Dynamic Comparative Advantage and the Welfare Effects of trade*

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Abstract

This paper argues that developing economies may face a trade-off between specializing according to existing comparative advantage (in low-technology goods), and entering sectors in which they currently lack a comparative advantage, but may acquire such an advantage in the future as a result of the potential for productivity growth (in high-technology goods). Comparative advantage is endogenously determined by past technological change, while simultaneously shaping current rates of innovation. As a result, it is possible that specialization according to current comparative advantage under free trade is welfare reducing, while protectionist measures are welfare increasing.

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1 Introduction

A study by the World Bank in the 1960s "expressed the view that an integrated steel mill in Korea was a premature proposition without economic feasibility." (Pohang Iron and Steel Co. Ltd (1984), p. 23, cited in Amsden (1989)). A number of factors, including Korea's deficiency in the required raw materials and its small domestic market for such a scale-intensive industry, suggested that steel making was an industry in which Korea was unlikely to have a comparative advantage.[1] Nonetheless, in 1973, the Korean government founded the Pohang Iron and Steel Company Ltd. (POSCO) with an initial investment of $ 3.6bn. Government assistance in a wide variety of forms, including subsidisation of the cost of capital and investments in infrastructure has been central to POSCO's development. The company soon became one of the lowest cost steel-producers in the world so that, in 1985, Korea unit costs of production were less than those of Japan and around 2/3 of those in the United States (Amsden (1989), Table 12.2). By 1988, POSCO had become the eleventh largest steel company in the world, operating 80 individual plants (Enos and Park (1988)).

Although at the time POSCO was founded Korea did not appear to have a comparative advantage in the iron and steel industry, it seems incontrovertible that it now does and that the Korean government has played a central role in its acquiring one. This paper investigates the idea that developing economies may face a trade-off between specialising according to an existing pattern of comparative advantage (often in low-technology industries) and entering sectors in which they currently lack a comparative advantage, but may acquire such an advantage in the future as a result of the potential for productivity growth (e.g. high-technology industries). We analyse the circumstances under which the actions of private sector agents will resolve this trade-off between current and future patterns of comparative advantage optimally. If the trade-off is not resolved optimally, then it becomes possible for free trade to be welfare reducing. Moreover, protectionist measures that induce specialisation in sectors where one

[1]See, for example, (Amsden, 1989, Chapter 12) on which the first two paragraphs of this Section draw.

does not currently have a comparative advantage may be welfare increasing.

This paper investigates these ideas within a general equilibrium model of endogenous growth, in which an economy's pattern of international trade and rate of economic growth are jointly and endogenously determined. The paper is part of a wider literature concerned with relationship been trade and growth. For example, Krugman (1981) examines the effect of international trade upon the world distribution of income when there are external economies to physical capital accumulation in the manufacturing sector. An early formalisation of the interrelationship between patterns of international trade and rates of technological change (although there is no welfare analysis) is provided by Krugman (1987). As a result of this interaction, initial patterns of international trade become increasingly "locked-in" over time.

More recently, (Grossman and Helpman, 1990, 1991), (Rivera-Batiz and Romer 1991a, 1991b) and (Taylor 1991, 1994) have examined the relationship between trade and growth, when endogenous growth is the result of profit-seeking investments in Research and Development (R & D).[2] Young (1991) analyses the links between trade and growth, when bounded learning by doing leads to the adoption of new varieties of goods; while Stokey (1991) examines the interaction between trade and human capital accumulation. In small open economy models, Matsuyama (1992) and Sachs and Warner (1995) respectively consider the effects of levels of agricultural productivity and endowments of natural resources on international trade and growth.

In fact, the existing literature suggests a number of channels through which trade may affect an economy's rate of growth. In this paper, motivated by the empirical discussion above, we focus upon the relationship between endogenous comparative advantage, economic growth and economic welfare. In contrast to much of the literature, which has emphasised the beneficial effects of trade on growth, the analysis suggests that specialisation according to initial comparative advantage may have negative effects upon both rates of growth and economic

[2] Where these investments may either yield new varieties or (as in Aghion and Howitt (1992)) successively higher qualities of intermediate inputs.

welfare. The analysis builds upon a number of existing studies of endogenous comparative advantage and growth (see, in particular, Krugman (1987), (Grossman and Helpman, 1990, 1991), and Young (1991)). This paper makes two main contributions.

First, we examine the endogeneity of comparative advantage within a particularly tractable, general equilibrium model of endogenous growth and international trade between two, large economies. The tractability of this framework enables us to undertake a complete analysis of the welfare effects of international trade and the potential case for selective trade and industrial policies. We are able to derive necessary and sufficient conditions for free trade, by inducing specialisation according to current patterns of comparative advantage, to be welfare reducing. Furthermore, we establish the circumstances under which selective trade and industrial policies, that induce specialisation in sectors where an economy does not currently have a comparative advantage, may be welfare improving. Throughout the analysis, the role of endogenous comparative advantage is made clear. Motivated by the earlier empirical discussion of the East Asian development experience (see also Amsden (1989) and Wade (1990)), the paper emphasises the potential trade-off an economy may face between specialising according to an existing pattern of comparative advantage, and entering sectors where it currently lacks a comparative advantage, but may acquire such an advantage as a result of the potential for productivity growth.

Second, the endogeneity of comparative advantage in models of growth and trade has led a number of authors in the theoretical literature (see, for example, Krugman (1987) and Grossman and Helpman (1991)) to speak in terms of 'dynamic comparative advantage.' This very same term appears in more informal discussions of the East Asian development experience (see, for example, Amsden (1989)). This paper's second objective is therefore to see whether, on the basis of the theoretical analysis of the relationship between international trade and economic growth, any substantiative content can be given to this often-used, but so far ill-defined concept. The paper suggests that, when comparative advantage is endogenous in dynamic trade models, the traditional (or 'static') notion of comparative advantage may be usefully augmented with a second 'dynamic' concept. This dynamic concept explains the evolution of patterns of international trade over time and sheds light upon the circumstances under which welfare improving selective trade and industrial policies exist. Interestingly, if such policies exist, they need only be temporary.

The paper is structured as follows. Section 2 introduces the model, while section 3 solves for static equilibrium under both autarky and free trade. Section 4 is concerned with the relationship between trade and productivity growth, and shows how comparative advantage is endogenously determined. Section 5 considers the implications of endogenous comparative advantage for the welfare effects of international trade. The standard static gains from trade are augmented with dynamic effects, which may either increase or decrease the intertemporal welfare of the representative agent. Section 6 addresses the related, but distinct question whether selective trade and industrial policies to induce entry into a sector where an economy currently lacks a comparative advantage may be welfare improving. Section 7 moves on to consider the popular notion of 'dynamic comparative advantage.' The popular notion is formalised and its relationship to the preceding analysis discussed. Finally, section 8 concludes.

2 A dynamic Ricardian model

In this section, a standard Ricardian model of international trade (see, for example, Krugman and Obstfeld (1994)) is augmented with a specification for productivity dynamics. Productivity in each sector is assumed to evolve endogenously over time as learning by doing occurs. We consider international trade between two economies ('home' and 'foreign'), where all foreign variables are denoted by an asterisk.

Each economy may produce two final goods, a low-technology, traditional good z (e.g. agriculture, textiles) and a high-technology, frontier good h (e.g. manufacturing, electronics).[3] Labour is the sole factor of production, and the

[3] See Dornbusch *et al.* (1977) for an exposition of the static Ricardian model with a continuum of goods.

two economies are populated with a number of representative consumers ($\bar{L}$ and $\bar{L}^*$). Time is continuous and is indexed by t.

2.1 The static model

Consumer preferences are assumed to be identical in the two economies, with instantaneous utility a Cobb-Douglas function of consumption of the low- and high-tech goods: $u(c_z, c_h) = c_z^{\beta} c_h^{1-\beta}$ where $0 < \beta < 1$.[4] Intertemporal utility is the sum of instantaneous utilities, discounted at the subjective rate of time preference ρ. For simplicity, we assume that there is no storage or savings technology so that, at each point in time, expenditure equals income for the representative consumer. Each consumer is endowed with one unit of labour, which is supplied inelastically with zero disutility.

Low- and high-tech goods are produced with labour L_j according to constant returns to scale technologies, whose productivity we index by A_j, for $j = z, h$. Aggregate output in each sector is thus,

$$Y_z = A_z.L_z, \qquad\qquad Y_h = A_h.L_h \tag{1}$$

Production is assumed to occur under conditions of perfect competition, and we make the standard assumption that labour is perfectly mobile between sectors and immobile across countries. Home labour market clearing requires $L_z + L_h = \bar{L}$.

2.2 Productivity dynamics

A wide range of empirical evidence suggests that learning by doing is an important source of productivity improvements. For example, Lucas (1993) cites evidence that each doubling of cumulative output of "Liberty Ships" in 14 U.S. shipyards during World War II was associated with a reduction of man-hours required per ship by between 12 and 24 per cent. Hence, following Krugman (1987), we assume that productivity in each sector A_j depends upon a stock of sector-specific

[4] In general, lower case letters are used for per capita variables. In order to simplify notation, we suppress an implicit dependence upon time, except where it is important.

production experience K_j, as well as exogenous factors ψ_j such as climate, culture, political institutions and laws,

$$A_z(t) = \psi_z.K_z(t), \qquad A_h(t) = \psi_h.K_h(t) \tag{2}$$

where $\psi_j > 0$ for $j = z, h$.

While producing output in a given sector, agents acquire productivity-enhancing production experience K_j (or *learn by doing*): for example, through trial and error, new methods of manufacture or new ways of organising existing processes are discovered. The rate at which this production experience is acquired is assumed to depend upon the flow of labour employed in producing a sector's output, so that K_j evolves according to,[5]

$$\dot{K}_z(t) = \mu_z.L_z(t).K_z(t), \qquad \mu_z > 0 \tag{3}$$

$$\dot{K}_h(t) = \mu_h.L_h(t).K_h(t), \qquad \mu_h > 0 \tag{4}$$

where μ_j parameterises the rate at which knowledge is acquired as part of the production process in sector j. Learning by doing is assumed to be a pure externality of the production process: in particular, learning by doing is assumed to be external to individual firms but specific to a sector and to an economy.[6]

[5]According to the specification in (3) and (4), learning by doing is technologically unbounded. It is possible to extend the analysis to the case of bounded learning by doing (see Redding (1996)), in which case comparative advantage is not only endogenous but the rate at which it evolves over time is a function of cumulative production experience. However, this only complicates the analysis without adding additional insight.

[6]There is considerable empirical evidence that international knowledge spillovers are imperfect (see, for example, Coe and Helpman (1995)) and that levels of Total Factor Productivity differ substantially across economies (see, for example, Islam (1995)). It is possible to introduce international knowledge spillovers. However, as long as these are imperfect, the analysis remains essentially unchanged.

3 Static equilibrium

3.1 Autarky

Autarkic equilibrium is fully characterised by the requirement that the relative price of the low-tech good equals both minus the Marginal Rate of Substitution (MRS) and minus the Marginal Rate of Transformation (MRT) between low- and high-tech goods. From the expression for instantaneous utility and (1), we require $\beta/(1-\beta).C_h/C_z = p_z/p_h = A_h/A_z$.

Consumer preferences over the low- and high-tech goods exhibit a demand for variety. Autarkic equilibrium is characterised by incomplete specialisation, with labour allocated in the constant proportions β and $(1-\beta)$ to the low- and high-tech sectors respectively,

$$L_z = \beta.\bar{L}, \qquad L_h = (1-\beta).\bar{L} \tag{5}$$

3.2 Free Trade

In this subsection, we allow two previously autarkic economies to engage in free trade from some arbitrary point in time t_1 onwards. With free trade and zero transport costs, the price of the low- and high-tech goods must be the same in each economy. Perfect competition implies that the home wage in the low- and high-tech sectors will equal $w_z(t) = A_z(t).p_z(t)$ and $w_h(t) = A_h(t).p_h(t)$ respectively; where, if specialisation in home is incomplete, we require $w_z = w_h = w$.

Throughout the following, we will be largely concerned with equilibria characterised by complete specialisation in both economies.[7] For home to specialise completely in the low-tech sector and foreign in the high-tech, we require $w_z > w_h$ and $w_h^* > w_z^*$. That is,

$$\frac{A_h^*(t)}{A_z^*(t)} > \frac{p_z(t)}{p_h(t)} > \frac{A_h(t)}{A_z(t)} \tag{6}$$

[7]This is merely for simplicity. It is straightforward to extend the analysis to cases of incomplete specialisation.

In such an equilibrium, the entire of home's supply of labour is employed in the low-tech sector and the entire of foreign's in the high-tech sector. Equation (6) and the associated allocation of labour to the two sectors defines the world supply of the low- relative to the high-tech good: $RS_{zh} = (Y_z + Y_z^*)/(Y_h + Y_h^*)$.

With Cobb-Douglas instantaneous utility, each representative consumer allocates expenditure to the low- and high-tech sectors in the constant proportions β and $(1 - \beta)$ at each point in time t. World demand for the low-tech relative to the high-tech good is thus,

$$RD_{zh} = \frac{C_z + C_z^*}{C_h + C_h^*} = \frac{\beta}{(1-\beta)}.\frac{p_h}{p_z} \tag{7}$$

General equilibrium of the static model may be fully characterised in relative supply, relative demand space, as shown in Figure 1.

Figure 1 about here

4 Endogenous comparative advantage

The pattern of international trade in the static Ricardian model is determined by the traditional or 'static' notion of comparative advantage. Thus, an economy is said to have a 'static comparative advantage' in the low-tech sector at time t if the opportunity cost of producing the low-tech good at home is lower than in the other economy,

$$\frac{A_h(t)}{A_z(t)} < \frac{A_h^*(t)}{A_z^*(t)} \tag{8}$$

where, from (6), this is a necessary condition for home to specialise in the low-tech sector in the free trade equilibrium. Throughout the paper, 'comparative advantage' will be used in this traditional, 'static' sense unless otherwise specified. We will largely be concerned with equilibria in which home has an initial comparative advantage in the low-tech sector.

From equation (8), it is clear that the pattern of comparative advantage at any point in time depends upon productivity in each sector of the two economies (A_j,

A^*_j, $j = z, h$). This, in turn, is a determined by a combination of exogenous factors on the one hand (such as climate, political institutions and laws as parameterised by ψ_j and ψ^*_j, $j = z, h$) and past technological change on the other (as manifested in the stocks of cumulative production experience K_j and K^*_j, $j = z, h$). Thus, comparative advantage depends upon past technological change in each sector; while, at the same time, determining the free trade allocation of labour across sectors and hence (from (3) and (4)) rates of productivity growth in each sector.

Under autarky, home is incompletely specialised in both sectors and, from (3), (4) and (5), accumulates production experience at the rates $g^n_z = \mu_z.\beta.\bar{L}$ and $g^n_h = \mu_h.(1-\beta).\bar{L}$ in the low- and high-tech sectors respectively.[8] Similarly, for foreign we have $g^{n*}_z = \mu^*_z.\beta.\bar{L}^*$ and $g^{n*}_h = \mu^*_h.(1-\beta).\bar{L}^*$. In contrast, in the free trade equilibrium, home's comparative advantage in the low-tech sector means that it specialises completely in the production of this good. Thus, home learns by doing in the low-tech sector alone (at the rate $g^f_z = \mu_z.\bar{L}$), while foreign learns by doing in the high-tech sector (at the rate $g^{f*}_h = \mu^*_h.\bar{L}^*$).[9]

Specialisation according to comparative advantage under free trade changes the (endogenous) rate of productivity growth in each sector of the two economies. Productivity levels dictate comparative advantage, which affects the allocation of labour between sectors. This in turn determines relative rates of productivity growth, and thereby feeds back to shape the evolution of productivity levels over time. In this way, current comparative advantage is endogenously determined.

The endogeneity of comparative advantage in models of growth and trade has led a number of authors to speak in terms of 'dynamic comparative advantage'; although, as yet, this concept has remained ill-defined. A later section comes back to discuss this idea. However, first, we move on to consider the implications of endogenous productivity growth and endogenous comparative advantage for the welfare effects of trade.

[8]Where the superscript n ('no trade') indexes the value of a variable under autarky.
[9]Where the superscript f ('free trade') indexes the value of a variable under free trade.

5 Trade and welfare

In this section, we compare the representative consumer's intertemporal welfare under the alternative regimes of remaining autarkic from time t_1 onwards and engaging in free trade. In each case, intertemporal welfare is given by the discounted sum of instantaneous utilities. Furthermore, since instantaneous utility is Cobb-Douglas, it follows that, under both autarky and free trade, the representative consumer will allocate the constant proportions β and $(1-\beta)$ of his/her expenditure at each point in time t to the low- and high-tech goods respectively.

5.1 Welfare under autarky

Beginning with autarky, specialisation is incomplete and the representative consumer's income is given by the wage $w(t) = p_z^n(t).A_z^n(t) = p_h^n(t).A_h^n(t)$. Using the fact that constant proportions of income are allocated to expenditure on the low- and high-tech goods, we obtain the following expression for intertemporal welfare,

$$U_{t_1}^n = \int_{t_1}^{\infty} e^{-\rho(t-t_1)} \left[\beta.A_z^n(t)\right]^{\beta} \left[(1-\beta).A_h^n(t)\right]^{1-\beta} dt \tag{9}$$

where $A_j^n(t)$ denotes the level of productivity in each sector $j = z, h$ under autarky at each point in time $t \geq t_1$.

5.2 Welfare under free trade

In contrast, under free trade, specialisation is complete and the representative consumer's income is equal to the wage in the low-tech sector $w(t) = p_z^f(t).A_z^f(t)$ for all $t \geq t_1$. Again using the fact that consumer expenditure is allocated in constant proportions, we arrive at an analogous expression for intertemporal welfare,

$$U_{t_1}^f = \int_{t_1}^{\infty} e^{-\rho(t-t_1)} \left[\beta.A_z^f(t)\right]^{\beta} \left[(1-\beta).A_z^f(t).p_z^f(t)/p_h^f(t)\right]^{1-\beta} dt \tag{10}$$

where the relative price of the low-tech good is determined on world markets.

5.3 Static gains from trade

The right-hand sides of equations (9) and (10) contain information about levels of instantaneous utility at all points in time $t \geq t_1$. From these two equations, it is immediately clear that instantaneous utility must be lower under autarky than under free trade at time t_1 when the choice between the two regimes must be made. Instantaneous utility will be lower under autarky if and only if $p_z^f(t_1)/p_h^f(t_1) > A_h(t_1)/A_z(t_1)$, where we use the fact that $A_z^n(t_1) = A_z^f(t_1)$ and $A_h^n(t_1) = A_h^f(t_1)$ (clearly, these equalities will not, in general, hold for $t > t_1$). This condition must be satisfied in a free trade equilibrium in which home has a static comparative advantage in and specialises in low-tech production. The existence of the standard static gains from trade (from specialisation according to comparative advantage) implies that instantaneous utility must be initially lower under a regime of autarky than one of free trade.

5.4 Dynamic effects and intertemporal welfare

However, the fact that technological change is endogenous means that a move from autarky to free trade has additional, dynamic welfare effects. Here, two aspects of the analysis are important. First, as discussed in the previous section, specialisation according to comparative advantage leads to reallocations of resources between the low- and high-tech sectors. These reallocations of resources affect rates of learning by doing and productivity growth in each sector of the two economies, and hence have dynamic effects on economic welfare.

Second, the literatures on both the microeconomics of technological change and endogenous growth suggest a number of reasons why the laissez-faire rate of technological change may be less than the socially optimal rate.[10] In the present case, technological change takes the form of serendipitous learning by doing. Be-

[10]Of course, there are also reasons why the laissez-faire rate of technological change may be higher than is socially optimal (e.g. the ‘business stealing effect’ and the ‘monopoly distortion effect’ in Aghion and Howitt (1992)). However, using a theoretical framework drawing on the endogenous growth literature, Jones and Williams (1997) review the empirical evidence and find that social rates to Research and Development (R & D) typically exceed the corresponding private rates of return.

cause technological change is a positive externality of current production, private sector agents do not fully take into account the potential for productivity growth in each sector.[11] As a result, agents fail to internalise the changes in rates of productivity induced by international specialisation and the consequent dynamic effects on economic welfare.

The effects of specialisation according to comparative advantage on productivity growth rates were the subject of the previous section. This section takes the analysis one stage further to consider the implications of changes in productivity growth for economic welfare. Combining the dynamic welfare effects of international trade with the standard static gains from trade enumerated above, we evaluate relative levels of intertemporal welfare for the representative agent under autarky and free trade.

Beginning with autarky, incomplete specialisation implies that home experiences learning by doing in both the low- and high-tech sectors at the rates $g_z^n = \mu_z.\beta.\bar{L}$ and $g_h^n = \mu_h.(1-\beta).\bar{L}$ respectively. Hence, productivity levels in the two sectors equal $A_z^n(t) = e^{g_z^n(t-t_1)}.A_z(t_1)$ and $A_h^n(t) = e^{g_h^n(t-t_1)}.A_h(t_1)$ respectively for all $t \geq t_1$. Substituting for levels of productivity in the two sectors in (9) and evaluating the integral, we obtain the following expression for intertemporal welfare under autarky,[12]

$$U_{t_1}^n = \frac{\beta^\beta (1-\beta)^{1-\beta}. \left[A_z(t_1)\right]^\beta . \left[A_h(t_1)\right]^{1-\beta}}{\rho - \beta g_z^n - (1-\beta) g_h^n} \tag{11}$$

Turning now to free trade, complete specialisation implies that home only experiences learning by doing in the low-tech sector (at the rate $g_z^f = \mu_z.\bar{L}$), while foreign only enjoys learning by doing in the high-tech sector (at the rate $g_h^{f*} = \mu_h^*.\bar{L}^*$). Hence, home productivity in the low-tech sector in (10) may be expressed as $A_z^f(t) = e^{g_z^f(t-t_1)}.A_z(t_1)$. However, from (10), before we can solve explicitly for intertemporal welfare, we require an expression for the equilibrium

[11] More generally, the same will be true in models of endogenous technological change through profit-seeking Research and Development (R & D), as long as the social rate of return to R & D exceeds the private rate of return (see an appendix available from the author on request and Redding (1996)).

[12] Where for the integral in (9) to converge and intertemporal utility to be finite, we require $\rho > \beta.g_z^n + (1-\beta).g_h^n$.

free trade relative price of the low-tech good.

With home and foreign specialising completely in the low- and high-tech sectors respectively, the relative supply of the low-tech good is simply $A_z^f(t)\bar{L}/A_h^{f*}(t)\bar{L}^*$; while relative demand is determined according to (7). Hence, the free trade equilibrium relative price of the low-tech good equals,

$$\frac{p_z^f(t)}{p_h^f(t)} = \frac{\beta}{1-\beta}\frac{A_h^{f*}(t)}{A_z^f(t)}\frac{\bar{L}^*}{\bar{L}} \tag{12}$$

where, from the above, $A_h^{f*}(t) = e^{g_h^{f*}(t-t_1)}.A_h^*(t_1)$ and $A_z^f(t) = e^{g_z^f(t-t_1)}.A_z(t_1)$ for all $t \geq t_1$. Using this equation for equilibrium relative prices in (10), substituting for the productivity levels $A_z^f(t)$ and $A_h^{f*}(t)$, and evaluating the integral, we obtain the following expression for intertemporal welfare under free trade,[13]

$$U_{t_1}^f = \frac{\beta.\left[A_z(t_1)\right]^\beta \left[A_h^*(t_1)\right]^{1-\beta}\left(\bar{L}^*/\bar{L}\right)^{1-\beta}}{\rho - \beta g_z^f - (1-\beta)g_h^{f*}} \tag{13}$$

From equations (13) and (11), intertemporal welfare under free trade will be lower than under autarky if and only if,

$$\frac{\left[A_h^*(t_1)\right]^{1-\beta}\left[\bar{L}^*\right]^{1-\beta}}{\rho{-}\beta g_z^f - (1-\beta)g_h^{f*}} < \frac{\left(\frac{1-\beta}{\beta}\right)^{1-\beta}\left[A_h(t_1)\right]^{1-\beta}\bar{L}^{1-\beta}}{\rho{-}\beta g_z^n{-}(1-\beta)g_h^n} \tag{14}$$

As we saw in the last subsection, the existence of the standard static gains from trade means that instantaneous welfare at the time t_1, when the choice between the two regimes is made, must be higher under free trade. The numerators in equations (13) and (11) are, in fact, simply instantaneous utility at time t_1 under the two regimes. Hence, it follows immediately that the numerator on the left-hand side of the inequality (14) must exceed the numerator on the right-hand side.[14]

However, whether intertemporal welfare will be higher under free trade than under autarky will depend, not only upon levels of instantaneous utility at time

[13]Where, for intertemporal utility to be finite, we require $\rho > \beta.g_z^f + (1-\beta).g_h^{f*}$.

[14]To confirm this, note that, by assumption, home has a comparative advantage in low-tech production at time t_1. Hence, $A_z(t_1).p_z(t_1)/p_h(t_1) > A_h(t_1)$. Substituting for $p_z(t_1)/p_h(t_1)$ from (12), we obtain $\left[A_h^*(t_1)\right].\bar{L}^* > \left(\frac{1-\beta}{\beta}\right).\left[A_h(t_1)\right].\bar{L}$.

t_1, but also upon the rate of growth of instantaneous utility from time t_1 onwards. Here, specialisation according to comparative advantage induces three dynamic effects upon intertemporal welfare.

First, the reallocation of labour to home's low-tech sector induced by specialisation under free trade raises home's rate of learning by doing in this sector (from $g_z^n = \mu_z.\beta\bar{L}$ to $g_z^f = \mu_z.\bar{L}$). Second, specialisation in the low-tech sector under free trade means that home forgoes its own potential to learn by doing in the high-tech sector (where, as a result, the domestic rate of productivity growth falls from $g_h^n = \mu_h.(1-\beta).\bar{L}$ to $g_h^f = 0$). Third, although forgoing its own potential to learn by doing in the high-tech sector under free trade, home experiences the benefits of foreign learning by doing in this sector in the form (see equation (12)) of a terms of trade gain (where, under free trade, foreign's rate of learning by doing in the high-tech sector is $g_h^{f*} = \mu_h^*.\bar{L}^*$).

The effect of free trade on the rate of growth of instantaneous utility will depend upon the net outcome of these three dynamic effects. In terms of inequality (14), the rate of growth of instantaneous utility will be lower under free trade if and only if $\beta g_z^f + (1-\beta)g_h^{f*} < \beta g_z^n + (1-\beta)g_h^n$. Substituting for the equilibrium rate of productivity growth in each sector under the two regimes, we obtain (from the above) the condition,

$$\beta.\mu_z.\bar{L} + \left[\mu_h^*.\bar{L}^* - (1-\beta).\mu_h.\bar{L}\right] < 0 \tag{15}$$

The first of the three dynamic effects identified above is unambiguously positive ($g_z^f > g_z^n$), as reflected in the strictly positive first term on the left-hand side of the inequality (15). The increase in home's rate of learning by doing in the low-tech sector brought about by free trade (reflecting increased employment in this sector) raises intertemporal welfare relative to that under autarky. This is essentially a 'scale effect' of international trade, whereby trade expands the size of the market for home low-tech goods.

However, home's rate of learning by doing in the high-tech sector under autarky ($g_h^n = \mu_h.(1-\beta).\bar{L}$) either may or may not exceed foreign's under free trade ($g_h^{f*} = \mu_h^*.\bar{L}^*$). Foreign allocates its entire labour force to high-tech production under free trade, while home only allocates a proportion $(1-\beta)$ under autarky. Nonetheless, the relative magnitude of the two rates of learning by doing also depends upon the size of the two economies (as measured by the labour forces $\bar{L}$ and $\bar{L}^*$) and the potential for learning by doing in the high-tech sector in each of the two economies (as determined by μ_h and μ_h^*). Therefore, the net impact of the second and third dynamic effects on intertemporal welfare may be either positive or negative, and this is reflected in the ambiguous term in parentheses in inequality (15).

The existence of the dynamic effects of international trade on economic welfare (due to the change in rates of productivity growth induced by specialisation according to comparative advantage) means that free trade is no longer necessarily welfare increasing, as in standard static theories of international trade. A necessary condition for free trade to be welfare reducing is that the rate of learning by doing in the high-tech sector is lower under free trade than under autarky, and that the effect of this on the rate of growth of instantaneous utility exceeds that of the increase in the rate of learning by doing in the low-tech sector. That is, we require inequality (15) to be satisfied.

From (15), this necessary condition for free trade to be welfare reducing is more likely to be satisfied, the larger home's potential (μ_h) for learning by doing in the high-tech sector relative to foreign's (μ_h^*) and the smaller the foreign economy (as measured by its labour force $\bar{L}^*$). The effect of the size of the home economy (as measured by its labour force $\bar{L}$) and the share of consumer expenditure devoted to low-tech goods (β) is ambiguous, and depends, for example, upon the relative values of home's potential to learn by doing in the low- and high-tech sectors (μ_z and μ_h respectively).

In order for intertemporal welfare to fall as a result of moving from autarky to free trade, we require that these dynamic welfare losses from free trade exceed the standard static gains from trade. From equations (13) and (11), this will occur whenever inequality (14) is satisfied (which thus provides a necessary and sufficient condition for free trade to be welfare reducing).

6 Policy intervention

The previous section has shown that, when technological change is endogenous, the static gains from trade are augmented with a number of dynamic welfare effects and international trade is no longer necessarily welfare increasing. Free trade will reduce the intertemporal welfare of the representative agent if an economy's initial pattern of (static) comparative advantage means that it fails to specialise in a sector in which its potential to learn by doing is large relative to its trading partner's.

This immediately raises a further question: could it ever be optimal for a policy-maker to induce an economy to specialise in the sector where it does not currently have a comparative advantage but exhibits considerable potential to learn by doing ? In terms of the analysis of the previous section, the free trade equilibrium is characterised by home specialising in the low-tech and foreign in the high-tech sector. Could it ever be optimal for the policy-maker to try to reverse this initial pattern of international specialisation ? Clearly, the answer to this further question will depend upon both the economies' potential rates of learning by doing in the sector where they specialise under the proposed policy intervention and the corresponding rates of productivity growth in the sector where they specialise under the alternative of free trade.

Another way of thinking about the issue is as follows. The pattern of comparative advantage at any one point in time is, as earlier noted, endogenous. In the free trade equilibrium, the home economy's initial pattern of comparative advantage leads it to specialise in one way. Given this initial pattern of specialisation, productivity growth rates and the evolution of comparative advantage over time are then determined. However, if the initial patterns of comparative advantage and international specialisation were otherwise (as, for example, the result of a policy intervention), then rates of productivity growth and the time path for comparative advantage could be very different indeed. Ascertaining whether the policy intervention is welfare improving relative to free trade involves an evaluation of productivity dynamics and the time path for comparative advantage under each of the alternative regimes.

In this section, we compare intertemporal welfare under free trade (as evaluated above) with intertemporal welfare under a policy of subsidising entry into the high-tech sector.[15] As before, home is assumed to have an initial comparative advantage in the low-tech sector and we will be concerned with equilibria characterised by complete specialisation. That is,

$$\frac{A_h^*(t_1)}{A_z^*(t_1)} > \frac{p_z^f(t_1)}{p_h^f(t_1)} > \frac{A_h(t_1)}{A_z(t_1)} \tag{16}$$

In the free trade equilibrium, home and foreign specialise in the low- and high-tech sectors respectively; and the equilibrium price of the low-tech good at time t_1 is determined by equation (12).

Consider now a policy intervention of subsidising production in the high-tech sector, where the home economy does not currently have a comparative advantage. For each unit of income earned in the high-tech sector, individuals are assumed to receive a production subsidy of monetary value $s > 0$. The subsidy is assumed to be self-financing, being fully funded by a tax ξ, $0 < \xi < 1$, on wage income. The after-tax/after-subsidy wages in the low- and high-tech sectors are thus,[16]

$$w_z^s(t) = (1-\xi)\, p_z^s(t) A_z^s(t), \qquad w_h^s(t) = (1+s)\,(1-\xi)\, p_h^s(t) A_h^s(t) \tag{17}$$

For a sufficiently large value of the production subsidy s, $w_h^s(t) > w_z^s(t)$, and home will now specialise in the high-tech sector under international trade. The initial pattern of comparative advantage is reversed, and again we restrict consideration to equilibria characterised by complete specialisation. Thus,

$$\frac{(1+s)\,.A_h(t_1)}{A_z(t_1)} > \frac{p_z^s(t_1)}{p_h^s(t_1)} > \frac{A_h^*(t_1)}{A_z^*(t_1)} \tag{18}$$

where the relative price of the low-tech good at time t_1 under the subsidy is now,

[15]The comparison between free trade and the subsidy seems empirically the most relevant. However, it is straightforward to extend the analysis to compare welfare under the subsidy with that under autarky.

[16]Where the superscript s indexes the value of a variable under the subsidy.

$$\frac{p_z^s(t_1)}{p_h^s(t_1)} = \frac{\beta}{1-\beta}.\frac{A_h(t_1)}{A_z^*(t_1)}.\frac{\bar{L}}{\bar{L}^*} \tag{19}$$

Appendix 1 shows that inequalities (16) and (18), and the two equations for the relative price of the low-tech good, (12) and (19), may be simultaneously satisfied for sufficiently large values of s and $\beta \in (1/2, 1)$. The assumption of complete specialisation under both free trade and the subsidy is thus validated.[17] For the production subsidy to be self-financing, we require $s.p_h^s(t).A_h(t) = \xi.(1+s).p_h^s(t).A_h(t)$; and the equilibrium tax rate is thus,

$$\hat{\xi} = \frac{s}{1+s} \tag{20}$$

General equilibrium under free trade and the subsidy, with the accompanying change in the pattern of comparative advantage and international specialisation, is illustrated diagrammatically in Figure 2. Under the production subsidy, home specialises in the high-tech sector and foreign in the low-tech. The representative agent's income in the home economy is given by the after-tax/after-subsidy wage in the high-tech sector. Replacing the tax rate ξ with its equilibrium value $\hat{\xi}$ in (17), we obtain an expression for disposable income. Using this expression and the fact that, in equilibrium, the representative agent allocates expenditure in constant proportions to each sector, we may solve for intertemporal welfare under the subsidy,

$$U_{t_1}^s = \int_{t_1}^{\infty} e^{-\rho(t-t_1)} \left[\beta.p_h^s(t)/p_z^s(t).A_h^s(t)\right]^{\beta} \left[(1-\beta).A_h^s(t)\right]^{1-\beta} dt \tag{21}$$

where the relative price of the high-tech good $p_h^s(t)/p_z^s(t)$ is determined according to equation (19).

Figure 2 about here

The existence of the standard static gains from trade means that instantaneous utility at the time t_1, when the choice between the two regimes is made,

[17] For simplicity, we restrict attention to the case of complete specialisation. Again, it is straightforward to extend the analysis to consider incomplete specialisation.

must be lower under the production subsidy (the home economy is choosing to specialise in a sector in which it has a comparative disadvantage).[18] However, as in the comparison between autarky and free trade, the change in the pattern of international specialisation between the two regimes has implications for rates of productivity growth and hence has dynamic effects upon economic welfare.

Under the production subsidy, complete specialisation implies that home experiences learning by doing in its high-tech sector (at the rate $g_h^s = \mu_h.\bar{L}$); while foreign enjoys the fruits of learning by doing in its low-tech sector (at the rate $g_z^{s*} = \mu_z^*.\bar{L}^*$). Thus, productivity levels in the high-tech and low-tech sectors in home and foreign respectively may be expressed as $A_h^s(t) = e^{g_h^s(t-t_1)}.A_h(t_1)$ and $A_z^*(t) = e^{g_z^{s*}(t-t_1)}.A_z(t_1)$ for all $t \geq t_1$. Under the subsidy, home forgoes its own potential to learn by doing in the low-tech sector, and instead benefits from foreign learning by doing in this sector in the form of a terms of trade gain.

Substituting for the relative price of the high-tech good (from (19)) in the equation for intertemporal welfare (21), then substituting for productivity levels in the two sectors and evaluating the integral, we obtain the following expression for intertemporal welfare under the subsidy,[19]

$$U_{t_1}^s = \frac{(1-\beta).\left[A_z^*(t_1)\right]^{\beta}.\left[A_h(t_1)\right]^{1-\beta}.\left(\bar{L}^*/\bar{L}\right)^{\beta}}{\rho - \beta g_z^{s*} - (1-\beta)g_h^s} \tag{22}$$

From equations (22) and (13), intertemporal welfare will be higher under the subsidy than under free trade if and only if,

$$\frac{\frac{(1-\beta)}{\beta}\left[A_z^*(t_1)\right]^{\beta}\left[A_h(t_1)\right]^{1-\beta}\left(\frac{\bar{L}^*}{\bar{L}}\right)^{2\beta-1}}{\rho - \beta g_z^{s*} - (1-\beta)g_h^s} > \frac{\left[A_z(t_1)\right]^{\beta}\left[A_h^*(t_1)\right]^{1-\beta}}{\rho - \beta g_z^f - (1-\beta)g_h^{f*}} \tag{23}$$

We saw in the discussion above, that the existence of the standard static gains from trade means that instantaneous welfare at time t_1 must be lower under the subsidy. The numerators in equations (22) and (13) are simply instantaneous utility at time t_1 under the two regimes. Hence, it follows immediately that the

[18] This is established formally in the proof of a later Proposition (see the proof of Proposition 1 in Appendix 2).

[19] Where, for intertemporal utility to be finite, we require $\rho > \beta.g_z^{s*} + (1-\beta).g_h^s$.

numerator on the left-hand side of the inequality (23) must be strictly less than the numerator on the right-hand side.[20]

A necessary condition for the production subsidy to the high-tech sector to be welfare improving is therefore that the rate of growth of instantaneous utility under the subsidy exceeds the corresponding rate of growth under free trade: $\beta g_z^{s*} + (1-\beta)g_h^s > \beta g_z^f + (1-\beta)g_h^{f*}$. As we saw in the discussion above, home's specialisation in the high-tech sector results in it accumulating production experience at the rate $g_h^s = \mu_h.\bar{L}$ under the subsidy, while foreign accumulates production experience in the low-tech sector at the rate $g_z^s = \mu_z^*.\bar{L}^*$. In contrast, under free trade, the pattern of international specialisation is exactly the reverse. Home experiences learning by doing in the low-tech sector at the rate $g_z^f = \mu_z.\bar{L}$, while foreign learns by doing in the high-tech sector at the rate $g_h^{f*} = \mu_h^*.\bar{L}^*$. A necessary condition for the production subsidy to be welfare improving is thus,

$$\beta.\left(\mu_z^*\bar{L}^* - \mu_z\bar{L}\right) + (1-\beta).\left(\mu_h\bar{L} - \mu_h^*\bar{L}^*\right) > 0 \tag{24}$$

That is, we require a weighted average of the change in rates of productivity growth induced by the reversal of patterns of international specialisation to be strictly positive. With Cobb-Douglas instantaneous utility, the weights are the shares of consumer expenditure allocated to each sector. Whether or not this inequality is satisfied will depend upon the two countries' relative potentials to learn by doing in both the low- and high-tech sectors (as parameterised by μ_j, μ_j^* for $j = z, h$), the share of consumer expenditure allocated to the low-tech sector (β), and the two economies' relative sizes (as measured by $\bar{L}$, $\bar{L}^*$).

While inequality (24) is a necessary condition for the subsidy to be welfare improving, it is clearly not sufficient. In order for intertemporal welfare to rise as a result of implementing the subsidy rather than adopting free trade, we require the dynamic welfare gains from home specialising in the high-tech sector and foreign in the low-tech sector to exceed the static welfare losses. From equations (22) and

[20]This may be shown formally by substituting for the relative price of the low-tech good $p_z(t_1)/p_h(t_1)$ under both the subsidy and free trade (using equations (19) and (12)) in the proof of Proposition 1 below.

(13), this will occur whenever inequality (23) is satisfied (which thus provides a necessary and sufficient condition for the subsidy to be welfare improving).

In the next section, we consider the relationship between this general equilibrium argument for selective trade and industrial policies and the often-discussed notion of 'dynamic comparative advantage.' First, we note that, although one may establish theoretical conditions for interventionist public policies to be welfare improving, it may be extremely difficult in practice to determine when these conditions are met. The information requirements to implement these policies are large - the analysis requires a policy-maker to have information on rates of productivity growth in either sector of each economy under both the proposed subsidy and free trade. Furthermore, the literature on the political economy of trade policy suggests that there may be hidden welfare costs to activist trade policies in the form of Directly Unproductive Profit-Seeking (DUP) activity (see, for example, Bhagwati (1982)).

Nonetheless, there may be instances where the potential for productivity growth in sectors where an economy does not currently exhibit a comparative advantage is large, and where an active trade policy can be justified in terms of the theoretical analysis of this section. Developing economies with high levels of general human capital, which may achieve rapid rates of productivity growth through imitation, may be a case in point. Indeed, there is empirical evidence that the development experience of some East Asian economies may be interpreted in these terms.

7 Dynamic comparative advantage and the case for policy intervention

The fact that comparative advantage evolves endogenously over time in theoretical models of endogenous growth and trade has led a number of authors to speak of 'dynamic comparative advantage' (see, for example, Krugman (1987) and Grossman and Helpman (1991)). Somewhat independently, the same concept has been applied in more informal discussions of the East Asian development experience (see, for example, Amsden (1989)). In each case, the concept is left ill-defined, with its exact usage and meaning unclear.

On the one hand, the use of the concept may reflect a desire to explain the way in which comparative advantage (as traditionally defined) evolves over time in dynamic trade models (see, in particular, the discussion in Grossman and Helpman (1991)). On the other hand, the concept's use may indicate a concern with some of the welfare considerations that have been the subject of previous sections. This seems to be particularly the case with regard to the literature on the East Asian development experience. Here, the use of the concept seems linked with the idea that a country's current pattern of comparative advantage may work against its long-term interests, and that there may be a trade-off between specialising according to current comparative advantage and realising dynamic benefits from specialising in other sectors (see, in particular, the discussion in Temple (1997)).

This paper has shown, in a model of endogenous technological change and growth, that specialising according to current patterns of comparative advantage may not be welfare maximising. Furthermore, in certain circumstances, policy interventions to induce specialisation in sectors in which an economy does not currently have a comparative advantage may be welfare increasing. This section now considers whether there is a concept of 'dynamic comparative advantage', that accords reasonably closely with popular usage, and that sheds light upon the circumstances under which selective trade and industrial policies are welfare increasing.

The traditional (or 'static') concept of comparative advantage is essentially concerned with relative levels of opportunity costs of production in different sectors of two economies. Thus, in our case, the home economy is said to have a ('static') comparative advantage in low-tech production at time t if the opportunity cost of producing the low-tech good at time t is lower in the home economy. In this section, we propose a simple definition of 'dynamic comparative advantage', concerned with changes over time in relative levels of opportunity costs. Thus, the home economy is said to have a 'dynamic' comparative advantage in low-tech production at time t if the rate of growth of the opportunity cost of producing the low-tech good at time t is lower in the home economy. That is, home will have a dynamic comparative advantage in low-tech production if and only if,

$$\frac{\partial \left(A_h(t)/A_z(t) \right)/\partial t}{A_h(t)/A_z(t)} < \frac{\partial \left(A_h^*(t)/A_z^*(t) \right)/\partial t}{A_h^*(t)/A_z^*(t)} \tag{25}$$

$$\Leftrightarrow \quad \left(\frac{\dot{A}_h(t)}{A_h(t)} - \frac{\dot{A}_z(t)}{A_z(t)} \right) - \left(\frac{\dot{A}_h^*(t)}{A_h^*(t)} - \frac{\dot{A}_z^*(t)}{A_z^*(t)} \right) < 0$$

This formalisation of dynamic comparative advantage is an extremely natural one, that is the dynamic analogue of the traditional 'static' definition. Nonetheless, although natural, the definition has (as will be shown below) a surprising amount of analytical content.

First, while static comparative advantage determines patterns of international trade at a given point in time, dynamic comparative advantage explains changes over time. In terms of the analysis of the previous section, the free trade equilibrium involves home specialising in low-tech production (learning at the rate $g_z^f > 0$) and foreign in high-tech production (accumulating production experience at the rate $g_h^{f*} > 0$). Hence, the opportunity cost of low-tech production in home (A_h/A_z) falls over time, while the converse is true for the opportunity cost of low-tech production in foreign (A_h^*/A_z^*). In terms of the definition (25), home will have a dynamic comparative advantage in the low-tech sector, and its initial static comparative advantage in this sector will be reinforced over time.

However, it is important to realise that dynamic comparative advantage, as defined above, is not invariant to changes in patterns of international specialisation. From (25), dynamic comparative advantage is completely determined by productivity growth rates in each sector of the two economies. However, we have already seen that these themselves are functions of patterns of international specialisation. Again, the argument may be illustrated in terms of the analysis of the previous section.

On the one hand, international specialisation in the free trade equilibrium implies that home has a dynamic comparative advantage in the low-tech sector (so that the initial pattern of static comparative advantage is reinforced over time, as described above). On the other hand, under the subsidy, home specialises in high-tech production (learning at the rate $g_h^s > 0$) and foreign in low-tech production (learning at the rate $g_z^{s*} > 0$). As a result, the opportunity cost of low-tech production in home (A_h/A_z) rises over time, while the converse is true for the opportunity cost of low-tech production in foreign (A_h^*/A_z^*). In terms of the definition (25), home will actually have a dynamic comparative advantage in the high-tech sector under the subsidy, and its initial static comparative advantage in the low-tech sector will be reduced over time. Ultimately, the initial pattern of static comparative advantage will be reversed; so that, were the subsidy to be removed at a future point in time, home would continue to specialise in the high-tech sector.

Thus, patterns of dynamic comparative advantage are very different under the alternative regimes of free trade and the subsidy (as a result of differences in international specialisation). This brings us to the link between dynamic comparative advantage, as defined above, and the circumstances under which selective trade and industrial policies may be welfare improving. As we have seen, an important element of the popular usage of this concept is the idea that a country's current pattern of static comparative advantage may work against its long-term interests. Instead, it is argued that an economy should specialise in sectors where it may enjoy various dynamic benefits (where it exhibits a 'dynamic comparative advantage'). It turns out that this informal argument may be straightforwardly related to the formal analysis of the previous section.

Proposition 1 *A necessary condition for a subsidy to the high-tech sector (where the economy does not currently have a static comparative advantage) to be welfare-improving is that the economy will (under the subsidy) acquire a static comparative advantage in the high-tech sector at some future point in time $t' > t_1$.*

Proof. A necessary condition for the production subsidy to yield a higher level of intertemporal welfare than under free trade is that at some future point in time $t' > t_1$ home attains a higher level of instantaneous utility under the subsidy than

by switching to free trade. Otherwise, a policy-maker could unambiguously raise intertemporal welfare by abandoning the subsidy.
In Appendix 2, we show that a necessary condition for instantaneous utility at time t' to be higher under the subsidy is for home to have acquired a static comparative advantage in the high-tech sector by t' (see Appendix) ■

In order for the representative agent's intertemporal welfare to be increased by a subsidy to a sector where the economy has no current static comparative advantage, it must be true that (under the subsidy) a static comparative advantage in this sector will be attained at some future point in time. However, a necessary condition for the initial pattern of static comparative advantage to be reversed in this way is that (under the subsidy) the home economy has a dynamic comparative advantage (as defined in (25)) in the very sector in which it initially has no static comparative advantage.

Thus, as suggested in informal discussions of the East Asian development experience, one can indeed think of an economy potentially facing a trade-off between static and dynamic comparative advantage (or between current and future patterns of static comparative advantage). Furthermore, the fact that the initial pattern of static comparative advantage must be reversed for the subsidy to be welfare improving implies that the selective trade or industrial policy need only be temporary. If the subsidy were removed at time t', home would (as discussed above) continue to specialise in the high-tech sector.

However, although the reversal of static comparative advantage (and hence having a dynamic comparative advantage in the subsidised sector) is a necessary condition for the subsidy to be welfare improving, it is important to note that it is not sufficient. Productivity growth rates and the way in which comparative advantage evolves over time are themselves dependent upon patterns of international specialisation (and, therefore, will be different under the subsidy and free trade).

In Proposition 1, we compare instantaneous utility under the subsidy at each point in time $t' > t_1$ with the level that could be achieved by abandoning the subsidy at t' and engaging in free trade (taking as given productivity growth rates over the interval of time $t \in [t_1, t')$ - as determined by the pattern of specialisation under the subsidy). This enables us to establish a necessary condition for the subsidy to raise intertemporal welfare. However, in order to arrive at a sufficient condition, two further steps must be taken. First, one must compare productivity growth rates and the evolution of comparative advantage under the subsidy with the corresponding values under free trade. In effect, this comparison involves an evaluation of the (different) patterns of dynamic comparative advantage under both the subsidy and free trade. Second, one must evaluate any dynamic welfare gains from implementing the subsidy relative to the standard static welfare losses. It was precisely such an analysis that was undertaken in the previous section.

8 Conclusion

This paper has considered the idea that developing economies may face a trade-off between specialising according to an existing pattern of comparative advantage (often in low-technology industries), and entering sectors where they currently lack a comparative advantage, but may acquire such an advantage in the future as a result of the potential for productivity growth (e.g. high-technology industries).

The analysis was undertaken within the context of a general equilibrium model of endogenous growth, involving international trade between two large economies. An essentially Ricardian model of international trade was combined with a model of endogenous technological change in the form of learning by doing. Comparative advantage - as traditionally defined ('static' comparative advantage) - depends upon past technological advances, while simultaneously determining current rates of learning by doing and technological change. Thus, comparative advantage itself becomes endogenous.

Specialisation according to current comparative advantage results in the standard static gains from trade. However, if individual agents fail to fully internalise the potential for productivity growth in each sector, it may also mean that an economy fails to specialise in sectors where its potential for productivity growth is large relative to its trading partners. As a result, free trade will induce dynamic welfare losses. If sufficiently large, these may outweigh the standard static welfare gains, so that trade reduces the intertemporal welfare of the representative agent.

Selective trade and industrial policies to induce specialisation in sectors where an economy currently lacks a comparative advantage, but exhibits a large potential for productivity growth relative to its trading partner, may be welfare improving. The case for these policies was related to the often-used, but as yet ill-defined, notion of 'dynamic' comparative advantage. A natural formalisation of this concept was suggested in terms of rates of growth of opportunity costs of production in each economy. So defined, dynamic comparative advantage explains the evolution of patterns of international trade over time and proves informative in evaluating the case for interventionist public policies.

A necessary condition for a selective trade and industrial policy (of the form suggested above) to be welfare improving is that the initial pattern of 'static' comparative advantage is reversed under the policy. However, the initial pattern of static comparative advantage will only be reversed in this way if the economy has a dynamic comparative advantage (under the proposed policy intervention) in precisely the sector in which it initially has no static comparative advantage. This necessary condition suggests that welfare improving selective trade and industrial policies, if they exist, need only be temporary.

However, while this yields a necessary condition for interventionist public policies to be welfare improving, it does not, alone, provide a sufficient condition. In order to evaluate whether subsidising production in a sector where no current comparative advantage exists is welfare improving, two further steps are necessary. First, one must compare productivity growth rates and the evolution of comparative advantage under the subsidy with the corresponding values under free trade. In effect, this comparison involves an evaluation of the (different) patterns of dynamic comparative advantage under both the subsidy and free trade. Second, one must evaluate any dynamic welfare gains from implementing the subsidy relative to the standard static welfare losses.

Once the complete welfare comparison is undertaken, a theoretical case for selective trade and industrial policies exists. Nonetheless, converting this theoretical case into practical policy advice is more difficult. It involves an appreciation of the large informational requirements of the theoretical argument, alongside potential hidden welfare costs in the form of Directly Unproductive Profit-seeking (DUP) activities. Nonetheless, developing economies with high levels of general human capital, which may achieve rapid rates of productivity growth through imitation, may be examples where a case for intervention exists.

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9 Appendix

9.1 Relative prices under free trade and the subsidy

Under free trade, inequality (16) and equation (12) jointly imply that, at time t_1,

$$A_z(t_1) > \beta/(1-\beta).\bar{L}^*/\bar{L}.A_z^*(t_1) \tag{26}$$

$$A_h^*(t_1) > (1-\beta)/\beta.\bar{L}/\bar{L}^*.A_h(t_1) \tag{27}$$

Under the subsidy, inequality (18) and equation (19) jointly imply that, at time t_1,

$$A_z(t_1) < (1+s).(1-\beta)/\beta.\bar{L}^*/\bar{L}.A_z^*(t_1) \tag{28}$$

$$A_h^*(t_1) < \beta/(1-\beta).\bar{L}/\bar{L}^*.A_h(t_1) \tag{29}$$

For values of $\beta \in (1/2, 1)$, inequalities (27) and (29) may both be satisfied.. At the same time, for sufficiently large values of s, inequalities (26) is compatible with (28) and with both (27) and (29). Hence, the assumption of complete specialisation under both free trade and protectionism is validated.

9.2 Proof of Proposition 1

From equations (21) and (10), instantaneous welfare at any time t' could be increased by abandoning the subsidy and moving to free trade if and only if,

$$\left[\beta A_h(t')\right]^{\beta}\left[(1-\beta)A_h(t')\right]^{1-\beta} < \left[\beta\frac{p_z^s(t')}{p_h^s(t')}A_z(t')\right]^{\beta}\left[(1-\beta)A_z(t')\frac{p_z^f(t')}{p_h^f(t')}\right]^{1-\beta} \tag{30}$$

In any equilibrium, in which home has a static comparative advantage in low-tech production and a subsidy is required to induce it to specialise in the high-tech sector, inequalities (16) and (18) jointly imply,

$$\frac{(1+s).A_h(t')}{A_z(t')} > \frac{p_z^s(t')}{p_h^s(t')} > \frac{A_h^*(t')}{A_z^*(t')} > \frac{p_z^f(t')}{p_h^f(t')} > \frac{A_h(t')}{A_z(t')} \tag{31}$$

Thus, $A_h < p_z^f/p_h^f.A_z < p_z^s/p_h^s.A_z$. As long as home has a static comparative advantage in the low-tech sector and the subsidy is required to induce it to specialise in the high-tech sector, inequality (30) must be satisfied.

Suppose instead, that home acquires a static comparative advantage in the high-tech sector and a subsidy is no longer required to induce specialisation in this sector. In this case,

$$\frac{(1+s).A_h(t')}{A_z(t')} > \frac{A_h(t')}{A_z(t')} > \frac{p_z^s(t')}{p_h^s(t')} = \frac{p_z^f(t')}{p_h^f(t')} > \frac{A_h^*(t')}{A_z^*(t')} \tag{32}$$

and $A_h > p_z^f/p_h^f.A_z = p_z^s/p_h^s.A_z$. Hence, inequality (30) is no longer satisfied.

It follows immediately that a necessary condition for the subsidy to yield a higher level of instantaneous utility at some point in time t' is for home to have acquired a static comparative advantage in this sector by time t'. ■