulting productivity gains. Eventually the economies may be put onto an export-led growth path, leading to a fuller integration into the world economy, and doing so in accordance with their comparative advantages.

Some of the potential gains from an EPZ operation are static in nature. Once a zone is successfully established, for instance, the production carried out by foreign firms creates jobs for local workers; the expanded export-processing activities in the zone contribute foreign exchange earnings to the host country. Other gains are dynamic in the sense that they can only be realized over time through deliberate efforts, such as learning and absorbing foreign technologies and transforming the pattern of economic growth from an inward-looking to an outward-looking one. By and large, the static gains have been evident, while the degree of dynamic gains varies greatly from case to case, as suggested by empirically based studies of the EPZs.[2]

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economic zones, free-enterprise zones, free manufacturing zones, economic and technology development zones, and industrial estates, to industrial or scientific parks. Bonded warehouses free ports, and duty-free shops can be regarded as zones of special types, where services are at the center stage of economic activities. Free banking zones or free insurance zones also fall into this category. To highlight the underlying economic structure of a zone, specific terms are often added to describe its main characteristics, such as electronics export-processing zones to signify the dominance of electronics manufacturing. We use the name export-processing zone here to signify the dominance of export-oriented production activities that tend to be most common among the real-world zones.

[2] For a descriptive discussion on some of the EPZs, see, for instance: Wall (1976), Ping (1979), Pollack (1981), Jayawardena (1983), Spinanger (1984), Sklair (1986), and Rondinelli (1987). More empirically and institutionally oriented case studies include: Warr (1984) about the zone in the Republic of Korea; Leinbach (1982); Warr (1987) about the EPZs in Malaysia; Kumar (1987) about the zones in India; and Wideman (1976) about the zones in Philippines. Vittal (1977) and Takeo (1978) have provided some general discussions about the export-processing zones established in Asian countries. In Germidis (1980), Basile and Germidis (1985), as well as in UNIDO (1980), and UNCTAD (1983), the export-processing zones in some other developing countries are described – such as those in Egypt, Peru, Sri Lanka, Brazil, Mexico, Mauritius, Tunisia, and Puerto Rico. Thoman (1956) addressed economic issues raised by the presence of free port and bonded warehouse for, to my knowledge, the first time, but the discussion is less relevant to the practice of the modern type of EPZs. Studies of the special economic zones in China include Chang (1986), Chu (1985), Crane (1990, 1993), Fewsmith (1986), Harding (1987), Howell (1993), Kleinberg (1990), Li and Zhao (1992), Oborne (1986), Pepper (1986), Solinger (1984), Stoltenberg (1984), Sit (1986, 1988), Sklair (1985), Wong (1987), Ge (1999a).

Analytically, existing studies of the EPZs have, to my knowledge, all been confined to a static framework along the lines of international trade theory.[3] The employment and welfare effects of opening an EPZ are the main concern to these studies. The issues of technology transfer and structural change resulting from an EPZ operation have recently been brought up by some authors; the static analytical framework which they adopted has, nevertheless, undermined the robustness of these analyses. Although these studies have captured certain features of the EPZs, a set of questions of fundamental importance are left unanswered. It is not clear that whether, or under what conditions, the opening of an EPZ would generate the above-mentioned dynamic gains in a host economy, and what would be the mechanism through which the gradual evolving development process might come about.[4] This recognition warrants a major shift in the ground on which the concept of EPZ is understood and the role of an EPZ in the process of economic growth and transition is analysed. There is a need for a dynamic framework to address these issues; developing such a framework is the purpose of this paper.

By taking explicitly into consideration the behaviour of foreign firms and the presence of a technology spillover (both of which will be specified shortly), we study the following questions in a dynamic setting. Would the export performance of a host country be improved by opening an EPZ? What are the conditions under which this improvement may be forthcoming? What are the changing patterns of EPZ production, exports of the host country, and the world market condition, and what are the factors that may affect these dynamic paths? And how can we comprehend the fact that some countries have been able to capture the dynamic gains from an EPZ operation, and some have not? These questions reach the central motive of the EPZ establishment, and address the most significant birthmark of the real world EPZs. It is hoped that the study will shed light on these crucial issues and stimulate further modelling efforts, so as to put the study of EPZ-related issues on a firmer footing.

The paper is organized as follows: the structure of the model is specified in chapter I; the solution to the model is derived in chapter II; chapter III examines the dynamics and stability of the system; chapter IV discusses the main propositions derived from the model; chapter V concludes the paper by discussing some of the policy implications of EPZ practice in the context of economic liberalization and development.

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[3] Theoretical studies of the EPZs include Hamada (1974), Rodriguesz (1976), Hamilton and Svensson (1982), Miyagiwa (1986), Young (1987), Young and Miyagiwa (1987), Chaudhuri and Adhikari (1993), Tsui (1993), Din (1994), Devereux and Chen (1995), Basu (1996), Litwack and Qian (1998), Ge (1999a).

[4] These issues were taken up in an intertemporary analytical framework by Ge (1993, 1995).

I. THE MODEL

To concentrate on the issues at hand, consider the following system. Prior to the establishment of EPZ, an article in the world market is produced mainly by a multinational firm (MNF), which possesses considerable monopolistic power and acts as a price-setter. The same article is also produced by a group of competitive domestic firms in an LDC, where an EPZ is about to be opened up. The output produced by the domestic firms is sold either on the world market at the price set by the MNF, or on the domestic market at a price that is determined domestically. Exports by the domestic firms may account for a relatively small share of their total production, due to inadequate production technology, inefficient management, and a lack of market access and marketing know-how. To improve the situation, an EPZ is established and various policy incentives are made available to foreign firms. These incentives, together with a lower cost of labour that is readily obtainable in the LDC, may be summarized into a single factor: the unit cost of production in the EPZ, c_1. Denoting the unit cost of production attainable outside the EPZ by c_2, we assume, without any loss of generality, that $c_1<c_2$, and that both c_1 and c_2 remain constant over time.[5]

Attracted by the lower unit cost of production in the EPZ, the MNF now diversifies its production into two separate locations: the EPZ and the rest of the world. At any period of time t, the output produced by its EPZ subsidiary is given by $Q_1(t)$, and the output produced elsewhere, $Q_2(t)$. The outputs from the two locations are sold in the world market at a price $p^*(t)$ charged by the MNF. Assume for simplicity that the EPZ production of this merchandise is carried out exclusively by the MNF subsidiary.

The presence of the MNF in the EPZ provides local firms in the domestic zone (DZ) with a technology source. The technologies include not only those embodied in a production process, but also designing, engineering, managerial, and marketing know-how and market information. These technologies may be transferred to the domestic firms through various channels. For instance, sophisticated equipment or production lines used in the EPZ may be operated and managed by local employees; the trained workers may carry their skills to other domestic jobs if they choose to do so. The foreign EPZ firm may set up subcontracting or joint venture

[5] The inequality $c_1<c_2$ may be interpreted as follows. When compared with the unit production cost attainable elsewhere, the policy incentives available in the EPZ, together with an improved regulatory framework, as well as physical and institutional infrastructure, tend to make the zone a more attractive location for foreign investment. This may hold, even when the cost of labour is the same in both locations.

arrangements with domestic firms, which may require the former to pass certain designing and engineering specifications and market information onto the latter. Information and knowledge concerning market condition, managerial and marketing techniques, trade and distribution networks, and changing consumer tastes may be transmitted to domestic firms through, for instance, formal or informal personal contacts, business dealings, or trade fairs. Once an EPZ is established, it is often difficult for the MNF subsidiary, regardless of its willingness, to prevent the technologies from being transferred to the locals through these linkages. That is, there exists a positive externality. The opportunity of learning from the foreign EPZ firm may, over time, help to enhance the productivity and international competitiveness of the domestic firms, and thereby accelerate export and economic growth in the host country. It is in this sense that the concept of EPZ may serve as a policy means of promoting trade and economic transition towards a fuller integration into the world economy.

To specify these linkages, we assume that the export of domestic firms at any period of time *t*, $Q_n(t)$, is a continuous, twice differentiable, function in the following two variables:

(i) The technological externality, or a learning factor, $T(t)$. $T(t)$ is assumed to be related to the EPZ production, $Q_1(t)$, in such a way that the change of $T(t)$ over time[6] is subject to:

$$\dot{T}(t) = aQ_1(t) \tag{1}$$

where α is a positive constant. The specification asserts that the degree of technological externality, measured at the site of domestic firms, is proportionate to the economic size of the EPZ; the larger the EPZ production is, the stronger the externality in the DZ will be. By treating *T* as an explicit function of time *t*, equation (1) takes into account the fact that technological learning is a cumulative process; it would take time and effort for the domestic firms to move up their learning curves, even with the presence of technological externality. The extent to which the domestic firms may gain from the opening up of the EPZ depends also on their learning capability. This may be influenced by such factors as the education level of local employees and their attitude towards learning, the institutional mechanism of technological adaptation and imitation in the host country, and public polices that facilitate technological spillover. The parameter α may be interpreted as a summary measure of these factors.

[6] For a given time variable, $X(t)$, denote the derivative of X with respect to time t by $\dot{X}$.

(ii) The price differential, $p(t)$, between the world price, $p^*(t)$, and the domestic price, p_0. That is:

$$p(t) = p^*(t) - p_0 \tag{2}$$

$p(t)$ is positive whenever $Q_n(t)>0$. Equation (2) states that domestic firms may choose to increase their export to the world market when the world price is favourable, and vice versa. Assuming p_0 remains constant over time, the time path of $p(t)$ is identical to that of $p^*(t)$; we may thus use $p(t)$ and $p^*(t)$ interchangeably.[7]

With these specifications, we can write algebraically the export function of the EPZ-operating country as:

$$Q_n(t) = Q_n\left[p(t), T(t)\right] \tag{3}$$

The first- and second-order partial derivatives of $Q_n(t)$ with respect to $p(t)$ and $T(t)$ are assumed to be positive; so is the second-order cross-derivative.

With the possible entry of domestic firms, the demand function facing the MNF in the world market is given by:

$$Q_1(t) + Q_2(t) = a - bp^*(t) - Q_n\left[p(t), T(t)\right] \tag{4}$$

where a and b are positive constants.

Recognizing that the production of its EPZ subsidiary generates a technological externality in the host country, which may allow the domestic firms to enhance their productivity and international competitiveness over time through learning, the MNF is facing a trade-off problem. On the one hand, the lower unit cost of production in the EPZ, c_1, tends to induce the MNF to diversify a larger proportion, if not all, of its production into the zone. On the other hand, the more its EPZ subsidiary produces, the greater the positive learning effect on domestic firms will be. This, in turn, will correspond to a shortened time period within which the domestic firms may manage to catch up and eventually compete with the MNF for world market shares. In making its decision on production and pricing, the MNF thus has to take the learning effect, as specified in equation (1), into consideration.

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[7] The domestic price p_0 may be thought of as the sum of two components: a competitively determined market price and an adjustment factor set by the government to influence the export behaviour of domestic firms. When the world price is relatively low, the government may, for instance, offer tax rebates or other types of subsidies to domestic exporters to induce more international sales, so as to maintain a desirable trade account position. For the purpose of this paper, we assume, for simplicity, that p_0 remains constant over time. The underlining implication of this assumption is that a change in the host country's export may take place without altering domestic market conditions. To put it differently, an increase in export, if any, may come from an increased production due to improved efficiency, rather than from a cutting back of domestic demand.

We assume, as the pricing rule, that the MNF chooses $p^*(t)$ so as to maximize its global profits, discounted over time, subjecting to the constraints of market demand and technological externality. Algebraically, the problem of the MNF can be formally stated as follows:

$$\begin{aligned}
&\underset{p^*(t)}{Max} \int_0^{\infty} \left\{ \left[p^*(t) - c_1 \right] Q_1(t) + \left[p^*(t) - c_2 \right] Q_2(t) \right\} e^{-rt} dt \\
&\text{s.t.} \quad Q_1(t) + Q_2(t) = a - bp^*(t) - Q_n\left[p(t), T(t) \right] \\
&\quad p(t) = p^*(t) - p_0 \\
&\quad \dot{T}(t) = \alpha Q_1(t) \\
&\quad T(0) = T_0 \quad given \\
&\quad a, b, \alpha > 0; \qquad 0 < r < 1; \qquad c_1 < c_2
\end{aligned} \tag{5}$$

where r is the constant discount rate.

For simplicity, we drop from now on the time notation t from all variables in the model unless it is needed.

II. THE SOLUTION

The Hamiltonian expression of problem (5) is:

$$H = \left[\left(p^* - c_1 \right) Q_1 + \left(p^* - c_2 \right) Q_2 + \lambda \alpha Q_1 \right] e^{-rt} \tag{6}$$

$$= \left\{ \left(p^* - c_2 \right) \left(a - bp^* - Q_n \right) + \left[\left(c_2 - c_1 \right) + \lambda \alpha \right] Q_1 \right\} e^{-rt}$$

The first-order conditions for the maximum can be derived as follows:

For the control variable p^*, we require that

$$\frac{\partial H}{\partial p^*} = 0 \tag{7}$$

That is:

$$a - bp^* - Q_n - \left(p^* - c_2 \right) \left(b + \frac{\partial Q_n}{\partial p^*} \right) + \left[\left(c_2 - c_1 \right) + \lambda \alpha \right] \frac{\partial Q_1}{\partial p^*} = 0 \tag{8}$$

For the state variable T, we have:

$$-\frac{\partial H}{\partial T} = \frac{d(\lambda e^{-rt})}{dt} \tag{9}$$

which leads to:

$$\dot{\lambda} = r\lambda - \left(p^* - c_2\right)\frac{\partial Q_n}{\partial T} \tag{10}$$

For the co-state variable λ, we have:

$$\frac{\partial H}{\partial \lambda} = \dot{T} \tag{11}$$

That is:

$$\dot{T} = \alpha Q_1 = \alpha\left(a - bp^* - Q_n - Q_2\right) \tag{12}$$

Equations (8), (10) and (12) consist of a set of the first-order conditions for the maximum of the MNF's problem (5).[8]

From equation (8), the optimal price set by the MNF at any time t, $p^*(t)$, can be derived as:

$$p^*(t) = \frac{a - Q_n + c_2\left(b + \frac{\partial Q_n}{\partial p^*}\right) + \left[(c_2 - c_1) + \lambda\alpha\right]\frac{\partial Q_1}{\partial p^*}}{2b + \frac{\partial Q_n}{\partial p^*}} \tag{13}$$

which is a function, among other things, of the learning factor T and the co-state variable of the system, λ.

Substituting equation (13) into (10) and (12) for p^*, we obtain a pair of differential equations that describes the optimal time path of the system:

8 The sufficient condition for the maximum of the problem (5) is that:

$$\frac{\partial^2 H}{\partial p^{*2}} = -2\left(b + \frac{\partial Q_n}{\partial p^*}\right) - \left(p^* - c_2\right)\frac{\partial^2 Q_n}{\partial p^{*2}} + \left[\left(c_2 - c_1\right) + \lambda\alpha\right]\frac{\partial^2 Q_1}{\partial p^{*2}} < 0$$

For this inequality to hold, we assume that the first- and second-order partial derivatives of Q_1 with respect to p^* are both negative.

$$\dot{T} = \alpha(a - Q_n - Q_2) - \alpha b \left\{ \frac{a - Q_n + c_2\left(b + \frac{\partial Q_n}{\partial \pi^*}\right) + \left[(c_2 - c_1) + \lambda \alpha\right]\frac{\partial Q_1}{\partial \pi^*}}{2b + \frac{\partial Q_n}{\partial \pi^*}} \right\} \equiv \Gamma(T, \lambda) \quad (14)$$

and

$$\dot{\lambda} = r\lambda + c_2 \frac{\partial Q_n}{\partial T} - \frac{\partial Q_n}{\partial T} \left\{ \frac{a - Q_n + c_2\left(b + \frac{\partial Q_n}{\partial \pi^*}\right) + \left[(c_2 - c_1) + \lambda \alpha\right]\frac{\partial Q_1}{\partial \pi^*}}{2b + \frac{\partial Q_n}{\partial \pi^*}} \right\} \equiv \Lambda(T, \lambda) \quad (15)$$

We evaluate the system below using the phase diagram.[9]

III. DYNAMICS AND STABILITY: THE PHASE DIAGRAM

To draw the phase diagram of the system, first derive from equations (14) and (15) four partial derivatives with respect to the state and co-state variables, respectively, and then evaluate their signs accordingly. The four partial derivatives are as follows.

From equation (14), we have:

$$\frac{\partial \dot{T}}{\partial T} = \Gamma_T = -\alpha \frac{\partial Q_n}{\partial T} + \alpha b \left(\frac{\frac{\partial Q_n}{\partial T}}{2b + \frac{\partial Q_n}{\partial \pi^*}} \right) = -\alpha \frac{\partial Q_n}{\partial T} \left(\frac{b + \frac{\partial Q_n}{\partial \pi^*}}{2b + \frac{\partial Q_n}{\partial \pi^*}} \right) < 0 \quad (16)$$

and[10]

$$\frac{\partial \dot{T}}{\partial \lambda} = \Gamma_\lambda = -\alpha^2 b \left(\frac{\frac{\partial Q_1}{\partial \pi^*}}{2b + \frac{\partial Q_n}{\partial \pi^*}} \right) > 0 \quad (17)$$

These lead to:

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[9] The system can be explicitly solved in algebraic terms, given the initial condition $T(0)=T_0$ and the transversality conditions $\lim_{t\to\infty} \lambda e^{-rt} \geq 0$ and $\lim_{t\to\infty} \lambda T e^{-rt} = 0$.

[10] The notation Γ_T represents the partial derivative of Γ with respect to T. Γ_λ, Λ_T, and Λ_λ are similarly defined.

$$\left.\frac{d\lambda}{dT}\right|_{\dot{T}=0} = -\frac{\Gamma_T}{\Gamma_\lambda} > 0 \tag{18}$$

From equation (15), we obtain:

$$\frac{\partial \dot{\lambda}}{\partial T} = \Lambda_T$$

$$= \frac{\left(\frac{\partial Q_n}{\partial T}\right)^2}{2b + \frac{\partial Q_n}{\partial \pi^*}} + \frac{\partial^2 Q_n}{\partial T^2}\left\{c_2 - \frac{a - Q_n + c_2\left(b + \frac{\partial Q_n}{\partial \pi^*}\right) + \left[(c_2 - c_1) + \lambda\alpha\right]\frac{\partial Q_1}{\partial \pi^*}}{2b + \frac{\partial Q_n}{\partial \pi^*}}\right\} \tag{19}$$

and

$$\frac{\partial \dot{\lambda}}{\partial \lambda} = \Lambda_\lambda = r - \frac{\partial Q_n}{\partial T}\left(\frac{\alpha \frac{\partial Q_1}{\partial \pi^*}}{2b + \frac{\partial Q_n}{\partial \pi^*}}\right) > 0 \tag{20}$$

These give us:

$$\left.\frac{d\lambda}{dT}\right|_{\dot{\lambda}=0} = -\frac{\Lambda_T}{\Lambda_\lambda} \tag{21}$$

It will be positive or negative depending on:

$$\Lambda_T \lesseqgtr 0 \tag{22}$$

since the denominator of equation (21), which is given by equation (20), is positive.

Since b and the partial derivative of Q_n with respect to p^* in the numerator of equation (21) are both positive, the condition (22) is equivalent to:

$$\left(\frac{\partial Q_n}{\partial T}\right)^2 + \frac{\partial^2 Q_n}{\partial T^2}\left\{c_2\left(2b + \frac{\partial Q_n}{\partial \pi^*}\right) - a + Q_n - c_2\left(b + \frac{\partial Q_n}{\partial \pi^*}\right) - \left[(c_2 - c_1) + \lambda\alpha\right]\frac{\partial Q_1}{\partial \pi^*}\right\}$$

$$= \left(\frac{\partial Q_n}{\partial T}\right)^2 + \frac{\partial^2 Q_n}{\partial T^2}\left\{bc_2 - a + Q_n - \left[(c_2 - c_1) + \lambda\alpha\right]\frac{\partial Q_1}{\partial \pi^*}\right\} \lesseqgtr 0 \tag{23}$$

or:

$$\frac{\left(\frac{\partial Q_n}{\partial T}\right)^2}{\frac{\partial^2 Q_n}{\partial T^2}} \lessgtr -\left\{bc_2 - a + Q_n - \left[(c_2 - c_1) + \lambda\alpha\right]\frac{\partial Q_1}{\partial p^*}\right\} \tag{24}$$

To sign equation (21), we can thus examine the sign of either the relationship (23) or (24). Since the second-order partial derivative of Q_n with respect to T has been assumed positive, and the numerator of the left-hand side of inequality (24) is always positive, the left-hand side of (24) as a whole is always positive. The sign of equation (21) thus depends on the sign of the right-hand side of (24), as well as the relative magnitude of the right-hand side and the left-hand side. There are three distinctive cases:

Case 1

$$Q_n + bc_2 - \left[(c_2 - c_1) + \lambda\alpha\right]\frac{\partial Q_1}{\partial p^*} > a \tag{25}$$

The right-hand side of inequality (24) in this case is negative. The sign of equation (21) is thus negative, regardless of the relative magnitude of the numerator and the denominator on the left-hand side of (24).

Case 2

$$Q_n + bc_2 - \left[(c_2 - c_1) + \lambda\alpha\right]\frac{\partial Q_1}{\partial p^*} < a$$

but $$\frac{\left(\frac{\partial Q_n}{\partial T}\right)^2}{\frac{\partial^2 Q_n}{\partial T^2}} > \left|bc_2 - a + Q_n - \left[(c_2 - c_1) + \lambda\alpha\right]\frac{\partial Q_1}{\partial p^*}\right| \tag{26}$$

In this case, although equation (21) will still have a negative sign, the relative magnitude of the numerator and the denominator of the left-hand side of (24) become relevant. Condition (26) is thus much stronger than that of (25). If the second inequality in condition (26) is violated, the sign of equation (21) can no longer be held negative. If this is so, the dynamic behaviour of the system, as shown in the next case, will be very different from what we have considered thus far.

The information derived so far – as summarized in relationships (16), (18), (20) and (21) – indicates that there exists a unique saddle-path along which both the state and co-state variables will move over time monotonically to the steady state, or the saddle-point, of the system. The direction of the movement of the two variables depends on the initial position of the system. In figure 1 we draw the phase diagram corresponding to both cases 1 and 2. Suppose that the initial value $T(0)<T(t)$ for any $t>0$. As figure 1 shows, the state variable will rise and the co-state variable will eventually fall monotonically along the saddle-path SS' towards their steady state values. The equilibrium is stable, provided that the initial condition can locate the system on its saddle-path.

Case 3

$$Q_n + bc_2 - \left[\left(c_2 - c_1 \right) + l a \right] \frac{\partial Q_1}{\partial p^*} < a$$

but

$$\frac{\left(\dfrac{\partial Q_n}{\partial T} \right)^2}{\dfrac{\partial^2 Q_n}{\partial T^2}} < \left| bc_2 - a + Q_n - \left[\left(c_2 - c_1 \right) + l a \right] \frac{\partial Q_1}{\partial p^*} \right| \qquad (27)$$

The sign of equation (21) in this case will be positive. The dynamic movement of the system now becomes much more complex in comparing with the two previous cases. Depending on the relative steepness of the demarcation curves, indicated by the relative magnitude of equations (18) and (21), three types of equilibrium may be distinguished.

If the value of equation (21) is greater than that of equation (18), the dynamic movement of the system from any conceivable initial point in this case is characterized by whirling phase paths. The steady state is either a focus or a vortex. In the former case, all the whirling paths flow cyclically either towards the steady state or away from it, depending on the relative positions of the two demarcation curves. In the latter case, the whirling phase paths form a set of loops orbiting around the steady state in a perpetual motion. The equilibrium is unattainable from any initial position that is away from the steady state point. If the value of equation (21) is smaller than that of (18), the steady state is characterized as a node. The equilibrium cannot be attained unless the initial condition locates the system there. We draw the phase diagrams for these cases in figures 2 to 5, respectively. As the figures show, the only stable equilibrium is the one where the slopes of both demarcation curves are sufficiently close in values, as in the case indicated in figure 2.

For the purpose of the present analysis, we assume that condition (26) holds without question so that the saddle-path solution is the only feasible solution to the system.

[Figures 1 and 2]

For technical reasons, these figures cannot be included here.

[Figures 3 and 4]

For technical reasons, these figures cannot be included here.

[Figure 5]

For technical reasons, this figure cannot be included here.

IV. THE TIME PATH OF $p^*(t)$, $Q_n(t)$, $Q_1(t)$ AND $Q_2(t)$

To find the time path of p^*, differentiating equation (13) with respect to time t to read:

$$\dot{p}^* = \frac{-\dot{Q}_n + \dot{l}\, a \frac{\P Q_1}{\P p^*}}{2b + \frac{\P Q_n}{\P p^*}} \tag{28}$$

Since:

$$\dot{Q}_n = \frac{\P Q_n}{\P T}\dot{T} + \frac{\P Q_n}{\P p^*}\dot{p}^* \tag{29}$$

substituting equation (29) into (28) and rearranging, we obtain:

$$\dot{p}^* = \frac{a \frac{\P Q_1}{\P p^*}\dot{l} - \frac{\P Q_n}{\P T}\dot{T}}{2\left(b + \frac{\P Q_n}{\P p^*}\right)} \tag{30}$$

Since the denominator in equation (30) is positive, the sign of the time derivative of p^* will be positive or negative, depending on whether the sign of the numerator of (30) is positive or negative. That is:

$$\alpha \frac{\partial Q_1}{\partial p^*} \dot{\lambda} \ \substack{> \\ <} \ \frac{\partial Q_n}{\partial T} \dot{T} \tag{31}$$

Assuming that the left-hand side of equation (31) is greater in value than the right-hand side, we may, in conjunction with equation (1), interpret this condition as follows. The right-hand side of (31) represents the marginal effect of a change in the learning factor T at any time t on the host country's export volume. The left-hand side of (31) may be thought of as the price effect on the MNF's objective function. To raise its discounted profits, the MNF may choose, at any time t, to increase p^* by limiting the production of its EPZ subsidiary, Q_1. The reduced Q_1 corresponds, from equation (1), to a lower rate of change in T. Condition (31) then states, other things being equal, that such a pricing policy will be effective and beneficial, evaluated in terms of the MNF's objective function, only if the marginal effect of the learning factor T on the export function of the host country, Q_n, is sufficiently high. This is so because for a given increase in p^* – which corresponds to a reduction in Q_1 and thus a lower rate of change in T – it tends to reduce Q_n by a larger amount if the marginal effect of T on Q_n, indicated by the partial derivative of Q_n with respect to T on the right-hand side of condition (31), is sufficiently high. As a result, the MNF's market share will increase, implying a higher level of discounted profits. The policy, however, will be counterproductive if the marginal effect of T on Q_n is relatively small. In this case, raising p^* by lowering Q_1 will in fact reduce the MNF's market share, for Q_n is now less sensitive to a change in T, and thus will not decline much.

We summarize these discussions in the following proposition.

Proposition 1

In the presence of technological externality, the monopolistic price set by the multinational firm in the world market increases or decreases over time along the optimal path, depending on whether the export of an EPZ-operating country is more or less responsive to the technological externality.[11]

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[11] The referee of the paper points out that when the EPZ-operating country is responsive to the technological externality, its exports rise and the world price decreases, as proposition 1 suggests. In the meantime, it is possible that the domestic wage level would also rise. The rising labour cost, in addition to the falling world price, may lower the profitability of the MNF associated with its operations in the EPZ, and, as a result, prompt the MNF to seek more favourable policy incentives from the EPZ-operating country. Whether this may imply a changing optimal level of incentives in the EPZ is largely an empirical question. But, analytically, the answer to this question rests primarily on the interpretation of the unit

We now examine the time path of the host country's export function Q_n by recalling equation (29). The time derivative of $Q_n(t)$ will be positive or negative, respectively, as:

$$\frac{\partial Q_n}{\partial T}\dot{T} \gtrless -\frac{\partial Q_n}{\partial p^*}\dot{p}^* \tag{32}$$

According to the sign of the time derivative of p^*, we sign (29) by considering condition (32) in the following two distinctive cases:

(i) p^* increases over time. The left-hand side of inequality (32) is always positive as long as Q_1 is not zero. With p^* increases over time, the right-hand side of (32) will have a negative sign, since the partial derivative of Q_n with respect to p^* is positive. Condition (32) in this case implies that the time derivative of Q_n will be positive.

(ii) p^* declines over time. The right-hand side of condition (32) now becomes positive. The time derivative of Q_n , however, will still be positive so long as the left-hand side of (32) is greater in value than the right-hand side. This could be so if the marginal effect of price on the domestic firms' export function, relative to the marginal effect of learning on Q_n , is sufficiently low. If this is not the case, Q_n will then decline over time.

While case (i) above may be viewed as a case where price effect dominates, case (ii) represents primarily the effect of learning on the export performance of the EPZ-operating country. Although p^* may decrease over time, as long as $p(t)$ remains positive, Q_n will still rise if the marginal effect of learning, relative to the marginal effect of price, on Q_n is significant. This leads to the following proposition.

Proposition 2

In the presence of technological externality, the export of an EPZ-operating country increases over time along the optimal path, regardless of whether the world price has increased, provided that the export is sufficiently responsive to the technological externality.

From a policy-making viewpoint, proposition 2 suggests, as far as facilitating technology transfer is concerned, that to make the best use of an EPZ in promoting export-led growth, the zone should be kept as open as possible to the rest of the domestic economy. In reality, fearing

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production cost in the EPZ. As noted earlier, since the cost of labour is only a part of the overall unit production cost in the zone, it is entirely possible for the rising labour cost to be offset by the benefits attainable in other aspects of the EPZ-operation. These may include, for instance, the favourable geographical location of the zone, easier access to both input and output markets, and a potentially high exit cost should the MNF decide to relocate its EPZ-operation elsewhere. The combined effect of these forces may lead to a lower incentive on the part of the MNF to demand too much concession from the host country by risking a sudden withdraw from the EPZ.

that EPZ activities may disturb the domestic economy too much, policy attempts to isolate the EPZ from the DZ have often been implemented, as in the case of “fenced-in” zones. Such a practice undermines the learning effect. A lack of consistent policy effort in diffusing technologies, or an inadequate capability of technological learning among local firms, yields a similar result. In all these cases, the potential contribution of the EPZ concept to economic development in the EPZ-operating countries tends to be greatly reduced. The finding stated in proposition 2 enables us to explain why some EPZs in the real world have played their presumed role, and did so better than others.

We now turn to the time path of $Q_1(t)$. Differentiating Q_1 from equation (4), with respect to time t, while holding Q_2 constant, yields:

$$\dot{Q}_1 = -b\,\dot{p}^* - \dot{Q}_n \tag{33}$$

which is positive or negative depending on:

$$b \;\substack{<\\>}\; -\frac{\dot{Q}_n}{\dot{p}^*} \tag{34}$$

Since b is a positive constant, the sign of equation (33) will be negative so long as the time derivatives of p^* and Q_n are the same in signs. As p^* increases over time, this corresponds to case (i) above. For case (ii), as p^* falls and Q_n rises over time, condition (34) can be restated as:

$$b \;\substack{<\\>}\; \left|\frac{\dot{Q}_n}{\dot{p}^*}\right| \tag{35}$$

That is, whether or not $Q_1(t)$ will increase over time depends on the relative magnitude of the demand-side response to price changes, relative to the ratio of the changes of Q_n to p^* over time. If b is sufficiently high – i.e. the market demand curve is sufficiently steep – Q_1 will decrease over time. This leads to the following proposition.

Proposition 3

In the presence of technological externality, the market share of the multinational firm’s EPZ subsidiary declines over time along the optimal path, provided that either p^* and Q_n eventually move in the same direction or that the world demand is sufficiently inelastic.

It is worth noting that, in deriving proposition 3, we have assumed that the MNF's output produced outside the EPZ, Q_2, is fixed over time. If this is indeed the case, the proposition 3 then predicts that the overall market share of the MNF will, under the above-stated conditions, decline over time as a result of diversifying its production into the EPZ. Raising p^* over time will not improve the situation, since the export of domestic firms will increase at the same time.

This raises an interesting question: how should the MNF adjust its overall production in order to prevent the possible loss of market share? Although producing in the EPZ might have its attractiveness in terms of production cost-saving, the potential loss of market share presents a threat to the MNF's monopolistic position on the world market; this is not attractive at all. To allow the MNF to adjust its production globally, we now relax the assumption of fixed Q_2 by permitting it to change over time.

Suppose that the MNF wishes, after establishing its EPZ subsidiary, to maintain a world market share, at least at its previous level. This requires the following inequality to hold:

$$\dot{Q}_2 \geq -\dot{Q}_1 \tag{36}$$

That is, the time paths of Q_1 and Q_2 must be opposite in signs; the increase in Q_2 must, at least, be able to compensate the decrease in Q_1 at any time t. As seen from proposition 3, the market share of the output produced by the MNF's subsidiary in the EPZ, Q_1, is likely to fall as domestic firms become more active in the world market, unless the market demand curve is sufficiently flat. To keep its overall market share from falling, therefore, the MNF must be prepared to expand its production in the rest of the world accordingly, even though the unit cost of production there would be higher than in the EPZ. We state this in the following proposition.

Proposition 4

In the presence of technological externality, the market share of the multinational firm declines, unless either the firm increases its production in locations outside the EPZ by an amount that offsets the market share loss of its EPZ subsidiary, or the would demand is sufficiently elastic.

Empirical case studies of the EPZs have identified a four-phase life cycle that the zones are likely to go through.[12] These are: (i) the construction of basic infrastructure; (ii) the increase of foreign direct investment into, and of exports from, the zones; (iii) levelling-off and upgrading; and (iv) an eventual integration of the zones into the domestic economy, either by

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[12] See, for instance, Basile and Germidis (1985).

disinvestment of foreign investors or by local entrepreneurs' takeovers. The discussion above provides an analytical account on why and how the last phase of the life cycle would take place. That is, under what circumstances Q_1 would fall over time.

IV. CONCLUDING REMARKS

Using a monopolistic pricing model as benchmark, this paper has developed a dynamic framework within which issues concerning the role of EPZs in promoting economic openness and transition may be assessed. Findings derived from the theoretical framework appear to be consistent with empirical observations, and are intuitively appealing. Technological learning and adaptation contribute profoundly to economic development in LDCs; the model signifies these critical factors. This said, several policy implications from the model, in a context of economic liberalization and development, are outlined below.

In recent years, foreign direct investment, in the form of multinational activities, has emerged as a main vehicle for transferring capital, technology and knowledge to LDCs from developed or newly industrialized countries. Compared with other types of international capital flows, such as foreign portfolio investment and commercial lending, the activities of multinational firms tend to be motivated by longer-term considerations and are much less volatile, as the recent Asian financial crisis would testify. In many cases, the opening up of EPZs has served as an effective means of attracting foreign firms. In order to maximize the dynamic gains that the EPZs may bring about, it is highly desirable to establish a strong linkage between the EPZ and the DZ. The linkage provides a key channel through which various technologies may be diffused from the EPZs to the rest of the host economies. To strengthen the linkage, deliberate and consistent policy efforts are crucial, especially those enhancing the openness of the EPZ to the DZ and the learning capability of local firms, employees and entrepreneurs. This requires further economic reforms of a wide range to be conducted in the DZ. Without these efforts, the gains from establishing an EPZ would be likely to be limited. This helps to explain why some EPZ-operating countries have done better than others in achieving greater economic openness and productivity gains. Simply opening up a zone would not do the trick.

From the standpoint of EPZ-operating countries, attracting foreign direct investment into the zones amounts to a partial opening of the capital account. As the model illustrates, this policy move tends to be trade-enhancing, provided that certain conditions are met. As trade expands, pressures for deepening policy and institutional reforms are likely to mount, pushing for further opening of the countries' current account. Demand for trade-related financial services may also rise, forcing the financial sector to perform. These forces may, in due course, lead the countries onto an irreversible path moving towards a greater degree of economic openness and liberalization. In this respect, the EPZ practice provides an alternative sequence to economic liberalization, which differs from the one that calls for the opening of the current account to precede that of the capital account, as often cited in literature and within policy-making circles.[13] A further study along this line might shed light on how a process of economic transition and liberalization could be better carried out.

The concept of EPZ has often been adapted as an integral component of the policy efforts aimed at promoting economic openness and development in a step-by-step fashion. The gradualist approach has showed distinct advantages over the so-called "shock therapy", which calls for "do-it-all-at-once" when it comes to economic transition and liberalization. What seems to have been missing in the shock therapy is the understanding that economic transition is a dynamic process, and that economic liberalization is the means of development, not the end. The modelling framework developed in this paper reflects this recognition, and may provide an analytical justification in favour of the gradualist approach, where the concept of EPZ has been at the core. [14]

It is hoped that with this framework, the role of the EPZ concept in facilitating the process of economic transition and liberalization may be better understood, and its increasing popularity in the real world better appreciated.

[13] For discussions on related issues see, for instance, Islam and Chowdhury (1997); Harwood and Smith (1997); Woo, Parker and Sachs (1997); and Ge (1999a).

[14] For more detailed discussion on the special economic zones in China and their impacts on China's economic transition see Ge (1999b).

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