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Wages, Profitability, and Growth in a Small Open Economy

Prepared by Bankim Chadha 1/

Authorized for Distribution by Michael P. Dooley

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Abstract

This paper examines issues raised by the evolution of a rapidly growing small open economy--Singapore--from a labor-intensive, low-technology production base to a capital-intensive, high-technology, knowledge-and-skill-intensive emphasis as it approached the limits of its resource constraints in the labor market. In order to analyze the process of restructuring a model of endogenous growth for a small open economy that is driven by increases in labor productivity from learning and that allows for the dynamic acquisition of comparative advantage is developed. In this framework the effects of various policies and exogenous shocks on the direction and pace of restructuring are investigated.

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Summary

This paper examines issues raised by the evolution of a rapidly growing small, open economy--Singapore--from a labor-intensive, low-technology production base to a capital-intensive, high-technology, knowledge-and-skill-intensive emphasis as it approached the limits of its resource constraints, in particular in the labor market. The paper first reviews historical developments in the labor market and their impact on the pattern of trade and growth in Singapore. It discusses the perceived need for, and anticipated benefits from, restructuring the composition of output and means of production, as well as the policy measures adopted to achieve this restructuring so as to sustain growth in the face of the labor constraint.

In order to analyze the process of restructuring, the paper develops a model of endogenous growth for a small, open economy that is driven by increases in labor productivity from learning and that allows for the dynamic acquisition of comparative advantage. A conclusion that emerges is that owing to the effects of learning-by-doing, initial comparative advantage tends to be amplified over time, and that market forces may not generate the impetus required for restructuring. In contrast to predictions of the standard neoclassical aggregate growth model, economic policy can, in the framework here, play a decisive role in restructuring output and can permanently alter the long-run growth potential of the economy.

The framework is employed to investigate the effects of various policies and exogenous shocks on the direction and pace of restructuring.

I. Introduction

In an attempt to obtain more satisfactory explanations for sustained differences in growth experiences, both over time and across countries, much attention has been focussed recently on endogenous sources or engines of growth. It has been increasingly recognized that models of endogenous growth hold the potential for explaining aspects of growth that the standard neoclassical aggregate growth model of Solow (1956), and its many variants are either directly at odds with or ill-equipped to deal with. 1/ An important prediction of the neoclassical model is that initial conditions or disturbances have no long run implications for growth. Regardless of an economy's initial per capita endowment of capital, it will converge to the same steady state per capita capital stock, after which growth in per capita output is determined purely by exogenous technological progress. There is, therefore, no room for an analysis of alternative phases or stages of growth induced by particular initial conditions. Moreover, the role for government intervention in the neoclassical model is limited. The model predicts, for example, that policies that succeed in increasing savings rates will increase the long-run level of per capita output and consumption, but will have no sustained impact on the growth rate of per capita output.

This paper examines and analyzes a particular episode in the growth experience of Singapore--that of economic restructuring, which encompassed changes in both the technique of production and in the composition of output. Singapore is a small highly-open economy whose development strategy has passed through several stages. A remarkably successful low-wage-export led period of industrialization from 1966-79 transformed it from a labor-surplus economy to one where domestic labor constituted an important constraint on growth. One of our purposes here will be to examine the objectives and instruments of policies, particularly in the labor market, subsequently employed in Singapore to restructure output so as to sustain growth despite this labor constraint.

Section II briefly reviews the historical interaction between labor market developments and growth in Singapore. Section III extends Lucas's (1988) model of endogenous growth to examine the process of restructuring that took place in Singapore in the 1980s. The model shows that in the absence of exogenous shocks or government intervention an economy will, over time, tend to one of two long run equilibrium growth paths--a "high-growth" path and a "low-growth" path--depending on the initial endowment of resources in each sector and hence historical comparative advantage. Thus, any government intervention that results in a diversion of resources from one sector to another can affect the pattern of growth and trade over time, indeed even to the extent of putting the economy on a high-growth or low-growth trajectory. The analysis presents an example of a change in

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1/ For a discussion of the failure of the neoclassical growth model in explaining various stylized facts of growth, and its limitations in general, see, among others, Romer (1986), Lucas (1988), and Helpman (1988).

the level of aggregate output, resulting from a shift in its composition, inducing a sustained change on the potential growth rate of the economy. Effects of stylized versions of actual policies followed in Singapore, and exogenous shocks are analyzed. Section IV offers some concluding observations.

II. Historical Developments

1. Low-wage-export led growth, 1966-1979

Following independence in 1965, a program of import substituting industrialization was abandoned. In 1966, the government adopted a development strategy of export-oriented industrialization, focused principally on labor-intensive manufactures. The strategy relied on attracting a substantial amount of direct foreign investment by multinational corporations to establish manufacturing facilities geared toward production for markets in industrialized countries. To facilitate the process, the government encouraged wage restraint and introduced, among other measures, labor legislation to promote stable labor relations.

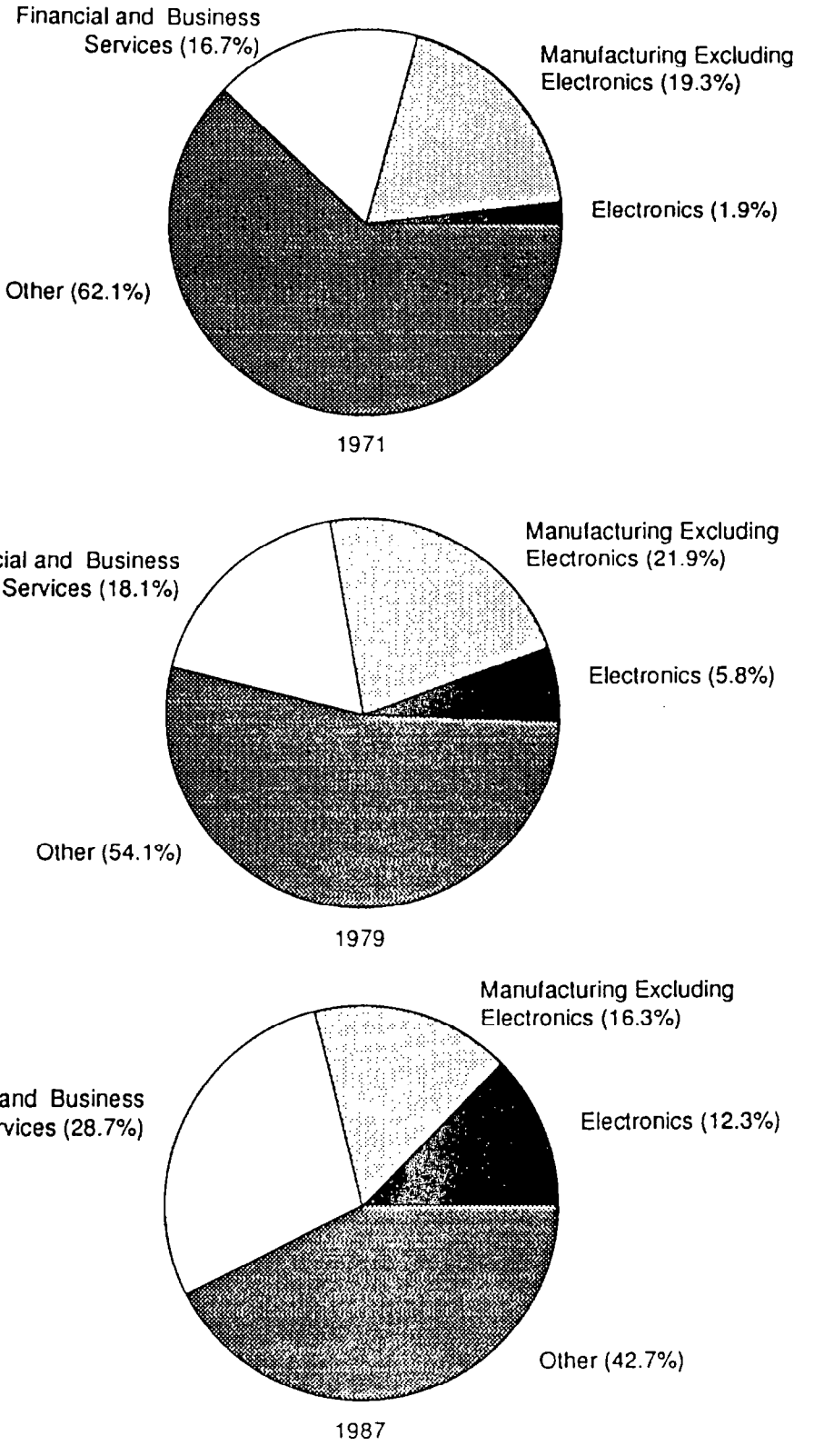
During the early years of this period, there was no formal institutional channel through which the government could influence the general wage level. In 1972, however, the National Wages Council (NWC), a tripartite body comprising representatives from the government, employers, and trade unions, was formed with the mandate of recommending specific quantitative wage guidelines each year. These guidelines, more often than not, recommended a lump-sum increase and a percentage increase, thereby affecting both wage differentials and the general wage level. The tripartite nature of the council ensured wide acceptance and implementation of its recommendations. The period was characterized by a rapid growth of relatively labor-intensive manufacturing, real wage increases that on average fell substantially short of productivity increases, and a sizeable reduction in unemployment. Chart 1 shows the rapid increase in the share of manufacturing output, while the share of financial and business services, which represents relatively skill-intensive activities, was virtually unchanged during the period 1971-79. During this period it is estimated that real product wages in manufacturing increased at an average rate of 2.3 percent a year from 1973-79, while labor productivity grew by 4.4 percent a year. With rapid economic growth, that averaged 9.4 percent a year from 1970-79, a large pool of unemployed labor was gradually absorbed into the workforce; between 1970 and 1979 the unemployment rate fell from 6.0 percent to 3.4 percent--close to the natural rate of unemployment, which estimates put at 3 percent.

2. Economic restructuring and the wage-correction policy, 1979-1985

By the late 1970s, a development strategy based on labor-intensive and relatively low-wage, export-driven growth was proving to be unsustainable for several reasons. First, full employment of the labor force

CHART 1

Structure of Output [1]



Source: *Yearbook of Statistics, 1987* and *1988*.
[1]Share of GDP at current market prices.

was generating upward pressure on wages. With limited prospects for growth in domestic supply, a continuation of the strategy would have required a growing reliance on imported foreign labor. This was ruled out as a socially and politically viable option. Second, the government realized that wage restraint had resulted in an excessive investment in, and retention of, labor-intensive activities. Thus increases in the demand for labor exceeded economic growth, exacerbating the pressure on wages. Moreover, the maintenance of low wages had hindered the natural process of economic upgrading and restructuring with technological progress, as it encouraged investment in relatively labor-intensive, low-technology goods. Third, it was observed that the small wage increases in Singapore had been accompanied by lower growth of labor productivity than in other newly industrializing economies (NIEs), where wage increases had been more rapid. It was felt that preventing wages from rising to higher levels had stunted productivity growth by reducing incentives for labor-saving investment and organizational rationalization.

In 1979, the government adopted an economic restructuring strategy, designed to shift the structure of production from low-technology, labor-intensive activities to technology-and-skill-intensive, higher value-added activities. This shift was to place the economy on a sustainable growth path by allowing it to economize on the usage of labor and to enter markets for high-technology and knowledge-and-skill-intensive goods and services. It was perceived that if this restructuring were not brought about, the labor constraint and consequent wage pressure would eventually lead to a deterioration in competitiveness and a declining share in traditional export markets. Moreover, the move towards high-technology goods would increase labor productivity and thus output.

There were three complementary policy initiatives. First, significant wage increases were encouraged to compensate for the previous wage restraint, which may have held wages at an artificially low level. This policy of allowing wages, and more generally, labor costs to rise in excess of productivity growth has thus alternatively been referred to as a "high-wage" policy and a "wage-correction" policy. It was envisaged that, with an increase in the relative price of labor, capital would be substituted for labor and consequently low-wage, labor-intensive activities would be phased out. Concomitantly, to reinforce this shift, labor supply measures were adopted that limited the inflow of foreign workers into lower-paid unskilled occupational categories, and sought eventually to phase them out. Second, it was perceived that restructuring was constrained by an inadequately skilled labor force. The government, therefore, embarked on an ambitious and successful program for increasing labor skills. In addition to various adult education and worker training programs, the Skills Development Fund (SDF) was formed in 1979. Financed by a tax on employers, the SDF was designed to provide incentives to employers to upgrade the skills of their employees and to increase on-the-job training. Third, through incentives offered by the Economic Development Board, investment in technology-and-skill-intensive activities, and for the automation of existing production facilities was promoted.

In June 1979 the NWC recommended a general wage increase amounting to approximately 14 percent of average monthly wages. In accepting the NWCs recommendations, the government made it known that similar wage increases were planned for the following two years. The measure coincided with an increase in the employers' contribution rate to the Central Provident Fund (CPF) by 4 percent of the wage bill, and the imposition of an employers' contribution to the SDF of 2 percent of the wage bill. The overall result was to raise employers' labor costs by 20 percent. Table 1 details the wage increase guidelines of the NWC during 1978-87 and employer CPF and SDF contribution rates. The recommended wage increases were large from 1979-1981, gradually tapering off with an eventual non-quantitative recommendation of wage restraint following a recession in 1985. Employer's contribution rates to the CPF were raised systematically during the period, from 16.5 percent of the wage bill in 1978 to 25 percent by 1984. The employer's contribution rate to the SDF was raised in 1980 to 4 percent.

The period from 1979-81, was originally the period targeted by the government, for the "correction" of wages. Table 2 compares the wage increases recommended by the NWC with actual increases in the aggregate and across occupational categories from 1979-87. It is notable that while average actual wages increased more or less in line with recommended increases from 1979-81, they increased substantially in excess of NWC guidelines during the subsequent period from 1982-84. This was probably due in part to the large increases in 1979-81 raising expectations on the part of employees and employers as to future wage increases, and in part due to the continued tightening of the labor market.

While the NWC recommendations raised labor costs for all employers, the lump sum increase affected wage relativities by increasing the lowest wages proportionately more than higher wages. Thus, firms engaged in low-skill, labor-intensive activities experienced the largest increases in labor costs. This was, as noted earlier, exacerbated by the labor supply measures that limited the supply of unskilled foreign labor. Table 2 confirms that, for 1979-81, percentage wage increases were negatively related to the wage level. Wages in the lowest-paid occupational category--production, transportation, and other manual workers--increased more rapidly than those of clerical, sales, and service workers, which in turn increased faster than those for the highest-paid category--professional, administrative, and managerial workers. Table 2 also shows that the large increases in wages during the period were accompanied by a slowing in the rate of growth of private non-construction investment, and this trend was only reversed following the moderate wage increases in 1986-87.

While some restructuring toward knowledge-and-skill-intensive and high-technology activities had already taken place in the 1970s, there was a considerable acceleration in the pace at which it occurred after the

Table 1. Guidelines of the National Wage Council and Measures Affecting Labor Costs, 1978/79 - 1986/87. 1/

	1978/1979	1979/1980	1980/1981	1981/1982	1982/1983	1983/1984	1984/1985	1985/1986	1986/1987
Recommended increase in monthly wages: 2/									
Dollar amount (S$)	12.0	32.0	33.0	32.0	18.5	10.0	27.0	--	wage
Percent change	6.0	7.0	7.5	6.0-10.0	2.5-6.5	2.0-6.0	4.0-8.0	3.0-7.0	restraints 3/
(Overall percentage increase)	(8.4)	(14.0)	(14.0)	(10.0-14.0)	(6.0-10.0)	(3.7-7.7)	(10.0)	(5.0)	--
Total contribution to CPF									
(Percent of monthly wages)	33.0	37.0	38.5	42.5	45.0	46.0	50.0	50.0	35.0
By workers	16.5	16.5	18.0	22.0	23.0	23.0	25.0	25.0	25.0
By employers	16.5	20.5	20.5	20.5	22.0	23.0	25.0	25.0	10.0
Contribution to the SDF by employers (Percent of monthly wages)	--	2.0	4.0	4.0	4.0	4.0	4.0	2.0	1.0
Percentage increase in employers' labor costs	9.4	19.9	19.0	16.0	9.0	6.5	11.7	1.8	--

Source: Data provided by the Singapore authorities.

1/ Recommendations apply to the period July-June.

2/ Recommendations had two components: an absolute dollar amount and a percentage increase. The overall percentage increase shown refers to the combined effect of the two components as a percentage of the previous years average wage.

3/ Wage restraint, with wages changes tied to productivity of workers and profitability of company and industry.

Table 2. Wage Guidelines, Actual Wage Increases, and Investment, 1979-87 1/

(Annual percentage change)

	NWC guideline 2/	Economy average	Professional, administrative, and managerial	Clerical, sales and service	Production transportation and other manual	Private non-construction investment
1979	11.2	8.7	6.9	7.5	9.5	25.1
1980	14.0	13.1	10.5	12.2	14.3	19.7
1981	13.0	14.0	8.7	10.0	16.9	6.8
1982	10.0	15.3	17.4	12.6	10.8	0.0
1983	6.9	8.9	7.7	7.1	9.0	-11.0
1984	7.9	9.3	8.6	8.6	9.1	7.7
1985	7.5	10.0	-5.1	5.6	8.4	-11.7
1986	2.0	1.6	1.1	2.2	-0.9	0.5
1987	wage restraint	1.7	0.7	2.1	4.3	27.1

Source : Singapore, Yearbook of Statistics, 1988; and data provided by the Singapore authorities.

1/ Professional, administrative, and managerial workers represent the highest paid occupational category, followed by clerical, sales, and service workers; the lowest paid occupational category consists of production, transportation and other manual workers.

2/ Adjusted to calendar year basis. NWC guidelines have typically been from July to June of the following year.

adoption of the wage-correction policy in 1979 (Chart 1). The share of financial and business services in total output rose from 18 percent in 1979 to almost 29 percent by 1987. Similarly, the share of electronics, which represents a relatively high-technology activity, increased sharply. Shifts in the composition of the labor force were another sign of restructuring; as Table 3 shows, from 1979-87 the share of professional, managerial, and administrative workers in the labor force rose significantly from 11 percent to 17 percent, while that of production, transport, and other manual workers fell from 39 percent to 35 percent.

In assessing the economic restructuring policies, several key questions need to be addressed. First, if the policies had not been undertaken, would restructuring necessarily have come about naturally? Second, while restructuring was expected to raise the level of productivity and hence the level of output, is there any reason to believe that it might also result in a permanent increase in the potential rate of growth of the economy? Third, what effects did changes in wage differentials and in the rate of return to capital have on the direction and pace of restructuring?

For a labor-constrained and otherwise naturally resource-poor economy, such as Singapore at the end of the 1970s, productivity increases must eventually become the primary source of sustained growth in the supply of output. Productivity of the raw labor force can be increased directly by investment in human capital, as emphasized recently by Otani and Villanueva (1989); or it can result from a process of "learning-by-doing". The potential importance of learning-by-doing in endogenously determining productivity growth was first advanced by Arrow (1962). Subsequently Bardhan (1970) and Krugman (1987) have emphasized its role in dynamically determining comparative advantage, and it is identified by Lucas (1988) as a potential, endogenously determined, source of growth. In the next section, the questions raised above on Singapore's economic restructuring program will be addressed in a simple model incorporating learning-by-doing.

III. A Model of Endogenous Growth and Restructuring

The model developed here builds on Lucas (1988). Consider a small open economy producing two (baskets of) traded goods, the outputs of which are denoted by Q^1 and Q^2, and the prices of which are determined in the rest of the world. Initially, for simplicity, abstract from the presence of physical capital. 1/ The population, or labor supply, is assumed to be constant. The two goods are produced by a Cobb-Douglas type technology, with diminishing returns to labor

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1/ The implications of the presence of physical capital and the role of investment are discussed below in an extended version of the model.

Table 3. Employment by Occupational Category, 1970-87

(Percent of total employed labor force)

	1970	1979	1987
Professional, administrative, and managerial	11.0	11.3	17.2
Clerical, sales and service	42.1	42.2	41.4
Production, transportation, and other manual	39.2	38.6	35.4
Other	7.7	7.8	5.9

Source: Singapore, Yearbook of Statistics, various issues.

$$Q_t^1 = h_t^1 \left[\ell_t^1 \cdot N\right]^{\alpha},$$

$$\text{and} \quad Q_t^2 = h_t^2 \left[\ell_t^2 \cdot N\right]^{\beta}, \qquad \text{where } 0 < \alpha < \beta < 1. \tag{1}$$

Here h_t^i is the skill level or human capital specialized in the production of good i, where i = 1, 2; N denotes the size of the labor force, and ℓ_t^1 is the share of the labor force employed in the production of good i.

The effect of the skill level or human capital h_t^i, is assumed to be entirely external to any of the large numbers of perfectly competitive firms in each industry. This positive externality cannot be captured by any single firm, that is to say the production of each firm depends on the average skill level in that industry. It is assumed that skills are acquired, according to

$$\dot{h}_t^1 = h_t^1 \cdot \delta_1 \cdot \ell_t^1,$$

$$\text{and} \quad \dot{h}_t^2 = h_t^2 \cdot \delta_2 \cdot \ell_t^2, \quad \text{where } \delta_1 > \delta_2, \tag{2}$$

and a dot over a variable denotes its derivative with respect to time. The growth of the skill-level should be interpreted as occurring due to learning and can be interpreted as learning by doing. The rate of growth of skills in (2) is a positive function of both the speed of learning, represented by δ_i, and the effort or resources devoted to producing good i, which is assumed to be related to the proportion of the labor force employed in the production of good i. Good 1 will be referred to as the "high-technology" good and good 2 as the "low-technology" good. It is posited further that the speed of learning is greater in the high-technology sector than in the low-technology sector, so that $\delta_1 > \delta_2$.

Equation (2) implies that the economy's production possibility frontier shifts out over time, with experience gained by the labor force resulting in an increase in the skill level and hence productivity of the labor-force. Note that the form of these learning equations imply constant returns to experience. This seems counter-intuitive, in that one would expect learning-by-doing or the acquiring of skill in any particular activity to occur rapidly at first, then more slowly, and then not at all. The constant returns to learning in (2) should be interpreted as representing an environment in which innovations are constantly occurring, and being adopted, so that learning is interpreted not only as the learning that permits doing things better, but also results in the doing of better things. Viewing learning as encompassing the adoption of innovations

provides a justification for the assumption of a higher speed of learning in the high-technology sector since innovations are likely to occur at a relatively more rapid rate in the sector.

It is assumed for simplicity that labor is perfectly homogeneous, mobile across sectors, and that wages are perfectly flexible. Full employment therefore implies

$$\ell_t^1 + \ell_t^2 = 1 \ . \tag{3}$$

For our purposes, it is convenient to allow for a subsidy on wages in sector 1, granted at the rate τ_1, and a tax on wages in sector 2, levied at the rate τ_2. Then combining firms' first-order conditions for profit maximization, and substituting in the full employment condition (3), yields

$$\frac{(1-\ell_t^1)^{1-\beta}}{(\ell_t^1)^{1-\alpha}} = \frac{\beta \cdot P \cdot N^{\beta-\alpha} \cdot (1 - \tau_1)}{\alpha \cdot H_t \cdot (1 + \tau_2)} \ , \tag{4'}$$

which can then be used to solve for the share of labor in sector 1 as a function of the relative skill level in sector 1 and the exogenous variables of the system, so that

$$\ell_t^1 = \ell_t^1 \underset{+}{(H_t} \ ; \ \underset{-}{P} \ , \ \underset{-}{N^{\beta-\alpha}} \ , \ \underset{+}{\tau_1} \ , \ \underset{+}{\tau_2}) \ . \tag{4}$$

In equation (4), H_t denotes the ratio of skill levels or human capital, i.e., $H_t = h_t^1/h_t^2$; P equals P_2/P_1 and denotes the internationally given relative price of good 2 in terms of the numeraire good 1. Signs underneath arguments in the ℓ_t^1 function indicate signs of the partial derivatives, and are straightforward to derive from (4'). The learning or skill accumulation equations can be combined to obtain a relative learning equation and, upon substitution of the full employment condition, yield

$$\frac{\dot{H}_t}{H_t} = (\delta_1 + \delta_2) \cdot \ell_t^1 - \delta_2 \ . \tag{5}$$

Figure 1 graphs the possible dynamic paths of the economy represented by equations (4) and (5). The growth of skills in each activity is determined by both the speed of learning and the effort or resources, i.e., proportion of labor force, devoted to each activity. Since the speeds of learning are posited to be different in the two sectors, there will exist distributions of the labor force between the two sectors such that the ratio of skill levels remains exactly constant over time: where, for example, the effect on the growth of the relative skill level of a smaller share of labor devoted to producing the high-technology good is offset exactly by the higher speed of learning in that activity. In Figure 1 the $\dot{H}_t = 0$ line denotes such a locus of points where relative skill levels remain constant. The arrows indicate the direction of movement of the relative skill level, H_t, when the economy is off the $\dot{H}_t = 0$ line. The curve OL represents the profit maximizing general-equilibrium employment share in sector 1, ℓ_t^1, as given by equation (4). Under our assumptions the economy is always on this curve, and the double arrows on this curve thus indicate the actual path of the economy at any relative skill level H_t. The two curves intersect at what is a critical relative skill level, H_t^c, in the production of the high-technology good. Given an initial ratio of human capital in the two sectors, H_o, and in the absence of exogenous shocks to the system, the future path of production is completely determined. Unless the economy is initially endowed with a relative human capital ratio of exactly H_t^c the economy will, over time, naturally traverse either up the OL ray eventually specializing in the production of the high-technology good 1, or it will move in the opposite direction specializing eventually in good 2. If the economy specializes in good 1, the growth rate of aggregate output is, from equations (1) and (2), δ_1, which is, by assumption, greater than δ_2, the growth rate if the economy specializes in good 2. Thus, movements in figure 1 toward L can be identified as converging to a "high-growth" path, and movements toward O as converging to a "low-growth" path. It can be shown that at any point in time along a transition path, i.e., at any point on the OL curve, the rate of growth of output increases monotonically from δ_2 at O to δ_1 at L.

The PPF shifts out, over time, proportionately in favor of the good which the country has an initial comparative advantage in producing, i.e., produces relatively more of, since its skill level will grow relatively more in the activity to which it devotes larger resources. Thus, at unchanged relative prices, except by pure chance, in the case where initially resources are divided in the production of each good such that relative skill levels remain constant, the economy will end up specializing in the production of one of the two goods over time. Initial comparative advantage is thus magnified over time. Since the speed of learning is posited to be greater in the high-technology good, eventual specialization in that good implies a higher steady state growth rate.

The analysis presents a manifestation of popular notions of bottlenecks to growth. 1/ There are no forces in the system just discussed which would necessarily place the economy on a path converging to the high-growth path. Whether the economy ends up on the high-growth path or the low-growth path will depend upon its initial relative skill levels and internationally given relative prices. Since the learning effects are assumed to be external, agents do not take them into account, and the high-technology good is thus under produced, and production and trade is determined by temporal or historical comparative advantage. The market, left to itself, will not necessarily pick the high-growth path, except by historical accident. There is thus a clear role for government intervention. In particular, allocating labor towards the high-technology good, relative to the free market solution, would result in an acquiring of comparative advantage over time in the production of the high-technology good and a higher growth rate.

An alternative reason for the existence of differential potentials for productivity increases that are external to any single firm, is different rates of technology transfer from the rest of the world to the two sectors. 2/ Imagine, for simplicity, that "available" technological

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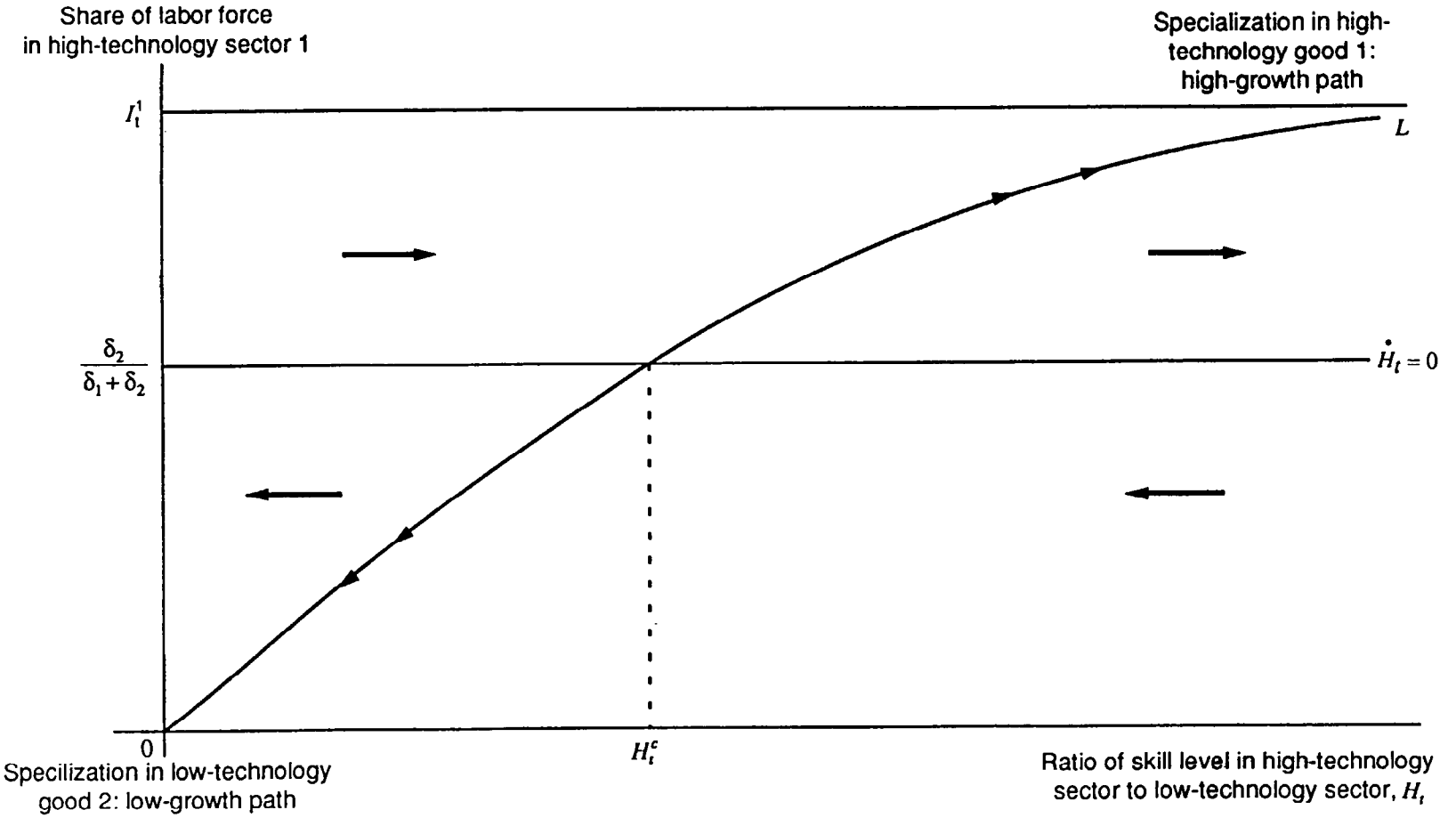
1/ Formally there is a bottleneck to "high" growth, rather than growth.
2/ This is particularly relevant in the case of Singapore.

Figure 1

Dynamic path of economy



progress occurs globally at a faster rate in the high-technology sector. Now suppose that the (relative) speed of adoption of these innovations, i.e., the actual transfer of the technology, is a function of the (relative) resources devoted to the production of each good. The analysis of different rates of technology transfer from abroad is then equivalent to that described above for endogenous productivity increases.

The role of skills upgrading is transparent in the framework of Figure 1. An exogenous increase in the relative skill level in the production of the high-technology good would move the economy to the right along the curve OL in Figure 1. Thus, a relatively skill scarce economy can, by increasing its skill level, cross the threshold value of H_t^c, putting it on a self-sustaining path of restructuring toward the high-technology good, leading eventually to complete specialization in the good, and a higher steady state growth rate.

1. The role of wage differentials in economic restructuring

A simple and convenient way to analyze the effect of an exogenous decline in the relative wages paid in the high-technology sector is to examine the effect of a tax on wages in the labor-intensive low-technology sector, or the effect of a subsidy on wages in the high-technology sector. 1/ Consider the effect of an increase in the tax rate on wages in sector 2, τ_2. Recalling equation (2), an increase in τ_2 results in an upward shift of the OL curve, as depicted in figure 2, to OL', so that as would be expected, an increasing proportion of the labor force is employed in the high-technology sector at any skill level. It now intersects the $\dot{H}_t = 0$ line at a lower relative skill level, $H_t^{c'}$. This implies that if the economy initially had a relative skill level between $H_t^{c'}$ and H_t^c, it would have been on a path converging to the low growth path; after the shift in the OL curve, skill levels between $H_t^{c'}$ and H_t^c become points

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1/ Although such a differential tax or subsidy was not actually implemented, it is analytically equivalent to changing wages in the low-wage sector relative to the high-wage sector from employers' point of view, and considerably more tractable.

converging to the high-growth path. The mechanism by which this occurs is straightforward. A decline in the relative wage paid by producers of good 1 shifts employment in favor of good 1, increasing the proportion of the labor force devoted to producing the high-technology good. By increasing the proportion of resources devoted to producing the high-technology good, the scope for learning or acquiring comparative advantage in that activity increases. The locus of initial conditions converging to eventual specialization in the high-technology good thus increases.

2. Effect of a change in the terms of trade

Consider the effect of an exogenous increase in the internationally given relative price of the high-technology good. This corresponds to a decline in P and, given the sign of the partial derivative in equation (4), results in an upward shift of the OL curve in Figure 2 to OL', exactly as in the previous exercise. An increase in the relative price of good 1 shifts production in favor of good 1, increasing the proportion of the labor force employed in sector 1, and hence expands the set of initial conditions converging to eventual specialization in the high-technology good. It follows directly that any commercial policy, for example a tariff, that shifts domestic producer prices in favor of the high-technology good, would have the same effect.

3. Role of foreign labor

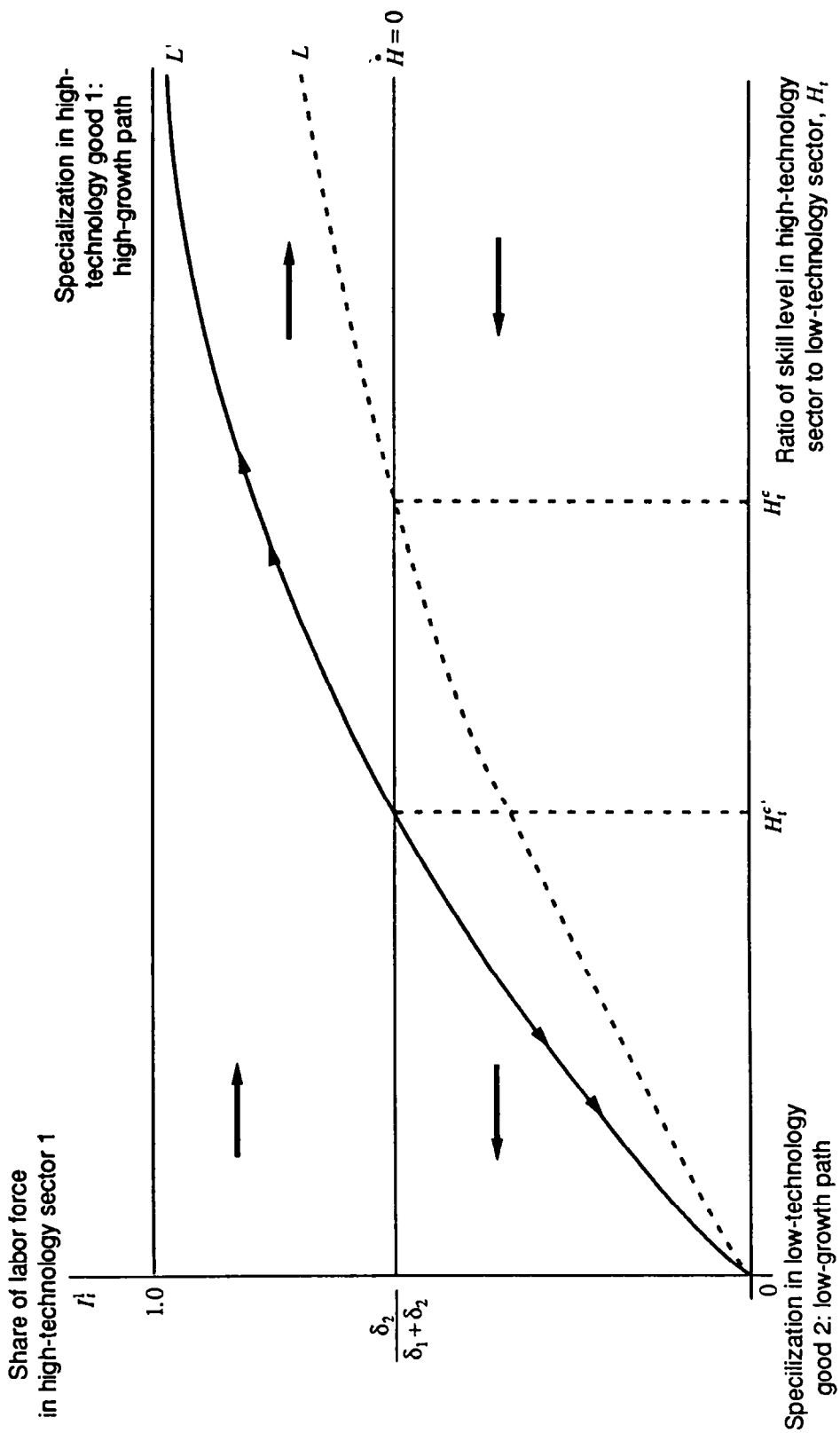
Consider the effect of an increase in the labor force, N. Note that, from equation (4), ℓ_t^1 is a negative function of $(N^{\beta-\alpha})$. The actual direction of movement of the OL curve therefore depends on whether $\beta \gtrless \alpha$. If, as we have assumed here, the low-technology good 2 is relatively labor-intensive, then β is greater than α, and hence an increase in the supply of labor will cause the OL curve in Figure 2 to shift down. 1/ 2/

1/ This is not shown as the effects are exactly opposite to those depicted for the previous exercise in Figure 2.

2/ To talk meaningfully about relative labor intensities, physical capital needs to be included explicitly in the production functions. It is implicitly assumed that the capital stock in each sector is fixed in this subsection and is therefore suppressed from the notation. The next subsection endogenizes physical capital accumulation.

Figure 2

Effect of an increase in the tax rate on wages in the low-technology sector 2



This effect of an increase in the labor force is a standard prediction of the familiar Rybczynski theorem: an increase in the supply of labor increases by relatively more the output of the relatively labor-intensive good. Thus output and employment shift in favor of the low-technology labor-intensive good, thus contracting the set of initial conditions that converge to eventual specialization in the capital-intensive high-technology good.

4. Role of investment

The rate of investment in physical capital plays an important role in the restructuring of output. 1/ An increase in the stock of physical capital would increase by relatively more the output of the capital-intensive sector. Thus, in the setting above, where the capital-intensive good is the high-technology good, an increase in the stock of physical capital will shift the composition of output and employment in favor of the high-technology good. Hence an increase in the rate of investment can be viewed as an alternative engine for the restructuring of output, while additionally providing an independent source of economic growth.

In introducing physical capital accumulation into the model above, in the interest of keeping the analysis tractable, some simplifying assumptions are made. We want to consider the case where the high-technology sector is relatively capital-intensive and where productivity increases at a faster rate because the speed of learning and hence the rate of skill accumulation is greater. A simple and tractable way to maintain these assumptions is simply to take the extreme case: capital is employed only in the high-technology sector; and while skills are accumulated by learning, as before, in the high-technology sector, the skill level in the low-technology good is simply constant and normalized to equal one. Production functions can then be written as

$$Q_t^1 = H_t \left[\ell_t^1 \cdot N\right]^{\alpha} \cdot K_t^{1-\alpha} \quad , \tag{6}$$

$$\text{and} \quad Q_t^2 = \left[\ell_t^2 \cdot N\right]^{\beta}, \qquad \text{where } 0 < \alpha < \beta < 1 \ ,$$

and K_t represents the stock of physical capital. Note the slight change in notation: the skill level in the high-technology sector is now denoted by H_t. This is to highlight the fact that while formally H_t now represents only the absolute skill level in sector 1 it can, without loss of

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1/ The effect of changes in the composition of investment are, of course, transparent. An increase in the share of total investment going into the high-technology sector will, by altering relative capital stocks, shift production and employment in favor of the high-technology good.

generality, still be interpreted as the relative skill level in that sector. As before, it is assumed that the rate of growth of the skill level in sector 1, H_t, increases with the proportion of the labor force, ℓ_t^1, devoted to producing good 1. Specifically,

$$\frac{\dot{H}_t}{H_t} = \delta_1 \cdot \ell_t^1 - \delta_2 , \qquad \text{where} \quad \delta_1 > \delta_2 . \tag{7}$$

We assume along with Kouri (1979) that as a small open economy net investment at home is an increasing function of the discrepancy between the actual rate of return to capital, r_t, adjusted for any taxes, levied at the rate ϕ, and the exogenously given rate of return, r^*, in the international capital market 1/

$$\dot{K}_t = \gamma\left[(1-\phi)\cdot r_t - r^*\right] . \tag{8}$$

Assuming a competitive market for capital, the rate of return (rental) to capital at home is given at any point in time by the marginal product of capital in sector 1

$$r_t = (1 - \alpha) \cdot H_t \cdot \left[\ell_t^1 \cdot N\right]^{\alpha} \cdot K_t^{-\alpha} . \tag{9}$$

As in the previous subsection, first order conditions for profit maximization can be combined with the full employment condition to yield

$$\frac{(1-\ell_t^1)^{1-\beta}}{(\ell_t^1)^{1-\alpha}} = \frac{\beta \cdot P \cdot N^{\beta-\alpha} \cdot (1 - \tau_1)}{\alpha \cdot H_t \cdot K_t^{1-\alpha} \cdot (1 + \tau_2)} \tag{10'}$$

so that

$$\ell_t^1 = \ell_t^1 \underset{+}{(H_t} , \underset{+}{K_t} ; \underset{-}{P} , \underset{-}{N^{\beta-\alpha}} , \underset{+}{\tau_1} , \underset{+}{\tau_2}) . \tag{10}$$

1/ Kouri (1979) argues that such an investment function can be derived if expectations are static and there are adjustment costs to investment. The traditional neoclassical model of investment, as developed by Jorgenson (1963), posits the flow of investment to be a function of the difference between an optimal capital stock, determined by maximizing the present value of the firm, and the current level of the capital stock. The formulation here is adopted to emphasize that in a highly open economy, investment at home is a function of relative rates of return.

Substituting (10) into (7), combining (8) and (9) and again substituting in (10), yields a pair of dynamic equations in the skills level and the stock of physical capital

$$\frac{\dot{H}_t}{H_t} = \delta_1 \cdot \ell^1_t(H_{+t}, K_{+t}; P, N^{\beta-\alpha}, \tau_1, \tau_2) - \delta_2 \ , \tag{11}$$

$$\dot{K}_t = \gamma\left[(1-\phi)(1-\alpha)\cdot H_t \cdot [\ell^1_t(H_{+t}, K_{+t}; P, N^{\beta-\alpha}, \tau_1, \tau_2)\cdot N]^{\alpha} \cdot K_t^{-\alpha} - r^*\right] . \tag{12}$$

It follows that

$$\frac{\partial \dot{H}_t}{\partial H_t} \ , \ \frac{\partial \dot{H}_t}{\partial K_t} \ , \ \frac{\partial \dot{K}_t}{\partial H_t} \quad > 0 \ , \tag{13}$$

and it can be established that

$$\frac{\partial \dot{K}_t}{\partial K_t} < 0 \ . \tag{13'}$$

To establish (13'), differentiate (12) with respect to the capital stock, and rearrange, so

$$\frac{\partial \dot{K}_t}{\partial K_t} = \gamma(1-\phi)(1-\alpha)\cdot H_t \cdot N^{\alpha} \cdot \alpha \cdot (\ell^1)^{\alpha} \cdot K_t^{-\alpha-1} \cdot \left[\frac{K}{\ell^1} \cdot \frac{\partial \ell^1}{\partial K} - 1\right] \ , \tag{14}$$

and, therefore,

$$\text{sign}\left[\frac{\partial \dot{K}_t}{\partial K_t}\right] = \text{sign}\left[\frac{K}{\ell^1} \cdot \frac{\partial \ell^1}{\partial K} - 1\right] \ . \tag{15}$$

Now, differentiating (10') and rearranging

$$\left[\frac{K}{\ell^1} \cdot \frac{\partial \ell^1}{\partial K}\right] = \frac{1}{\frac{(1-\beta)}{(1-\alpha)} \frac{\ell^1}{(1-\ell^1)} + 1} \qquad < 1 \ . \tag{16}$$

so that $\partial\dot{K}/\partial K < 0$. Given (13) and (13')

$$\left.\frac{dH}{dK}\right|_{\dot{K}=0} > 0 \ , \quad \text{and} \quad \left.\frac{dH}{dK}\right|_{\dot{H}=0} < 0 \ , \tag{17}$$

so that a phase diagram describing the possible dynamic paths of the economy can be drawn, as in Figure 3.

Note that both the skill level, H_t, and the stock of capital, K_t, are predetermined variables given by history at any point in time. As the arrows indicate, there exists a locus of initial H, K combinations, labelled CC in Figure 3, that places the economy on a path converging to a steady state combination of $\bar{H}$, $\bar{K}$. 1/ The curve CC corresponds in this setting to the point H_t^c, in the previous subsection. Again, the initial combination of skill level and capital stock determine the entire future path of production, and there are three possibilities : if the initial H, K endowment places the economy above CC then over time, the economy will tend toward specialization in the capital-intensive high-technology good; if below, then the economy will tend toward specialization in the labor-intensive low-technology good; if the initial endowment places the economy exactly on CC, then the economy will remain diversified, converging over time to $\bar{H}$, $\bar{K}$. Interestingly enough, note that CC is downward sloping in Figure 3. This implies that a "high" stock of capital can offset a low skill level as a bottleneck, and vice versa, in attaining a self-sustaining path to restructuring towards the capital-intensive high-technology good.

This expanded framework allows a consideration of the two main components of the wage-correction policy: a change in relative wages and an increase in the overall level of wages. Consider first the relative wage effect of the wage-correction policy. As before, consider the effect of an increase in the rate of tax, τ_2, on employment in the labor-intensive low-technology sector 2. Given the signs of the partial derivatives in equation (10) it follows that both the $\dot{H}_t = 0$ and the $\dot{K}_t = 0$ curves shift down in the H, K plane, as shown in Figure 4 where the original curves are depicted with dashes. This implies that the curve labelled CC, which separates initial conditions converging to eventual specialization in the high-technology good from those converging to specialization in the low-technology good, also shifts down. The shaded area in Figure 4 then denotes the set of points that originally would have resulted in the economy continuously expanding its share of labor-intensive low-technology goods, but now become points leading to eventual specialization in the high-technology good.

1/ Formally, the Jacobian matrix, with elements defined in equations (13) and (13'), has a negative determinant so that the system has one stable and one unstable root, and is therefore characterized by saddlepath stability. CC denotes the saddle path in Figure 3.

Figure 3

Dynamic path of economy with endogenous capital accumulation

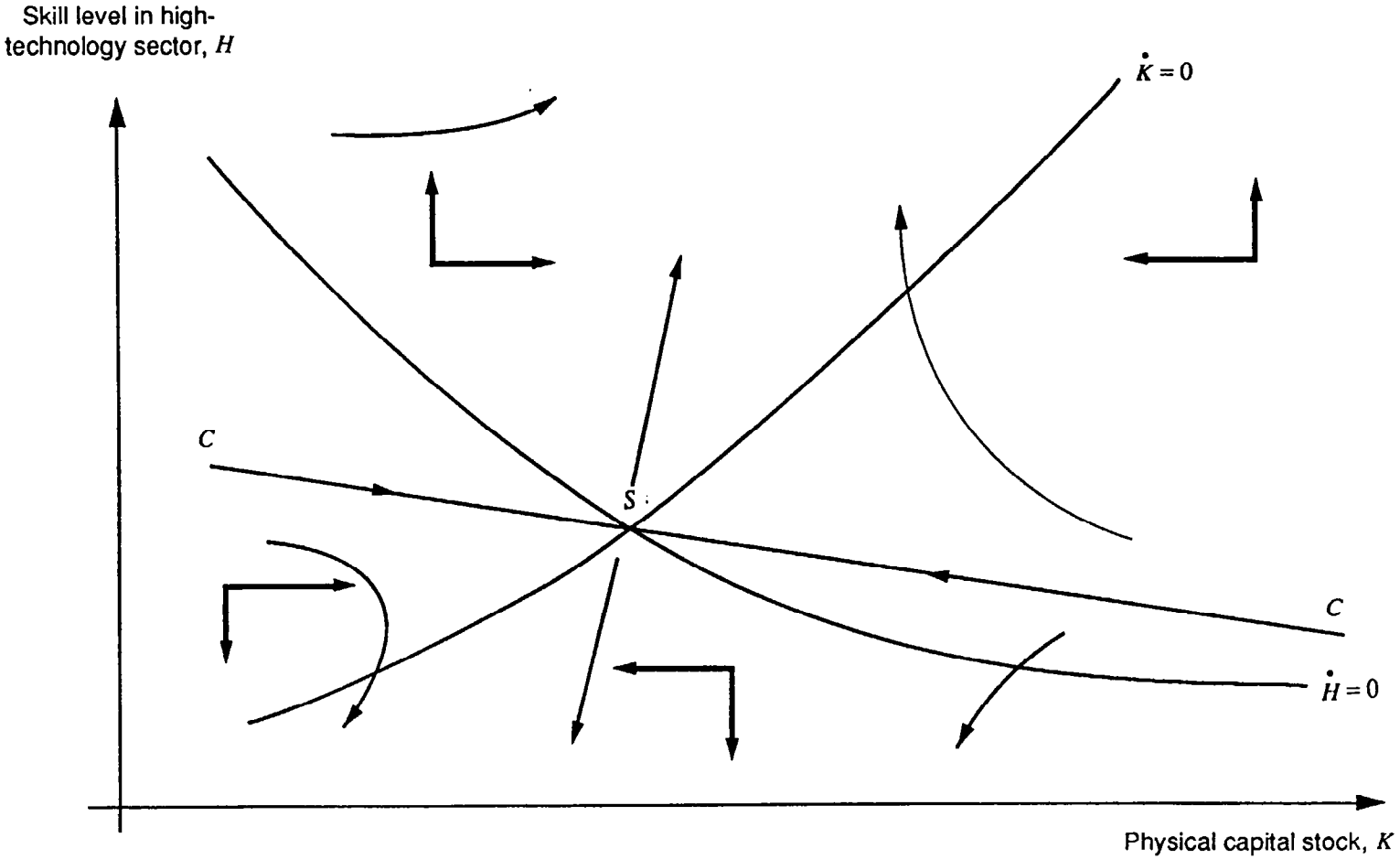


Figure 4

Effect of an increase in the tax rate on wages in the low-technology sector 2 with endogenous capital accumulation

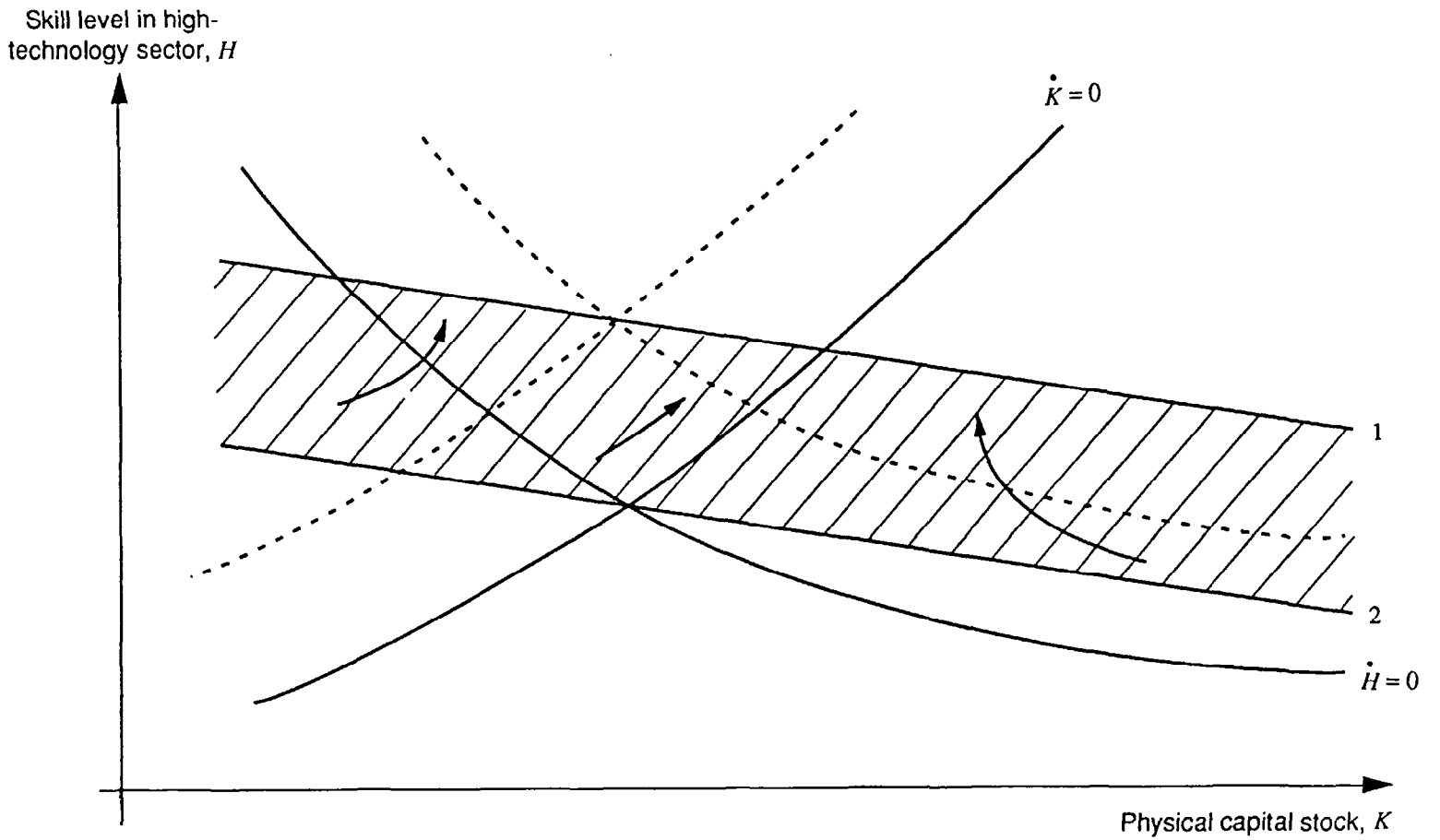
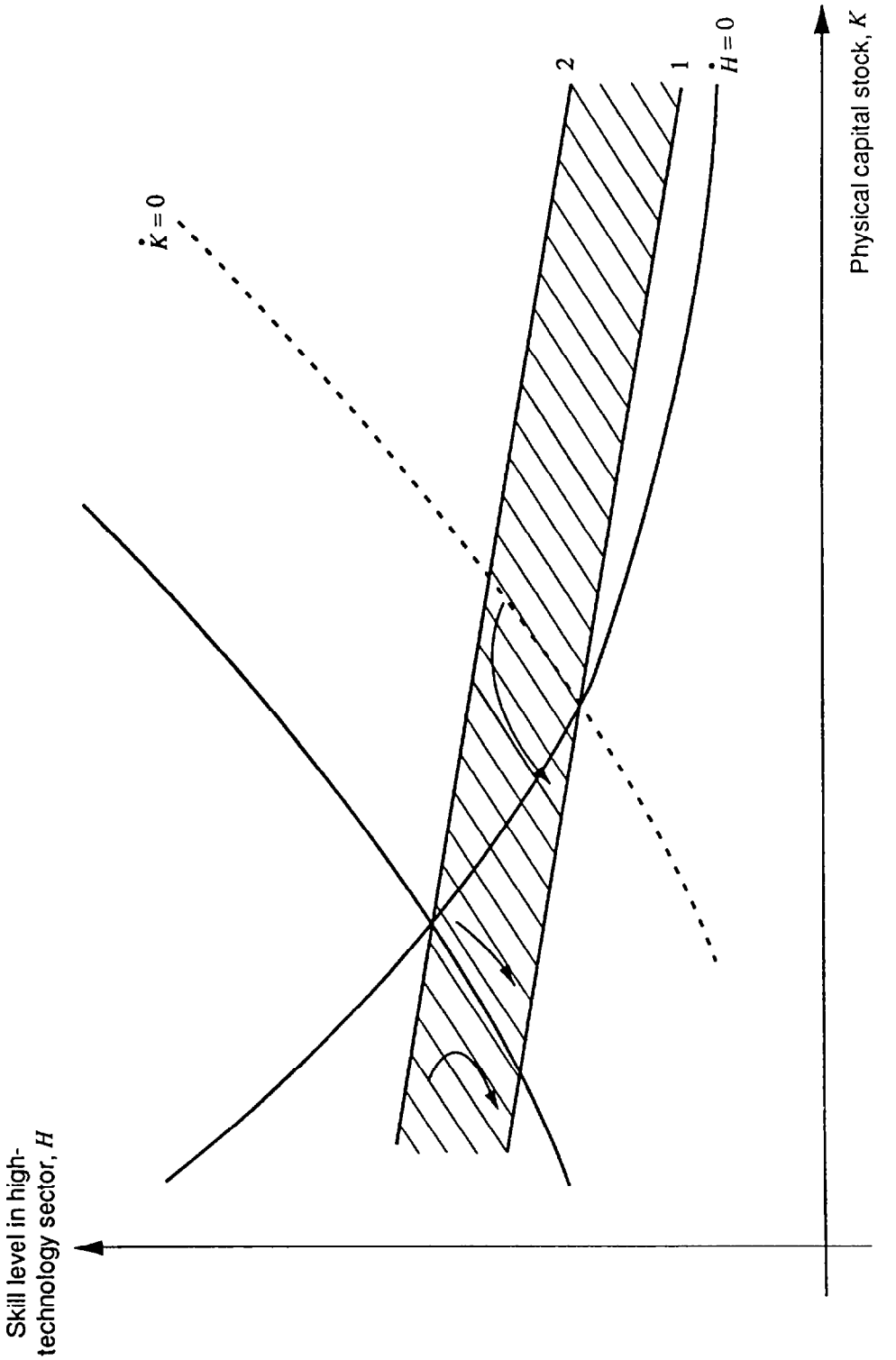


Figure 5

Effects of an increase in the tax rate on the return to capital



Consider now the effect of an increase of average real wages in excess of productivity growth. As this would reduce the rate of return to capital, or profitability, a convenient way to model this is to examine instead the effect of an increase in the tax, ϕ, on the return to capital. 1/ In this case there is no effect on the $\dot{H}_t = 0$ curve, since ϕ does not enter equation (11). From equation (12), however, the $\dot{K}_t = 0$ curve shifts up or to the left in the H, K plane as shown in Figure 5. Thus at each skill level, the rate of investment is zero at a smaller level of the capital stock. Each point on the original $\dot{K}_t = 0$ curve represents a pair of skill and physical capital levels such that the tax adjusted rate of return to capital was just equal to that in the rest of the world. An increase in the tax rate thus requires, for any skill level, a lower level of capital so that the marginal product of capital rises sufficiently to equate the domestic tax adjusted rate of return to that given exogenously in the rest of the world. The upward shift of the $\dot{K}_t = 0$ curve implies a consequent upward shift of the CC curve in Figure 5. In this case the shaded area denotes a set of points which originally would have resulted in production converging to specialization in the high-technology good but, as a result of the decline in the rate of return to capital, become points converging to specialization in the labor-intensive low-technology good.

To summarize, we return to the questions raised at the end of the last section on restructuring. First, in the framework developed above, government intervention can play a pivotal role in providing an initial impetus for restructuring, which market forces may not naturally generate due to the presence of external learning effects. A second question was whether restructuring would simply raise the level of output or could influence long-run growth potential. The framework developed here clearly suggests scope for latter if the high-technology and knowledge-and-skill-intensive sectors inherently have the potential for higher productivity growth. Finally, on the third issue--the effect of the wage-correction policy on economic restructuring--the analysis suggests that there were probably two opposing influences. The decline of relative wages in the higher-paid occupations tended to shift employment in favor of these occupations thus moving the economy onto, or further along, a path to self-sustaining restructuring toward capital-intensive, high-technology and knowledge-and-skill-intensive activities. The rapid increase in real wages across the board, on the other hand, lowered the rate of return to

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1/ Sufficient conditions for an exogenous increase in wages or labor costs to reduce the rate of return to capital are that the labor supply curve be positively sloped and that the capital stock be predetermined at a point in time. In the tradition of two sector trade models it has been assumed, for simplicity, that labor is inelastically supplied.

capital and thus lowered investment which tended to move the economy away from such a path. 1/

IV. Conclusion

This paper has examined a particular phase in the growth experience of Singapore--that of economic restructuring. To examine the process of restructuring in general a model of endogenous growth and restructuring for a small open economy incorporating learning-by-doing was developed. A broad conclusion from this framework is that impediments to restructuring may exist because of the potential importance of external learning effects, the benefits of which redound not to individual firms but to a sector as a whole. Such externalities present bottlenecks to market driven restructuring and create a role for government intervention. In particular, it was shown that a diversion of resources, even temporary, can induce an acquisition of comparative advantage and hence permanently effect the pattern of trade and growth. Thus the framework suggests that if high-technology and knowledge-and-skill-intensive sectors inherently have the potential for higher productivity growth, economic restructuring would not simply raise the level of output but could permanently raise the rate of long run growth.

The framework was employed to analyze the effects of, among other things, the wage-correction policy on the direction and pace of economic restructuring in Singapore. The results indicate that there were probably two opposing influences. The decline of relative wages in the higher-paid occupations tended to shift employment in favor of these occupations thus moving the economy onto, or further along, a path of self-sustaining restructuring toward higher-technology and knowledge-and-skill-intensive activities. The absolute increase in average real labor costs across the board in excess of productivity growth, on the other hand, lowered the rate of return to capital and thus lowered investment, tending to move the economy away from such a path. However, note that in Singapore restructuring did not hinge on the net effect of these two opposing forces alone since it was boosted in addition by the upgrading of skills and the promotion of investment in relatively labor-saving and knowledge-and-skill-intensive activities. Indications are that initial bottlenecks to restructuring in Singapore have been overcome--a basic level of skills and trained manpower now exists, and a critical mass of high-technology and knowledge-and-skill-intensive activities has been established-- and comparative advantage in these activities is likely to grow naturally.

1/ If investment at home is unresponsive, however, to differences between domestic and international rates of return--for political risk reasons, for example--but is responsive to differences in rates of return across sectors, then an increasing proportion of the investment that does take place is likely to go into the labor-saving capital-intensive sector, spurring restructuring.

It is worth emphasizing that the framework developed here for examining alternative growth strategies was for a small highly-open labor-constrained economy. The policy conclusions reached, therefore, may not be applicable for all countries, and it should be noted that a shift toward production of high-technology goods is not sustainable for the world as a whole. Two crucial assumptions were made. First, the analysis was carried out on the assumption of a fully-employed and constant labor force. This seems accurate for Singapore at the end of the 1970s. For a labor-surplus economy, however, a shift toward labor-saving means of production may clearly not be appropriate in the presence of a large pool of unemployed labor. Second, as a small open economy, world demand was assumed to be infinite. A global shift in production towards any one good would, in the absence of any change in tastes, undoubtedly shift the terms of trade against the good, making its production less profitable and limit the scope for growth. 1/

1/ In this context, see Lucas (1988), who considers a world where, because of an assumed Ricardian technology, each country specializes in the production of one of two goods. His model predicts some interesting cycles in the pattern of production and trade.

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