Issues in Economic Growth and Trade Policy in East Asia

by

Shin Ohinata

Thesis submitted in partial fulfilment of the requirements

for the degree of Doctor of Philosophy in Economics

University of Warwick

Department of Economics

June 2010

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Acknowledgment

I would like to thank my two supervisors, Dr. Carlo Perroni for his patient supervision and Professor John Whalley for his encouragement. I would also like to thank other research students at the University of Warwick, especially Ana-Maria Iregui, Silvia Sgherri and Jesus Gonzalez-Garcia for advising against the idea when I considered giving up halfway.

Declaration

All the material in this thesis is my own work. The thesis has not been submitted for a degree at another university, and no part of it has been published or used in other academic or professional project.

Abstract

This thesis consists of three studies. The topics discussed are in the area of international trade and economic growth with a reference to the policy issues in East Asia.

The study in Chapter 2 presents a model of North-South trade which can explain the observed cross-country variations in factor prices. Intuition and evidence suggest that knowledge is largely non-excludable and hence all countries should have access to broadly similar technology. However, this public-good assumption for technology leads to implausible predictions of factor prices in standard models. The model in this study does not assume any differences in technology but its predictions are consistent with observations.

In Chapter 3, the implications of the two vintage models for growth accounting are examined. Growth accounting studies have shown that total factor productivity growth in East Asian economies has been slower than expected. Analysis of the vintages models suggests that this puzzling finding could be due to mismeasurements of capital arising from the particular characteristic of East Asian growth experience.

In Chapter 4, it is shown that when asymmetric economies adopt an open regionalism policy, some of them may gain at the expense of others. This result is very different from the commonly held view in the literature. In certain situations, some economies in the bloc achieves a higher welfare level than under global free trade. A policy of open regionalism could therefore turn out to be an obstacle to the process of multilateral trade liberalization.

Chapter 1

Introduction

1.1 An overview

This thesis consists of three studies in the area of international trade and economic growth with a particular reference to the policy issue in East Asia.

The observed cross-country variations in per capita income and factor prices cannot be explained easily without assuming that the technological levels are vastly different between the rich and poor countries. However, given the non-excludable nature of knowledge, assuming large differences in the technological level is hard to justify.[1] What is necessary therefore is a model which can account for the observed cross-country variations without introducing differences in technology. In Chapter 2, I will present a variant of the AK model and argue that the predictions of the model are consistent with the available evidence. The results rely on two key elements of the model. First, the capital goods sector has the structure of the AK model. Second, specialisation takes place as a result of North-South trade.

The study in Chapter 3 provides an explanation for the modest total factor productivity (TFP) growth in East Asia. I will argue that this puzzling finding in the growth accounting studies for East Asia is largely due to mismeasurements of capital. It is shown that if the mechanisms described by the vintage models are at work, then TFP residuals for East Asian economies are likely to understate the real extent of technological progress for two reasons.

[1] As I will discuss later, this is a very controversial area.

First, the vintage model of Solow (1959) imply that if capital inputs are measured in real terms, TFP residuals are likely to understate the actual extent of technological progress. Moreover, the problem of understatement would be worse in capital goods importing economies such as those of East Asia. Hence the TFP growth rates of East Asian economies may appear to be modest when compared with the industrialised economies. It is likely that the actual rate of technological progress has been higher than the findings in recent growth accounting studies suggest. Second, in the "fixed-proportions" vintage model, the substitution possibilities between labour and capital are limited. In this case, the retirement rate of the existing capital stock is endogenously determined. When rapid accumulation of capital takes place, a larger proportion of the existing capital stock is made obsolete. This means that estimates of the capital stock obtained by assuming a constant rate of capital depreciation tend to overstate the growth of capital when the rate of investment is high. Overstating the growth of capital, in turn, reduces TFP residuals. This model can therefore account for the observed negative correlation between measured TFP growth and the rate of capital accumulation.

In Chapter 4, potential problems associated with the policy of open regionalism are discussed. In the post-war years, the success of the negotiations at the GATT has resulted in increasing worldwide openness to trade. However, a growing number of regional trade blocs have been formed in recent years, raising the concerns that the emergence of regionalism may slow down the process of multilateral trade liberalization. In response to such criticism, proponents of regional trade blocs have suggested the idea of "open regionalism" at the Asia Pacific Economic Cooperation (APEC). In the theoretical literature, the term "open regionalism" refers to a number of different nondiscriminatory trading arrangements. This study focuses on the policy known as unconditional MFN, under which a trade bloc unconditionally extends the trade liberalization measures agreed among the member countries to non-members on an MFN basis. It is shown that if asymmetric countries form a trade bloc and adopt this form of open regionalism, some economies in the bloc may gain at the expense of the others. Moreover, the policy of open regionalism could turn out to be an obstacle to the process of multilateral trade liberalization.

In the remainder of this chapter, I will briefly discuss the background of the issues examined in this thesis.

1.2 Accounting for the cross-country variations in per capita income and factor prices

The aim of the study in Chapter 2 is to provide an explanation for North-South inequality in per capita income and wages. I will first discuss why the explanations that rely on differences in the technological level are not convincing. An important aspect of the model in Chapter 2 is trade in capital goods. I will briefly discuss the literature of trade in capital goods in this section also.

A useful point to start the examination of the issue is to consider the following simple production function;

$$y = Ax^{\alpha}, \tag{1.1}$$

where y is income per worker and x is (broadly defined) capital per worker. In this framework, it is evident that differences in output per worker can be attributed to either differences in the levels of technology, represented by the parameter A in this model, or differences in capital per worker.[2] In standard growth models, a higher level of technology leads to a higher steady state level of capital per worker. Hence, when we discuss what contributes to the cross-country variations in per capita income in this framework, the question is whether capital per worker alone can explain the cross-country variations or differences in technology also play a role.

Let w denote the wage rate. We assume throughout this study that the labour market is competitive and the wage rate is given by the marginal product of labour. With the Cobb-Douglas production function as in (1.1), the wage rate is therefore given by $w = (1-\alpha)Ax^{\alpha}$. It is clear that the issue of the cross-country variations in the wage rate is essentially the same as that of per capita income.

In the literature, there are two opposing views on the availability of technology in low-income countries. One takes the view that international knowledge transfers should be relatively easy while the other maintains that there are large differences in technologies available to the rich and poor countries.[3]

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[2] Although quantities are clearly different when measured in "per capita" and "per worker" but they can be treated as equivalent for the purpose of discussion in this thesis.

[3] Clearly, the controversy is over the degree of availability. Even those who regard technology as largely non-excludable do not suggest that the exactly the same sets of technology are available to all firms in all countries.

Intuition and evidence suggest that differences in the technological level are unlikely to be large enough to explain the vast North-South inequality. If less developed countries were poor because of their technology, there would be a huge incentive to adopt better technology from richer countries. Given that large returns could be expected from adopting better technology, one would have to ask why differences in the technological level should persist. Most scientific formulae and other accumulated knowledge applicable to production are available in print and other forms of media and hence accessible in most countries. Therefore technology seems to be non-excludable to a large extent, in which case there should be relatively small differences in the availability of technology anywhere in the world.

There is some evidence to confirm that much of technology is non-excludable. Olson (1996) notes that according to a study for Korea for the period from 1973 to 1979 (Koo, 1982), "royalties and all other payments for disembodied technology were minuscule". Suppose that the Korean firms had had much inferior technology without these licensing agreements and that the licensing agreements allowed the Korean firms to raise their productivity significantly. Then such gains would have been reflected in the value of these license agreements, provided that the market for licenses was competitive. A small value of royalties implies that the gains in terms of productivity from these licensing agreements were relatively small. Therefore it suggests that access to technology was less of a problem for Korean firms.[4]

The quantitative aspect of the issue is also worth noting. Mankiw (1995) comments that "If technological change enhances productivity by 2 percent per year, and if rich countries are five times as productive as poor countries, then poor countries must be using a production function that is about eighty years out of date." It is implausible that low-income countries do not have access to technologies which have become so out of date in industrialised economies. It is quite likely that there are difficulties in transferring state-of-the-art technologies to less developed countries.[5] However, the scale of North-South inequality is such that it cannot be explained by the fact that poorer countries do not possess the most modern technologies.

Neither does the other side of the debate argue that no international transfers of knowledge take place. The question is whether differences in technology are responsible for a significant part of North-South inequality.

[1]Note, however, that the actual compensation for the transferred technologies could have been paid through so-called transfer pricing.

[5]For a recent study on transfers of state-of-the-art technologies, see, for example, Glass and Saggi (1998). Teece (1976) shows that the costs of technology transfer by multinational corporations decline with the age of technology being transferred.

Absorptive capacity, institutions and economic policies

Sometimes a distinction is made between access to technology and absorptive capacity. The idea is that although knowledge about technologies may be freely available, that in itself is not enough to apply these technologies to industrial use efficiently. In order to make use of the available technologies, the economy needs to have workers with appropriate skills or human capital. Moreover, firms need to make efforts to adopt technologies to suit their particular circumstances.[6]

This approach contrasts with the neoclassical model which assumes that all factor markets are able to respond efficiently to the given prices and that firms possess the capabilities to adopt advanced technologies. Lall (1990), for example, argues that the "acquisition of industrial capabilities is not an easy, automatic or costless process." Furthermore, it cannot be assumed that "firms start by operating on a production function where such capabilities are already fully formed".

Introducing the idea of limited absorptive capacity would apparently reconcile the fact that knowledge is non-excludable with the argument that the total factor productivity in poorer countries is much lower. However, a closer examination reveals that there are difficulties in using the idea of absorptive capacity to explain North-South inequality in a general equilibrium framework.

In fact, the concept of absorptive capacity has equivalents in endogenous growth literature. First, consider the idea that human capital is needed to adopt more advanced technologies. This argument amounts to saying that the economy needs to allocate some of its human capital to activities which are aimed at raising the economy's productivity. If we express this idea in a formal model, it is analogous to models of innovation such as Romer (1990) and Grossman and Helpman (1991, Ch. 7).[7] I will discuss later why these endogenous growth models do not provide a satisfactory explanation for North-South inequality in more detail. The essential idea is simple. As Olson (1996) notes, the argument based on the scarcity of human capital "overlooks the fact that the rewards to those missing skills, when other things are equal, would then be higher in the poor societies than in societies in which these skills were relatively plentiful." It is evident

[6] For an overview, see Evenson and Westphal (1995).

[7] See also Keller (1995) which explicitly refers to absorptive capacity.

that this is not the case. As the flow of immigration demonstrates, the skilled wage is higher in the rich countries.

If technology were the cause of North-South inequality, there would be a huge incentive to adopt better technology. The idea of limited absorptive capacity is meant to solve this apparent puzzle. However, if lack of skilled workers were the problem, then a much higher wage rate should be offered to skilled workers contrary to the observed fact. Hence the puzzle remains.

One answer to this criticism is the possibility of a market failure. Lall (1990) comments that "individuals tend (due to externalities, risk-aversion and inadequate foresight) to under-invest in their own education". Given that we are trying to explain the low skilled wage (despite its scarcity) in poorer countries, the issue is not market failures in financing human capital investment. Hence, risk-aversion and inadequate foresight are not very relevant to this discussion. In this context, if there is a market failure, it means that skilled workers are underpaid. Although externality is a possibility, it is hard to grasp how positive externalities from human capital arises. I will discuss this point later in this chapter.

The second approach to absorptive capacity emphasises the need for expending resources to acquire modern technologies.[8] This argument is also unsatisfactory for a similar reason. If investment is needed to adopt modern technologies, such investment should yield very high returns, which apparently is not the case. In response, it could be argued that the activity to adopt modern technology has a low productivity level. However, an obvious question follows; why should the productivity of adopting modern technologies be so low? Thus, if we are to analyse the concept of absorptive capacity in a general equilibrium framework, it is difficult to point to what the obstacles to adopting freely available technologies are.

Olson (1996) stresses the importance of economies' institutions and economic policies which have large influence on the structure of incentives. It is argued that the "intricate social cooperation that emerges when there is a sophisticated array of markets requires far better institutions and economic policies than most countries have." This line of argument could help explain the lack of absorptive capacity. Again this approach rejects the neoclassical assumption that economies necessarily achieve the most efficient outcome given the available technology

[8] See Bell and Westphal (1984). Endogenous growth models which incorporate this idea are found in Aghion and Howitt (1998) and van Marrewijk (1999).

and resources.

The reason that the neoclassical approach makes rather simplistic assumptions is not necessarily that it view the world as such. One advantage of making those simplifying assumptions is that it allows quantitative examinations possible. The possible causes for limited absorptive capacity are all plausible and probably more accurate description of the world but it is harder to assess their significance quantitatively. This issue is therefore likely to remain controversial.

In this thesis, I will take the neoclassical approach in that the firms in all countries use the same technology at the same efficiency. This is not to dismiss the ideas I have mentioned here. The aim is to suggest an alternative explanation for North-South inequality. I will argue that even if the same technology is used in all countries, North-South inequality could persist in the long run.

Those who assume that there are differences in technology have found it necessary to do so in order to account for the cross-country variations in income and factor prices. To support their argument, they point to the apparent differences in the methods of production between the rich and poor countries. It is argued that such differences are due to the limited availability of technology in the South. Furthermore, it is argued that the endogenous growth models can provide the theoretical underpinning for this argument.

In Chapter 2, I will show that North-South inequality in per capita income and wages can be explained without assuming differences in technology. In this section, I will examine the validity of the other two claims. First, I will argue that observed differences in the methods of production does not necessarily imply that there are differences in the availability of technology. Moreover, endogenous growth models are useful in explaining improvements of technology over time but when it is used to explain the cross-country variations in technology, they are less convincing. I will discuss these two points in turn.

The methods of production and the availability of technology

It is apparent that the methods of production used in the rich and poor countries are often very different. Such differences are sometimes pointed to as evidence to support the premise that the availability of technology differs from country to country. This argument is clearly too simplistic. Differences in the chosen method of production do not necessarily imply that there are differences in the availability of technology. It is quite plausible that differences in

the methods of production reflect differences in factor prices.

In defence of the neo-classical model, Mankiw (1995) makes the following argument. The apparent differences in the method of producing goods and services do not necessarily imply that they represent differences in technological levels. Mankiw mentions the method of digging ditches as an example. In poor countries, workers use shovels to dig ditches whereas big bull-dozers are used by their counterparts in rich countries. Does this imply that the rich countries are more technologically advanced? Leave aside the obvious functional differences and assume that these two types of tools are used to perform exactly the same task. Mankiw simply states that using bulldozers rather than shovels should be regarded as a movement along the same production function rather than an upward shift. The answer to the question is an empirical one and depends on the cost of using the tools. In particular, it is entirely plausible that the method of production is determined by the relative factor prices rather than the availability of technology.

Consider the example of digging ditches again. Casual observations suggest that the sub-stitution possibilities between labour and capital (i.e. shovels or bulldozers) are limited. So technology is best described by a Leontief production function which requires inputs of labour and capital in fixed proportions. Suppose that the two methods of production, shovels and bulldozers are describe by the following production function:

$$Y = \min\left[\frac{K}{\delta_i}, \frac{L}{\gamma_i}\right], i = S, B, \tag{1.2}$$

where K and L are inputs of labour and capital. This subscript S is used for shovels and B for bulldozers. The differences in factor requirements are represented by the coefficients, δ_i and γ_i. Suppose that the following are the case:

$$\delta_S \leq \delta_B, \tag{1.3}$$

$$\gamma_S \geq \gamma_B. \tag{1.4}$$

This assumption essentially means that using bulldozers is the more capital intensive of these two methods and this seems entirely reasonable. Suppose that technology for both methods are commonly known and that firms in low-income countries are able to choose between them. Do

the firms in low-income countries always choose bulldozers, which most people would regard as "technologically advanced"? The answer is no. It is clear that the profit maximizing firm does not necessarily use bulldozers given those assumptions.

In low-income countries, wages needed to attract workers are low relative to the price of capital. Therefore, firms are likely to choose a method of production that are more labour intensive, i.e. shovels. In this case, firms are using less advanced technology by choice and not because "advanced technology" is not available.

On the other hand, labour costs in high-income countries are generally higher. It is likely therefore that firms use technology that allows savings in labour costs. Then they will use bulldozers. Hence, we expect to observe that shovels are used in low-income countries while bulldozers are in use in high-income countries. In this example, this difference in the method of digging is due to factor prices and not availability of technology.

The point to note is that the apparent differences in the method of production tells very little about the technology known to the economy. Using less complicated tools does not necessarily mean that firms have access only to less advanced technology. Therefore, the apparent differences in the methods of production cannot be interpreted as evidence for limited availability of technology.

The inadequacy of endogenous growth models in accounting for cross-country variations

Endogenous growth models explicitly specify the process by which technology improves over time. However, these models are not suited to explain or justify the assumption that there are large differences in the technological level across countries.

Earlier endogenous growth models assume that the level of technology increases as a result of an externality effect from physical and human capital accumulation. The most well-known is the model of Arrow (1962), which links the accumulation of non-excludable knowledge to the accumulation of physical capital. One interpretation of this model is that knowledge is created as firms produce capital goods. Hence, the model is often referred to as the model of "learning-by-doing". Grossman and Helpman (1991) use this interpretation and write the model in the following simplified way:

$$Y = F[K, A(K)L],$$

where K denotes capital, L denotes labour and $A(K)$ represent the level of technology. The function $F[.]$ is a standard neoclassical function and $A(K)$ is monotonically increasing in K. If the accumulation of capital (or, equivalently, production of capital goods) were to raise the total factor productivity of the aggregate economy, then it must be that newly created knowledge is non-excludable and flows freely into the public domain.[9] If we were to argue that the level of technology differs across countries, then it would mean that at least some of the spillover effects stop at the border. The problem is that if the knowledge freely flows into the public domain in one country, it is not clear why it should be so difficult for the firms in other countries to make use of this knowledge. Moreover, the firms in the North would have incentives to move production to poor countries with lower wages taking the knowledge that has become available in the North with them.

The same argument applies to the model of Lucas (1988, 1990), which attributes the externality to human capital. Lucas writes the model as

$$\hat{y} = A\hat{k}^{\eta}h^{\gamma},$$

where $\hat{y}$ is output per effective worker ($y = Y/HL$), $\hat{k}$ is capital per effective worker ($\hat{k} = K/HL$) and h is human capital per worker ($h = H/L$). The term h^{γ} is an externality effect. Lucas recognises that knowledge is available to all countries and therefore should not be the source of differences in the total factor productivity. Therefore, the term h^{γ} is not due to knowledge created as a result of human capital accumulation. In Lucas (1988), he suggests the idea of "cluster". The idea is that when there is a concentration of people with human capital, the productivity of these people as a whole should be higher than when they are sparsely placed. It is obviously hard to quantify such effects and it is not clear how significant, if at all, these effects due to interaction of people in proximity are.[10]

Endogenous growth models based on innovation

The concept of designs or blueprints is used in models of innovation.[11] A design is non-rival in

[9] If knowledge were excludable, then analysis would have to be modified to accommodate increasing returns implied by that assumption.

[10] In the brief survey of Lucas (1990), the idea of "cluster" is not mentioned at all.

[11] Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1998).

production but excludable in that the owner of the design can stop others from making use of it. It can be regarded as a one-off fixed cost required for starting production with a degree of monopoly power. The creation of designs requires resources and this up-front cost is covered by the stream of monopoly profits the design enables the firm to earn once production is started. In these models, having a greater number or better quality of designs results in higher total factor productivity. It is undoubtedly the case that more innovation takes place in rich countries. Some authors argue that this difference in innovation activities demonstrate the differences in the availability of technology.

However, there are difficulties in using the models of innovation to account for North-South inequality. An essential part of the models of innovation is that there are externality effects from innovation activities. The usual assumption is that creation of designs contributes to the accumulation of *non-excludable* knowledge capital which in turn increases the productivity of innovation activities. This assumption is crucial in explaining sustained growth in the long run. But this key assumption is what makes the models of innovation less convincing when they are used to justify assuming technological differences across countries. If knowledge capital is non-excludable, it is difficult to reason that this knowledge capital is accessible to anybody within the border but not to those who are outside. It is therefore more reasonable to assume that all countries have access to the same knowledge capital. However, if all countries have access to such knowledge capital, the model cannot explain the observed pattern of factor prices in the rich and poor countries. The details of the argument are found in Grossman and Helpman (1991, Chapter 7). In essence, the argument is as follows. The main input for the innovation activities is usually assumed to be human capital. Non-excludability of knowledge capital implies that the productivity of innovation activities is the same in all countries. Hence, if the poorer countries are poor because they do not innovate enough, it must be due to the scarcity of human capital. If human capital is scarce in poor countries, then workers with education must be earning more in poorer countries than in richer countries. This is not consistent with the observed pattern of factor prices. The fact that both skilled and unskilled workers earn more in rich countries is the very argument which is directed against the neoclassical model in favour of models which incorporate differences in technology.[12] However, models of innovation

[12] See Romer (1995).

run into exactly the same problem. Thus, attributing the cause of North-South inequality in wages to differences in technology has a problem. There does not appear to be any convincing explanations for assuming that knowledge transfers do not take place relatively easily.

Trade in capital goods

One important aspect of the model of North-South trade presented in Chapter 2 is trade in capital goods. It is quite evident that trade in capital goods is an increasingly important part of international trade. For example, according to the statistics compiled by the Japanese Tariffs Association, nearly 60% of Japanese exports now fall in the category of "capital goods". Many authors on development issues emphasise the importance of importing technologically advanced capital goods from industrialised economies. A number of empirical studies have shown that the price of capital has a significant effect on economic growth.[13] Studies on the growth experience of East Asian economies have identified the policy to encourage capital goods imports as the key element of the success throughout the region.[14]

These findings are not surprising from the theoretical point of view. If capital becomes available at a lower cost as a result of international trade, it will stimulate investment and lead to faster growth. It is often assumed that the cause of trade in capital goods is the technological advantage of the North over the South. This point should not be confused with the argument that the same technology should be available everywhere in the world. When we assert that the same technology is available everywhere in the world, what is implied is that if there are differences in the level of technology, such differences can explain only a small part of North-South inequality. On the other hand, small differences in technology can create opportunities for trade, provided that they cover transportation costs and trade barriers.[15]

In any case, North-South trade in capital goods can also be explained by the Hecksher-Ohlin trade model, which assumes common technology for all countries. In fact, the neoclassical model of trade in capital goods has been studied extensively.[16] In the Hecksher-Ohlin trade model, comparative advantages arise from differences in the factor endowments between countries and differences in the factor intensities between sectors. Consider the standard two-country, two-

[13] Jones (1994), Lee (1995)
[14] World Bank (1993).
[15] Eaton and Kortum (2000).
[16] For example, Oniki and Uzawa (1965), Baldwin (1966) and Baxter (1992).

sector, two-factor neoclassical model of trade and growth. One of the sectors produces consumption goods while the other produces investment goods. The factors of production are labour and capital, both of which are assumed to be internationally immobile. The two countries in the model have the same technology and preferences. At the time trade becomes possible, the North is more abundant in capital and the South in labour. The behaviour of consumers is described by the solution to a standard intertemporal optimisation problem.

The predictions of the Hecksher-Ohlin trade model are well known. In this case, the North will export capital goods to the South if the capital goods sector is more capital intensive. As capital accumulation continues in both countries, the price of the capital intensive goods gradually falls. It follows from the non-substitution theorem that there is only one equilibrium outcome for all economies in the long run, and therefore trade will eventually cease.[17]

Although the model does predict trade in capital goods in the short run, the predictions of factor prices and growth rates are widely different from observed facts. First, the rate of convergence predicted by this model is likely to be even faster than the one-sector closed economy neoclassical model. The reason for this is explained in Baldwin (1966). If the interest rate is constant, the effect of trade in capital goods is stimulating investment in the South. The availability of cheap imported capital goods makes future consumption relatively inexpensive and encourages savings and investment.[18] Hence, the model does not help in explaining that convergence of low-income countries does not take place in general.

One proposed explanation for general absence of convergence in the South is trade barriers against imports of capital goods from the North. The most extreme case of this would be a closed economy. But we know from the analysis of the one-sector neoclassical model that even closed economies should exhibit faster convergence than it is currently the case. Thus, trade barrier alone is unlikely to provide an explanation for slow growth rates of low-income countries.

Richard Baldwin and Elena Seghezza (1996a, 1996b) argue that the effects of trade on growth in the neo-classical model is that it stimulates investment in countries that export capital-intensive good while it discourages investment in countries which export labour intensive

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[17] Oniki and Uzawa (1965) shows the dynamics of the case with a constant savings rate in detail. Baxter (1992) examines the effects of tax and fiscal policy in determining the long-run trade patterns.

[18] In the North, the effect on investment is less clear. Since the consumption good becomes cheaper, there is a substitution effect towards current consumption but the income effect may dominate resulting in an increase in savings and investment.

goods. If this were the case, North-South trade could slow down convergence. However, their reasoning neglects the effect of trade in lowering the price of capital goods in the South compared to the autarky situation. It is not true to say that North-South trade discourages investment in the South.

The predictions of the neoclassical model for factor prices present another obvious problem. It is well known that the Hecksher-Ohlin trade model predicts factor price equalization. When specialisation takes place, the factor prices will differ between the economies. However, the problem is that a much higher wage rate in the North implies that a much higher rental price in the South. Numerical simulations show that it is hard to reconcile the predictions of the model with observations. In this regard, the problem is the same as in the case of the one-sector neoclassical model.

Thus, introducing trade in capital goods in the neoclassical framework does not solve the problems of the one-sector neoclassical model. If anything, the possibilities of trade make it even more difficult to reconcile the predictions of the model with observation.

The model presented in Chapter 2 predicts that wage rates are higher in the capital-rich North and convergence in general does not place. Hence it addresses the inadequacy of the neoclassical model while maintaining the assumption that the same technology is available to all countries.

1.3 Total factor productivity growth in East Asia

The aim of Chapter 3 is to provide explanations for the puzzling finding in a number of growth accounting studies for East Asian economies. These studies have shown that TFP growth in East Asian economies over the past few decades has been slower than expected.[19] I will argue that the characteristics of East Asian growth experience cast doubt on these findings. Two types of vintage models are used to show that mismeasurements of capital could have resulted in understating TFP residuals.

First, I will review the purpose of measuring TFP growth and emphasise that growth accounting is not just an exercise in measuring what we do not know. The primary aim is to

[19] Young (1994, 1995), Collins and Bosworth (1996).

measure the extent of technological progress and hence the economy's long-run growth prospect. The term "mismeasurement" in this context therefore means that TFP residuals do not represent the economy's long-run growth prospect.

Quality improvements in goods present a particular problem for growth accounting. It is widely agreed that output should be adjusted for quality improvements although it involves a number of practical difficulties. Growth accounting adds further complications to the issue. It turns out that data for capital inputs should not be adjusted for quality improvements if the aim is to obtain meaningful TFP residuals. If the data are adjusted, then it can be shown with the vintage model of Solow (1959) that TFP residuals are not a meaningful measure and are likely to understate the extent of technological progress in the economy. It is shown that this problem of understatement becomes worse in economies which import capital goods such as those of East Asia.

The second strand of the vintage model presented by Solow, Tobin, von Weizsäcker and Yaari (1966) suggests another source of mismeasurements in growth accounting. Casual observations suggest that the substitution possibilities between labour and capital are limited. If this is the case, then investment in new capital has the effect of turning older capital obsolete. Such instances of obsolescence are easy to find in reality. For example, a worker with however many type-writers at their disposal cannot hope to compete with another similarly skilled worker with one modern word processor. As the wage rate rises, the firm would make a loss if they continued to employ workers with type-writers. Therefore, when cheap word processors are introduced in the economy, most type-writers are made obsolete although they may be in a perfect working condition.

Suppose therefore that the retirement of capital is due to the limitation of substitution possibilities between labour and capital. An implication of such limits is that when a large amount of new capital is introduced to the economy, the amount of old capital that is made obsolete increases; i.e. the retirement rate of capital is endogenously determined. However, most growth accounting studies are carried out assuming that the rate of capital depreciation is constant. Hence, it is likely that estimates of growth of capital overstates the actual growth rate when there is large new investment. Overstating growth in capital in turn reduces TFP residuals. I will argue that this hypothesis can account for the particularly slow TFP growth

in East Asia between 1973-84. Numerical simulations are used to show that mismeasurements due to endogenously determined retirement rate can be quantitatively significant.

A closer examination of the findings in those growth accounting results appear to confirm this model's prediction. In the period when the rate of new investment is particularly high, the economy experiences a slowdown in TFP growth.

Hence, I will argue that the finding in growth accounting studies need to be interpreted with caution and the pessimism with regard to the technological progress in East Asian economies is perhaps unwarranted.

The model also suggests an explanation for the high TFP growth rates observed after the Second World War in some industrialised countries. Destruction of the capital stock during the war meant that capital was relatively scarce given the available land and labour. Hence the retirement rate of capital is likely to have been lower in the aftermath of the Second World War. The logic is simple; it makes economic sense not to throw out capital when it is scarce. Thus, growth accounting with a constant depreciation rate for capital would have overestimated the retirement rate for capital. Hence, the measured TFP growth rates would have been greater than the actual extent of technological progress. The data in Maddison (1988) does show that countries with large war damage experienced faster TFP growth rates immediately after the Second World War. Again this is consistent with the predictions of the model, assuming that the actual rate of technological progress has been stable. Therefore, the model also provides an explanation for the high TFP growth for industrialised economies after the Second World War.

1.4 Open regionalism

It is widely accepted that free trade policy helps economies grow faster and improves the welfare of the economies. Although numerous studies have shown various theoretical possibilities by which economies may gain from protection, few mainstream economists would attempt to justify a long-run protectionist policy in practice.

In recent years, a growing number of regional trade blocs have emerged despite the well-known problems associated with regionalism. Although regional trade agreements liberalise trade within each region, there are concerns that the formation of a trade bloc may worsen

the welfare of non-members. Also, once such trade blocs are formed, the member countries may become reluctant to take further part in the process of multilateral trade liberalization. To avoid these potential problems, the idea of open regionalism has been suggested. The term "open regionalism" refers to a number of non-discriminatory arrangements which a trade bloc could adopt with regard to trade with non-members. In this study, I will focus on a trading arrangement in which the members of a trade bloc extend the trade liberalization measures agreed within the bloc to non-member countries on an MFN basis with or without reciprocal liberalization on part of the non-members.

In the literature, it is usually thought that unconditional MFN is not motivated by the member countries' self-interest but rather the countries in the bloc are making concessions for the wider good. This study shows that this is not always the case. It is shown that some members countries of the bloc may gain more from the policy of open regionalism than from other forms of regional agreements or global free trade.

This result is due to the fact that tariffs imposed by one country to manipulate the terms of trade in its favour has the effect of benefiting other countries also. A large economy could impose tariffs to lower the international price of goods it imports taking advantage of its monopoly power. But lower prices of the targeted goods will benefit not only the economy that levies the tariffs but also all other economies that import the same goods. When a trade bloc adopts open regionalism policy, it tends to encourage non-member countries to increase their trade barriers. If the countries in the trade bloc are asymmetric, the lower international prices of some goods due to the increased tariffs of non-member countries could benefit some member countries of the trade bloc at the expense of others. In certain situations, some member countries in the bloc as well as the outside countries obtain a higher welfare level from open regionalism policy than in other forms of trading arrangements. Hence, the policy could reduce the incentives to pursue further multilateral trade liberalization even for some member countries. In another word, open regionalism policy could turn out to be a "stumbling" block to global free trade.

The analysis in this study is carried out by using numerical simulations. This is necessary as the analytical approach becomes intractable when more than two asymmetric economies are involved. The examples in this study assume that some coalitional arrangements are ruled out for political or other reasons. It is evident that political considerations are invariably involved in

the decision making concerning trade bloc formation. Therefore, although such an assumption may seem ad hoc, it seems justifiable given the political reality that exists today.

The approach of this study largely follows Riezman (1985, 1999) and Kennan and Riezman (1990). First, numerical simulations are used to obtain the welfare levels countries would achieve under different trading arrangements. To determine the equilibrium outcome, the concept of the core is used. It will be shown that when some coalitional arrangements are ruled out, a trading arrangement involving open regionalism can be in the core. Moreover, the welfare levels associated with this outcome is such that there is little incentive to pursue multilateral trade liberalization not only for the non-member countries but also for some of the member countries.

Chapter 2

Accounting for the cross-country variations in factor prices in a public-good model of technology

2.1 Introduction

Although few would argue that the level of technology is exactly the same across countries, the extent to which differences in technology can account for the observed inequality in the living standard is less clear. Since knowledge is widely available in print and other forms of media, we would expect that firms in all countries have access to broadly similar technology. Capital has become increasingly mobile, as confirmed by the relatively small variations in returns to capital. However, if knowledge and capital flow freely across borders, standard economic growth models cannot explain the large cross-country variations in per capita income.

The aim of this study is to account for cross-country differences in wages while accepting that capital is internationally mobile and technology is a global public-good. I will present a model which adds a non-traded consumption good sector to the two-sector AK model of Rebelo (1990). This model is applied for the analysis of two trading economies which share the same technology but differ in capital per worker. The model predicts that when there is large difference in capital per worker, specialisation will take place in the capital rich country.

Then the wage rate in the capital rich country will be higher while the return to capital is internationally equalised. Moreover, it is shown that inequality in wages will persist in the long run. I will also argue that the model's predictions in a number of other aspects are consistent with the available evidence.

The rest of this chapter is organised as follows. In the next section, I will discuss the problem with the neoclassical model in explaining the observed pattern of factor prices. In Section 2.3, I will present the three-sector AK model and discuss its properties. Although this model has a non-traded consumption good sector, it is essentially the same model as the AK model of Rebelo (1990). The importance of including a non-trade good sector becomes only apparent in the context of North-South which is analysed in Section 2.4. It is shown that the model can explain North-South inequality and the absence of general convergence. In Section 2.5, various implications of the model are discussed and it is shown that these are consistent with observations. In Section 2.6, the quantitative aspects of the model's predictions are examined by means of numerical simulations. This simple quantitative exercise is important in that the main criticism against the neoclassical model is its failure to explain the magnitudes observed in the data. Concluding remarks are given in the final section.

2.2 Technology and factor returns

In this section, I will briefly review the problems with the existing models in accounting for the observed pattern of factor prices. The essence of the problem is as follows. It is hard to explain why the level of technology should differ widely across countries given the non-excludable nature of knowledge. However, if we assume that the same technology is available everywhere in the world, the predictions of the standard models for factor prices will be inconsistent with observations.

The basic neoclassical model

As we discussed in Chapter 1, it is hard to explain why the level of technology should differ widely across countries. Therefore, the neoclassical model assumes that the same technology is available to all countries.

The problem with the predictions of the neoclassical growth model can be illustrated with

a model of the form:

$$y = Ak^{\alpha}, \tag{2.1}$$

where y and k denote income per worker and capital per worker respectively. The parameter A is often referred to as the "technological level" of the economy. It is clear that if the same technology is available everywhere in the world, cross-country variations in per capita income must be due to differences in the amount of per capita capital. However, if poor countries are poor because they have less capital, a simple calculation shows that the marginal product of capital in poorer countries would be vastly larger than in rich countries. Suppose that per capita income in rich countries is ten times larger than that in poor countries. If we take the factor share of capital to be $\alpha = 1/3$, the model implies that the marginal product of capital in poor countries would be one hundred times larger than in rich countries. Clearly, this is not the case. On the contrary, the observed variations in returns to physical capital are relatively small.

The neoclassical model with human capital

A neoclassical approach to remedy the problem with the predictions of the basic model is to include a third factor of production, human capital.[1] Throughout this study, the term "human capital" is used to represent the skill and knowledge embodied in workers as opposed to the general knowledge the society accumulates.

There are two ways of incorporating human capital into the model. The first is to assume that human capital augments labour and assumes a production function of the form $Y = AK_i^{\alpha}(L_iH_i)^{1-\alpha}$ where H_i is the human capital per unit of labour. The combined unit (L_iH_i) is sometimes referred to as the effective labour. The second approach is to treat workers with human capital as a different factor of production from workers without human capital. With this approach, workers without human capital are usually referred to as unskilled workers and workers with human capital are called skilled workers. In this case, the production function can be written as $Y = AK_i^{\alpha}H_i^{\beta}L_i^{1-\alpha-\beta}$ where L represents the number of unskilled workers and H the number of skilled workers. The differences in these two approaches are merely a matter of definition but it needs to be made clear which approach is taken.

[1] Mankiw, Romer and Weil (1992) and Barro, Mankiw and Sala-i-Martin (1994).

Suppose that we take the first approach and assume that the cross-country variations in wages are due to the differences in the average human capital embodied in workers, which also affect equilibrium per capita capital. Lucas (1990) uses the estimates of human capital stock from Krueger (1968) to show that including human capital considerably reduces the difference in the marginal product of capital implied by the model even though a large difference still remains.[2] However, this explanation is rather problematic. Lucas points out that if including human capital eliminated the difference in the marginal product of capital completely, this would lead to another prediction which is empirically unsustainable. Suppose that the return to capital is internationally equalised. Then the constant-returns-to-scale technology implies that the return to effective labour must also be the same across countries. This would mean that workers with the same skill level would earn the same wages whether they are in rich countries or in poor countries. This appears to be contrary to observations.

The same problem can be seen in the context of the model using the second approach. Suppose that there are two type of workers, skilled and unskilled. In a comment to Mankiw (1995), Romer (1995) considers the implication of the model with the following ratios which approximate the observed relative factor returns. Consider two countries, the rich and the poor. Capital is assumed to be mobile between the two countries and therefore the returns to capital are the same. Skilled workers earn twice as much as unskilled workers in the rich country. The wage for unskilled workers in the rich country is ten times that of unskilled workers in the poor country. If we take $\alpha = \beta = 1/3$, then the one-sector neoclassical model together with these ratios imply that the ratio of the skilled wage to the unskilled wage in the poor country would be an implausibly large two hundred. If this were the case, skilled workers in the rich country would earn ten times more by moving to the poor country. One would therefore expect skilled workers to migrate from richer countries to poorer countries in large numbers.[3] Again, this is not the case. Hence, including human capital creates another set of problems for the neoclassical model in explaining the observed cross-country variations in factor prices.

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[2] According to Lucas' calculations, the model without human capital predicts that the marginal product of capital in India should be 58 times of that in the United States. Including human capital reduces the ratio of predicted return to 5.

[3] It is not difficult to think of an economic reasons for the skilled workers wanting to stay in a rich country even if there are opportunities to earn higher wages in a poor country. For example, if the government of the country provides non-rival public goods, then the government of a rich country can provide more public goods to its residents than a poor country's government for given a tax rate.

If we abandon the public-good assumption for technology and allow the technological level to differ across countries, the predictions of the factor prices can easily be made consistent with the observed pattern. The problem with this approach is that it is difficult to explain why there should be such large differences in technological levels. Some authors have applied endogenous growth models to justify the argument. The key idea in these models is the existence of excludable designs or blueprints. As I have discussed in Chapter 1, however, these models do not solve the problem. Factor price equalisation applies in these endogenous growth models also.

A variant of the AK model presented in this study shows that North-South inequality could result from differences in the capital stock and the observed pattern of the factor prices can be explained without assuming differences in technology. I will first present the closed economy model in the next section and then discuss how this model can be applied to analysis of North-South trade and growth.

2.3 The closed economy model

There are three sectors in the economy indexed by the subscript i. Sector 1 produces the non-traded consumption good and Sector 2 produces the traded consumption good. Sector 3 produces the investment good which is assumed to be tradable. The two consumption goods are produced according to a Cobb-Douglas technology:

$$Y_i = K_i^{\alpha} L_i^{1-\alpha} \quad i = 1,\ 2, \tag{2.2}$$

where K_i and L_i denote capital and labour used in producing sector i output. Although the factor shares may differ between these two sectors, it adds little to the model in this context. Therefore I have assumed that the two consumption good sectors have the same production function to simplify the analysis.

The investment good sector is assumed to have the linear production function as in the AK model:

$$Y_3 = AK_3. \tag{2.3}$$

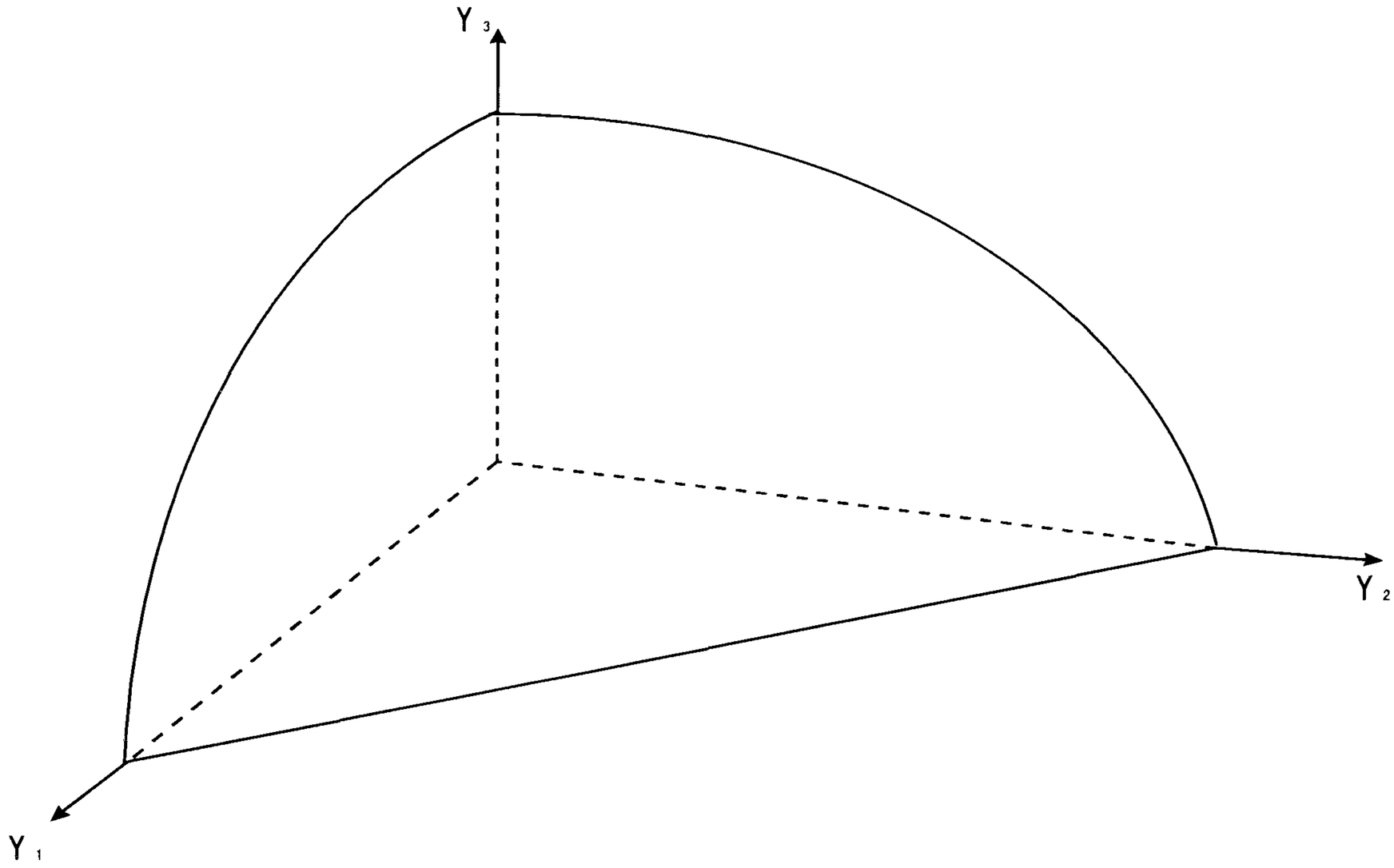

Figure 2-1: The production possibility set of the three sector model

It is important to note that production is assumed to be linear in *physical* capital. The non-diminishing returns exhibited by this production function is not due to knowledge externality as assumed in some variants of the AK model. For a given supply of labour and capital, the production possibility set in three dimensions will look like Figure 2-1. The production possibility frontier on the $Y_1 - Y_2$ plane is a straight line since I have assumed that the factor intensities of these two sector are the same.

The rest of the model follows standard growth models. The representative household in this economy aims to maximize intertemporal utility over an infinite horizon. Let $C_1(t)$ denote consumption of the non-traded consumption good and $C_2(t)$ denotes consumption of the traded consumption good. Preferences are given by

$$U = \int_0^\infty e^{-\rho t}[\phi \log C_1 + (1-\phi)\log C_2], \tag{2.4}$$

where ρ denotes the subjective discount rate and ϕ denotes the expenditure share of the non-traded consumption good. There is a market for consumption loans which allow the households

to lend and borrow freely at the instantaneous interest rate r. Let the traded consumption good be the numeraire and denote the price of the non-traded consumption good by $p(t)$ and the price of the investment good by $q(t)$. Provided that both consumption goods are being produced as it will be the case in the closed economy, $p(t) = 1$. Each household is endowed with one unit of labour. The budget constraint for the representative household is given by

$$\int_0^\infty e^{-R(t)}[C_1(t)p(t) + C_2(t)]\ dt \leq \int_0^\infty e^{-R(t)}w(t)\ dt + W, \tag{2.5}$$

where $R(t) = \int_0^t r(\tau)\ d\tau$ and W denotes the assets the household holds at time 0.

The total stock of capital in the economy is denoted by $K(t)$. Capital is assumed to depreciate at a constant rate δ. The accumulation of capital is described by

$$\dot{K}(t) = I(t) - \delta K(t), \tag{2.6}$$

where $I(t)$ denotes investment. Let $\bar{L}$ denote the number of household which is assumed to be fixed. Then resource constraints for the factors of production are given by

$$L_1 + L_2 - \bar{L} = 0, \tag{2.7}$$

$$K_1 + K_2 + K_3 - K(t) = 0. \tag{2.8}$$

Finally, the market clearing conditions for output are given by

$$C_1 - Y_1 = 0, \tag{2.9}$$

$$C_2 - Y_2 = 0, \tag{2.10}$$

$$I - Y_3 = 0. \tag{2.11}$$

Equilibrium path

Maximization of (2.4) subject to the budget constraint gives the growth rates of consumption:

$$\frac{\dot{C}_1}{C_1} = \frac{\dot{C}_2}{C_2} = r - \rho. \tag{2.12}$$

The no-arbitrage condition is given by

$$A + \frac{\dot{q}(t)}{q(t)} - \delta = r(t), \tag{2.13}$$

where $q(t)$ denote the price of investment goods. Let π denote the rate of decrease in the price of investment goods; $\dot{q}/q = -\pi$. Combining (2.12) and (2.13), the growth of consumption per household can be obtained:

$$\frac{\dot{C}_1}{C_1} = \frac{\dot{C}_2}{C_2} = A - (\pi + \rho + \delta). \tag{2.14}$$

Factor markets are assumed to be competitive and capital is mobile between sectors. Hence the marginal product of capital is equalised across sectors:

$$q(t)A = \alpha K_i^{\alpha-1} L_i^{1-\alpha} \quad i = 1,\ 2. \tag{2.15}$$

From these equations, the following can be obtained:

$$\pi = (1-\alpha)(A - \rho - \delta), \tag{2.16}$$

$$g_K = (A - \rho - \delta), \tag{2.17}$$

$$\frac{\dot{C}_i}{C_i} = \alpha(A - \rho - \delta). \tag{2.18}$$

It is noted that these growth rates do not depend on the capital to labour ratio. As pointed out by Rebelo (1991), the model has no transitional dynamics.

The fact that there is no transitional dynamics simplifies the analysis of the effects of international trade. Since all variables are growing at a constant rate, the "snapshot" of the economy will look the same at all point in time (except in sizes). Therefore, we can treat the model as if it is a static model.

Before examining the consequences of the North-South trade, it is worth considering the patten of factor prices the model predicts when economies are closed. Suppose no trade takes place between economies and consider the differences between the capital-rich North and the capital-poor South.

The first point to note is that the share of capital allocated to each sector is constant in this

model. It follows from growth rate of capital given in (2.17) that the share of capital allocated to the investment good sector is $(1 - \rho/A)$. This means that an economy with a larger amount of capital per worker will always have greater capital per worker employed in the consumption good sectors. It is easy to deduce therefore that the wage rate will be higher in the North, where there is more capital per worker, than in the South. As the price of capital falls at the same rate, $(1 - \alpha)(A - \rho)$, the interest rate will be the same in both economies. Income and consumption per household also increase with the amount of the capital stock. Thus, if we assume that the economies are closed, the predictions of the model are consistent with the fact that there are large cross-country variations in income and wages while the variations in interest rates are small.

It is clear, however, that we observe North-South inequality in reality while trade takes place between the rich and poor countries. In the next section therefore I will apply this three sector model to analysis of North-South trade.

2.4 International trade and North-South inequality in wages

To examine the pattern of factor prices when North-South trade takes place, the model needs to be modified to accommodate the fact that trade is now possible. The subscripts N and S are used to indicate the economies, the North and the South respectively. The market clearing conditions for the two traded goods, i.e. (2.10) and (2.11) in the closed economy model, are replaced by

$$C_{2N} + C_{2S} - Y_{2N} - Y_{2S} = 0, \tag{2.19}$$

and

$$I_N + I_S - Y_{3N} - Y_{3S} = 0. \tag{2.20}$$

The rest of the economy is essentially the same as the closed economy model.

Changes brought about by North-South trade are most easily illustrated with the use of diagrams. For the purpose of analysis in this section, it is useful to examine the $Y_1 - Y_2$ plane of the production possibility set in (2-1). The production possibility frontier for the two consumption good sectors for a given level of output in the investment good sector can be drawn

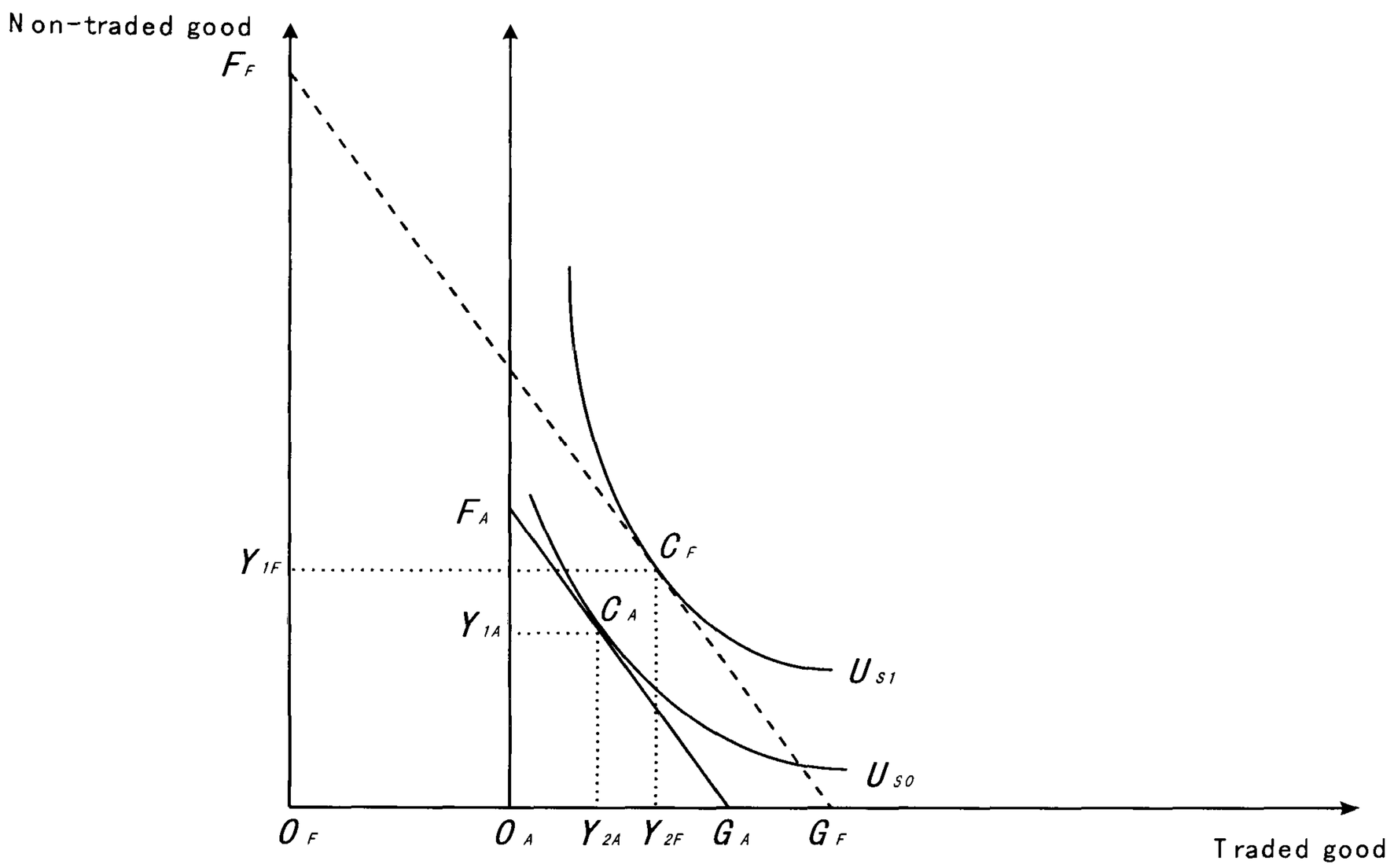

Figure 2-2: The effect of trade in the South

on this plane.

Suppose that the economies are initially in autarky. The North has a larger amount of capital per worker. Thus, the autarky price of the investment good is lower in the North than in the South. When trade opportunities open up, the North exports the investment good and imports the traded consumption good. The effects of trade can be shown in Figure 2-2, Figure 2-3 and Figure 2-4.

No specialisation case

Figure 2-2 and Figure 2-3 shows the case when no specialisation takes place in either economy.

The changes in production and consumption in the South is shown in Figure 2-2. The traded consumption good is represented on the horizontal axis and the non-traded good on the vertical axis. Consumption is measured from the point O_A, and hence the indifference curves U_0 and U_1 have the origin at O_A. The origin of the production possibility set is at O_A in autarky but moves to O_F when trade is allowed. The production possibility set in autarky is the triangle $O_A D_A E_A$. When trade is opened up, the production possibility set expands to $O_F D_F E_F$. This

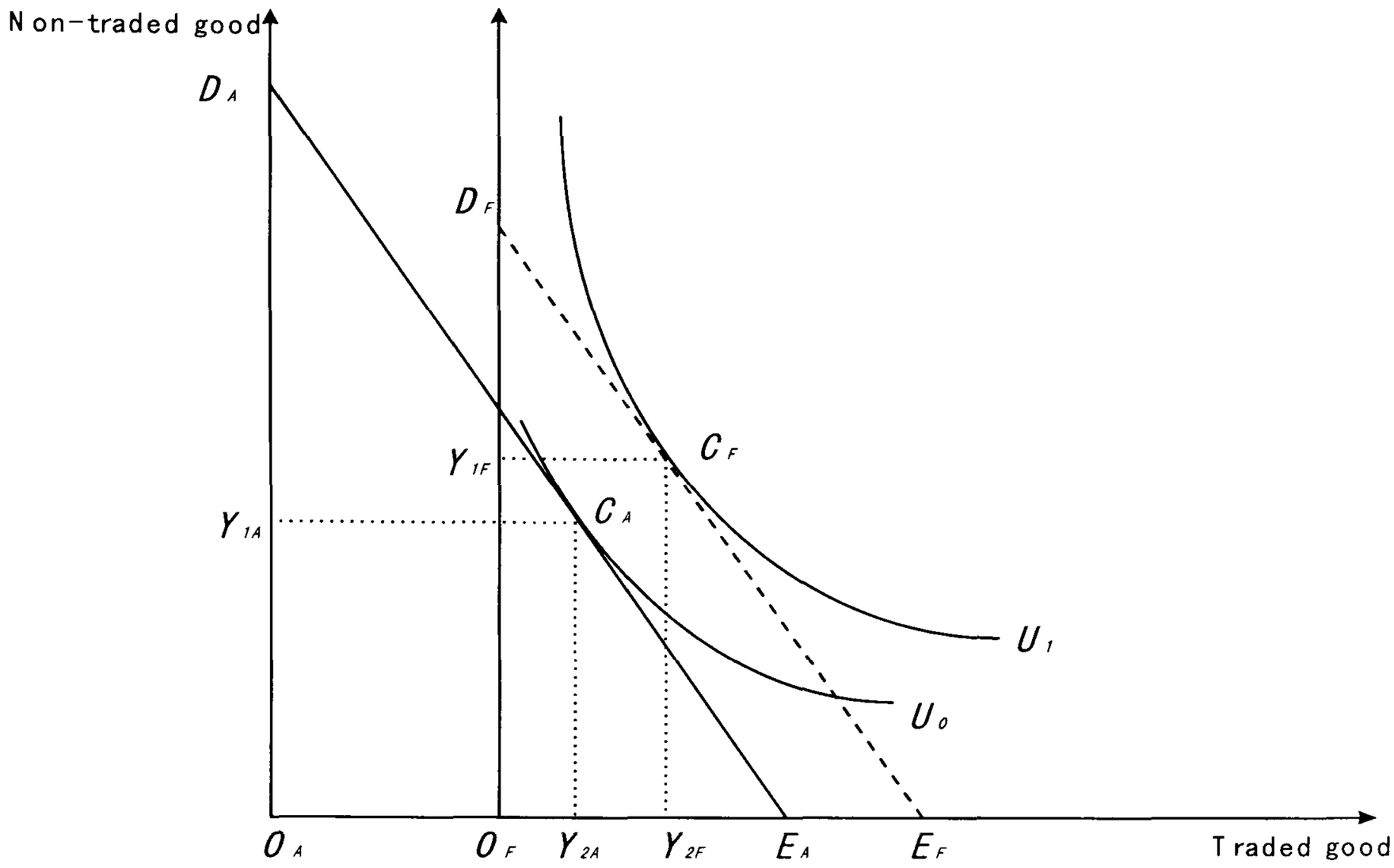

Figure 2-3: The effect of trade in the North without specialisation

change is due to the fact that the investment good sector in the South contracts when trade with the North is opened up. Hence capital shifts from the investment good sector to the two consumption good sectors expanding the production possibility set. As a result, production of the non-traded good increases from O_AY_{1A} to O_FY_{1F} and production of traded goods increases from O_AY_{2A} to O_FY_{2F}. Although the quantity equal to the length O_FO_A is exported to the North, both of these goods are consumed more at the new equilibrium C_F than in autarky.

Figure 2-3 shows the changes in the North as a result of opening up of trade. The production possibility set in autarky is represented by the triangle $O_AF_AG_A$. The autarky equilibrium is at the point C_A . Note that the relative price of the two consumption goods is equal to the slope of the production possibility frontier on the $Y_1 - Y_2$ plane. The relative price will be the same in both economies as long as both sectors produce positive output.

Both production and consumption of the traded consumption good are represented by the length O_AY_{2A} and for the non-traded good by O_AY_{1A}. This consumption set at C_A gives the utility level of U_0. When the opportunity to trade with the South opens up, the investment

good sector expands reducing the production possibility set to the triangle $O_F F_F G_F$. The new equilibrium is represented by the point C_F. Production of the non-traded good increase to $O_F Y_{1F}$. Although production of the traded consumption good decreases to $O_F Y_{2F}$, its consumption increases to $O_N Y_{2F}$ due to the import from the South.

In this case with no specialisation in either economy, all good and factor prices are equalised. This example does not help explain the observed pattern of factor prices. However, a more interesting case is when the North specialises and ceases production of the non-traded good.

Specialisation in the North

When differences in capital per worker is very large in autarky, it is possible that specialisation takes place in the North alone or both in the North and in the South when trade is opened up. Specialisation in the South means that the investment goods sector shuts down. In this case, the return to capital would be higher in the South and hence it can only be temporary. Numerical simulations indicate that specialisation in the South is very unlikely. Therefore I will only consider the case of specialisation in the North where the traded consumption good sector shuts down.

When the difference is sufficiently large, the North will cease production of the traded consumption good. This is illustrated in Figure 2-4. It is evident that the slope tangent to the indifference curve at the point C_F in Figure 2-4 is less steep than the production possibility frontier. In the South, the relative price of the two consumption goods are still equal to the slope of the production possibility frontier. Therefore it follows that the price of the non-traded good measured in units of the traded good is higher in the North.

Thus, I have demonstrated that the price of the non-traded good is higher in the North when specialisation takes place. If the price of the non-traded good is higher in the North, it follows that the wage rate in the North will be also be higher. This result can formally be stated as follows.

Proposition 1 *Suppose that trade takes place and the capital-rich economy specialises and stops production of the traded consumption good. Then the real wage in the capital-rich economy will be higher than in the capital-poor economy.*

Proof

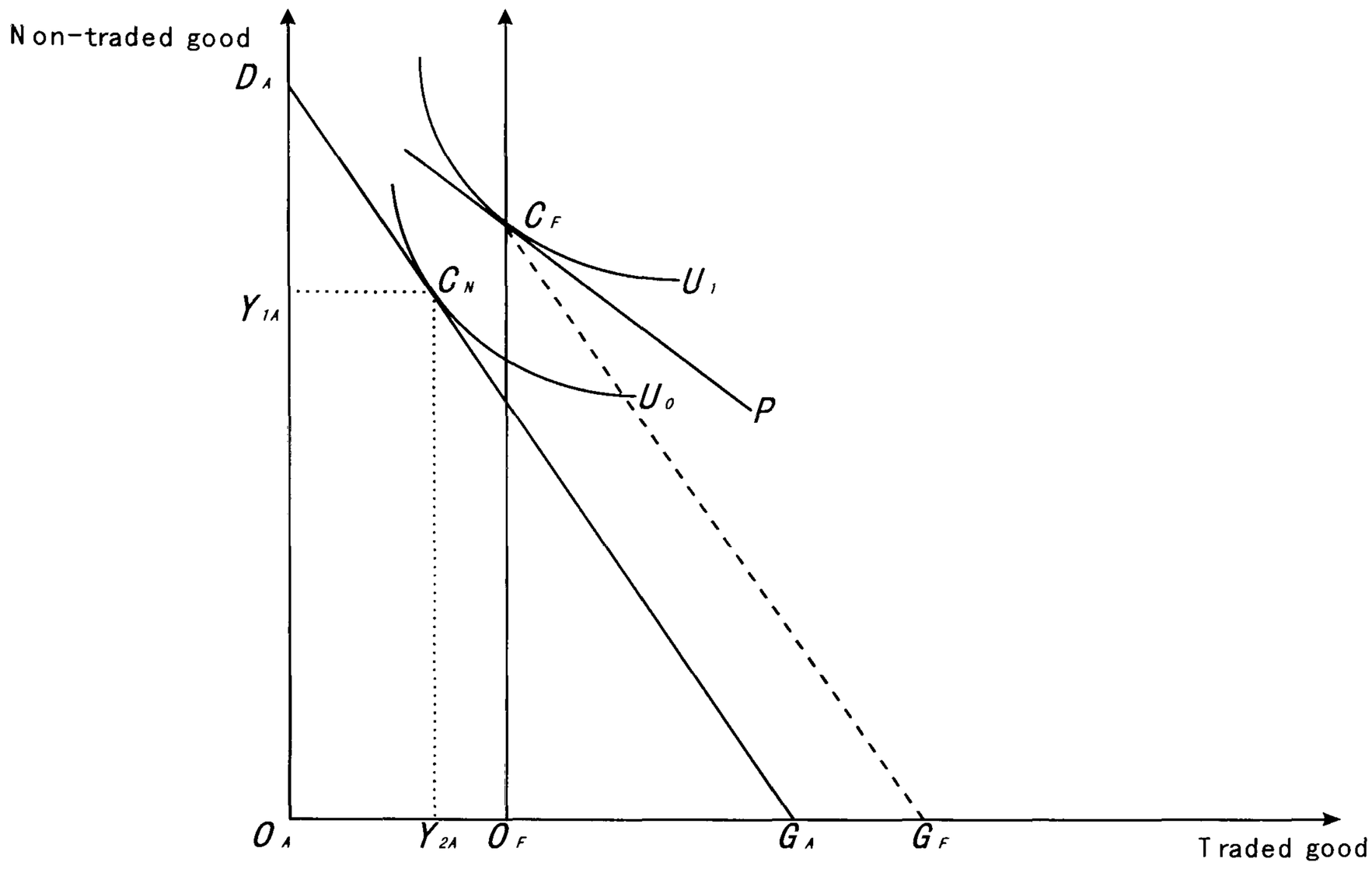

Figure 2-4: The effect of trade in the North with specialisation

Let w_j denote the wage measured in units of the traded consumption good. The traded good is used as the numeraire. Thus, in order to show that the real wage is higher in the North, it would be sufficient to show that $w_N > w_S$ and $w_N/p_N = w_S/p_S$.

The rental price capital is equal to $q(t)A$. Since trade equalises the price of the investment good, the rental price must be equal in both economies. Then, it must be that specialisation in the North is due to its higher wage rate. If this were not the case, the cost of producing the traded goods would be the same in the North and specialisation would not take place. It therefore follows that

$$w_N > w_S. \tag{2.21}$$

The variation in the price of the non-traded good can be written as

$$\frac{dp_1}{p_1} = \alpha\frac{dr}{r} + (1-\alpha)\frac{dw}{w}. \tag{2.22}$$

Since the rental price of capital is the same in both economies, the higher wage rate in the North

implies that the price of the non-traded goods must be higher in the North. Furthermore, the proportional difference in the output price is smaller than the proportional difference in wages. It follows therefore that

$$\frac{w_N}{p_N} \geq \frac{w_S}{p_S}. \tag{2.23}$$

Thus, the real wage is lower in the South. Q.E.D.

Hence the predictions of the model are that the return to capital is internationally equalised while the wage rate is higher in the North. These predictions are consistent with the observed pattern of factor prices. As we will see later, numerical simulations show that adding skilled labour as a third factor production changes this pattern of prices little. Thus, we have a model that can account for the observed cross-country variations in factor prices without assuming differences in technology.

2.5 Other predictions of the model

The three sector AK model presented in the last section has a number of predictions other than those of factor prices that are consistent with observations. These are the price of non-traded goods, the falling price of investment goods and the absence of general convergence. In this section, I will discuss these predictions in turn.

The price of non-traded goods

As we have seen in the last section, the model predicts the price of the non-traded good to be lower in the South than in the North. It is a well recognised fact that non-traded goods tend to be more expensive in richer countries. In the literature, there are two strands of theories that account for the lower prices of non-traded goods in poorer countries. One of them relies on international differences in technology.[4] The idea is that the traded good sector in richer countries has a higher level of productivity while there are little differences in the productivity of the non-traded good sector. Such differences in productivity will result in a higher price of the non-traded good (measured relative to the traded goods) in richer countries.

Bhagwati (1984) formalises this idea in a general equilibrium framework and show that this

[4] Balassa (1964), Samuelson (1964).

explanation has two unrealistic implications. One of them is that the wage-rental ratio will be equal across countries. The wage-rental ratio is clearly higher in richer countries. Second, capital to labour ratios are equal across countries within each activity. Bhagwati therefore presents an alternative model which explains the lower price of non-traded goods in terms of factor endowments. Like the model presented in this study, it relies on the fact that specialisation takes place so that factor price equalisation no longer holds. The difficulty with the Bhagwati's model is that it would predict implausibly large returns to capital in low-income countries just as in the single sector neoclassical model discussed earlier.

The model presented in this study retains the spirit of Bhagwati's model and at the same time reconciles its predictions with the observed pattern of factor prices by assuming the AK structure for the investment good sector.

Falling price of the investment good.

Although assuming the AK structure seems *ad hoc* at first, the evidence on the relative price of investment goods is consistent with this model. The model predicts that the price of the investment good measured in units of the consumption good falls over time. Greenwood, Hercowitz and Krusell (1997) and Hercowitz (1988) use the data on the price of capital goods compiled by Gordon (1990) to show that the price of investment goods in the U.S. has indeed fallen over time.

The authors of these studies attribute the falling price of the investment good to the technological progress specific to the investment good sector. Their findings, however, are entirely consistent with the variant of the AK model presented in this study. In fact, the vintage model of Solow (1959) on the balanced growth path behaves in the exactly the same as the two-sector AK model of Rebelo (1991).

The falling price of the investment good has another implication. Jones (1994) finds that the share of investment in GDP has grown over the years in industrialised countries while the growth rate has remained stable. Jones cites this finding as evidence against the AK model. However, this is exactly what the two-sector AK model of Rebelo (1991) and its variant in this study predicts. According to these models, investment measured in *real* terms grows faster than output. Therefore the finding in Jones (1994) that investment shares in developed countries are showing an upward trend is consistent with the prediction of the model.

Convergence

One of the problems with the predictions of the neoclassical growth model is the absence of general convergence. Although growth in a small subset of low-income countries such as those of East Asia have outperformed high-income countries, this is not generally the case. The model presented in this study could explain this observed pattern of growth rates.

In the two-sector AK model and its variant presented in this study, the growth rate does not depend on income per capita and economies grow at a constant rate. Hence we do not expect convergence to take place in general.

At the same time, the model can explain why a small subset of low income countries do succeed in achieving much faster growth rates than in rich countries. Let Z_A denote output of the South in autarky and Z_F denote output when trade is allowed. National output in this model is defined as $Z = Y_1 + Y_2 + qY_3$. Suppose that the South is initially in autarky and opens up for trade at time t_0. The growth in the South before and after time t_0 is depicted in Figure 2-5. At time t_0, the equilibrium price of the investment good falls and output of the investment good sector falls as a result. Capital shifts from the investment good sector to the consumption good sectors. Since capital can be reallocated from one sector to another instantaneously, output "jumps" to the new level. The economy resumes expansion at the balanced growth rate as before but at a higher level.

In reality, reallocation of capital from one sector to another is likely to take time if possible at all. It is conceivable that new equilibrium allocation of capital is reached largely through new investment. Hence the economy is likely to have a transitional phase to a new balanced growth path rather than an instantaneous "jump". In such a transitional phase, the return to capital will in fact be higher in the South. In any case, it is clear that opportunities to import the investment good from high-income countries could allow faster growth rate in low income countries. The potential for faster growth is determined by the length equal to $Z_F - Z_A$ in Figure 2-5. It is easy to see that this length is in turn determined by the equilibrium terms-of-trade between the North and the South. If the terms-of-trade is closer to the autarky price of the North, the new equilibrium income level of the South will be closer to that of the North. On the other hand, if the South levies tax on capital good imports, the potential for catching-up will be smaller.

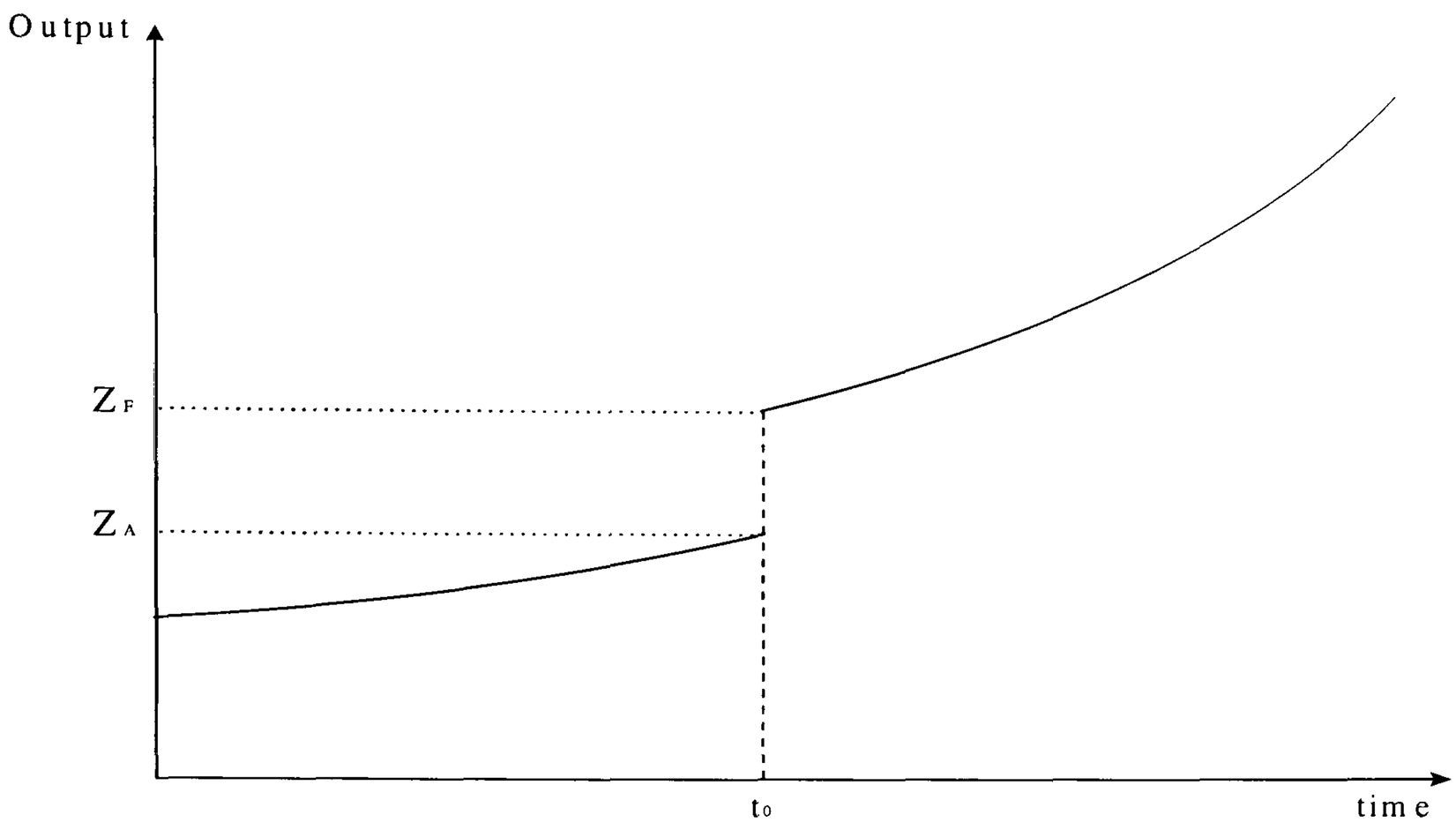

Figure 2-5: The effect of trade on growth in the South

Thus, the model predicts that convergence does not take place in general. However, less developed countries which open up for trade with richer countries will experience faster growth provided that the equilibrium terms-of-trade favours them.

We note from the analysis in the previous section that countries with a higher savings rate grow faster. Encouraging imports of capital goods from developed countries and having high savings rates are the hallmarks of the East Asian growth experience. It is no surprise therefore that East Asian economies have been successful.

Using a slightly modified AK model, Lee (1995) argues that the economy would have a transitional dynamics. Furthermore, if tax is levied on capital good imports from the North, the growth rate of the South in this transitional phase would be slower. I will show in the appendix why this argument is incorrect and the economy has no transitional dynamics even in his modified model. However, economies with less tax on imports are likely to grow faster in response to opening up of opportunities to import capital goods from the North. Lee is correct in arguing that the model predicts a negative correlation between growth rates and tax

of capital goods imports but his reasoning is incorrect.

2.6 Numerical investigation of the model's predictions

The analysis so far has shown that it is possible to explain the observed pattern of factor prices. This explanation, however, relies on the fact that specialisation takes place in the North. It is then necessary to ask how likely it is that such specialisation takes place. Furthermore, although it can be shown that wages will be higher in the North qualitatively, would the prediction be of right magnitude? What effects including human capital in the model have? In this section, I will examine these are the quantitative aspect of the three-sector AK model of North-South trade using numerical simulations.

Numerical simulations are carried out with an artificial set of numbers. The two-economy model is highly stylised and the aim here is not to reproduce the world economy accurately. These numerical examples are used to assess the magnitude of the predictions of the model using a set of reasonable parameter values.

The importance of this numerical exercise is in the fact that the main criticism against the public-good model of technology is that it predicts an implausible patten of factor prices. In a comment on Mankiw (1995), Romer uses the following approximate ratios of factor returns to point out that the neoclassical growth model is empirically unsustainable:

- The wage of unskilled workers in the poorest countries is one-tenth of the wage of unskilled workers in the United States.
- The ratio of the wage of skilled workers to that of unskilled workers is two in the United States.
- The rates of return on physical capital are internationally the same.

Given these ratios, the one-sector neoclassical model, $Y = AK_i^{1/3}H_i^{1/3}L_i^{1/3}$, predicts that the wage of a skilled worker is two hundred times the wage of an unskilled worker in the poorest countries. The return to education is larger in the poorest countries than in the United States by a factor of one hundred. This is so wide of the mark that it does put the usefulness of the neoclassical model into question.

Romer suggests that the return to education in the poorest countries is two or three times the return in the United States. Therefore, if we take the unskilled wages in the poorest countries to be one, then the ratio of wages would be

	Unskilled wage	Skilled wage
United States	10	20
Poorest Country	1	3 or 4

.

The aim of the simulations is to examine whether the AK model discussed in this study could predict wage inequalities of a similar order. We need to note first that the three-sector AK model is a two-economy of trade in which the terms of trade is determined endogenously. Thus, when we apply the model for the analysis of North-South inequality, a correct interpretation would, for example, be that the North is the OECD countries put together and the South is the rest of the world. The ratios of wages suggested by Romer is for the United States and the poorest countries. If we compare the average wages in the OECD countries with those of the rest of world, we expect that the order of inequality would be less but the pattern of inequality is likely to be the same.

The fact that the model has no transitional dynamics simplifies the experiment considerably. All real variables grow at a constant rate and the ratio of wages do not change over time. Hence, the experiments can be carried out in a static setting.[5]

The following changes are made to the model to include skilled labour. The production function in (2.2) are replaced by

$$Y_i = K_i^{\zeta} H_i^{\eta} L_i^{1-\zeta-\eta} \quad i = 1,\ 2, \tag{2.24}$$

where H_i denotes skilled labour. As before, the production functions for the two consumption good sectors are the same. The supply of both types of labour is assumed to be fixed. In addition to (2.7) and (2.8), the following resource constraint is added:

$$H_1 + H_2 - \bar{H} = 0, \tag{2.25}$$

where $\bar{H}$ denotes the fixed supply of skilled labour.

[5] Demand for investment is such that it results in capital growing at the equilibrium rate.

In order to determine the parameter values in the model, I will make the following further assumptions. The factor shares in the aggregate income are one third each for unskilled workers, skilled workers and physical capital. The growth rate of income measured in units of the consumption goods is 1%. The subjective discount rate (plus the rate of physical depreciation of capital) is 0.05. The share of investment in national income is 1/6. The share of consumption of traded goods and consumption of non-traded goods in national income are 1/6 and 2/3 respectively.[6] These assumptions imply that $A = 0.1$ and the factor shares in the consumption goods sectors are $\zeta = 0.2$ and $\eta = 0.4$.

The supplies of the factors are assumed to be as follows;

	Unskilled Workers	Skilled Workers	Physical Capital
North	4	2	60
South	45	15	60

.

The South has 10 times as many workers as the North. The ratio of skilled to unskilled workers is 1:2 in the North and 1:3 in the South. Capital per worker in the North is 10 times as large as the South. Given this pattern of endowments, the North will specialise in production of the non-traded consumption good and the investment good. The equilibrium ratios of the wages are as follows:

	Unskilled wage	Skilled wage
North	4.5	9.0
South	1	3

.

Hence, the model does produce a pattern of factor prices in which both skilled and unskilled workers are paid more in the North.[7] The ratio of unskilled and skilled wages exactly reflect the ratios of the two types of labour supplies. Given that skilled workers earn three times as much in the North as in the South, the model predicts the net-flow of skilled workers to be from the South to the North and therefore it is consistent with observations. Although the model is a highly stylised one, this example demonstrates that the observed pattern of factor prices can be reproduced without assuming differences in technology.

---

[6] Admittedly, these numbers are more representative of industrialised countries than those of developing countries. However, the same set of parameters are used for both economies in order to assess the effect of differences in capital per worker.

[7] The structure of the model ensures that the return to capital is equalised.

We can use the simulation above as the benchmark and vary some of the parameters to investigate the implications of these changes for the predicted inequality.

A. Difference in the per capita endowment of capital.

Suppose the parameters of the model are as in the previous example but factor supplies are different. The numbers of skilled and unskilled workers are the same as before but the residents in the North are assumed to own twenty times more capital worker rather than ten times in the benchmark simulation. In this case, the ratio of the wage are as follows:

	Unskilled wage	Skilled wage
North	6.9	13.8
South	1.0	3.0

.

As expected, the North-South wage inequality increases. Note that the wages in this case differ from the benchmark case by relatively a small amount considering that capital per worker is doubled. The actual capital stock is hard to estimate, especially in developing countries. But the results here suggest that the predictions of the model are not too sensitive to the amount of capital stock.

B. Different factor intensities between sectors.

If we replace the production functions of the two consumption goods sectors with a more capital intensive one so that the factor shares are one third each for unskilled workers, skilled workers and capital (i.e. $\eta = \zeta = 1/3$), this also has the effect of increasing the wages in the North;

	Unskilled wage	Skilled wage
North	5.3	10.6
South	1.0	3.0

.

C. Less expenditure on the traded goods.

Suppose that the expenditure shares in aggregate consumption are such that one tenth (rather than one fifth in the benchmark above) is spent on traded goods. This again increases equilibrium wages in the North. Perhaps, this is not surprising. If the expenditure share of the traded goods shrinks, an open economy becomes more like a closed one;

	Unskilled wage	Skilled wage
North	6.8	13.5
South	1.0	3.0

.

These experiments are carried out simply to assess the properties of the model and the numbers used are completely artificial. However, it is evidently possible to replicate the pattern of factor prices mentioned in Romer (1995).

The predictions of the one-sector neoclassical model for factor prices are clearly at odds with observations. This inconsistency has been used as an argument against assuming that the same technology is available in all countries. However, the three-sector model presented in this study show that is entirely possible to explain the observed pattern of factor prices without introducing large cross-country differences in technology into the model.

2.7 Concluding remarks

This study is motivated by the unsatisfactory nature of using differences technology for explaining cross-country variations in factor prices. The level of technology is not an observable quantity. If we were to argue that the availability of technology is the problem, we would need to explain why it is so difficult for less developed economies to adopt better technology. In the absence of such explanations, the approach taken in this study and explanations based on inefficiency of factor allocation as suggested in Olson (1996) seem to be more promising.

One difficulty in this debate is that it is often hard to distinguish changes due to capital accumulation from those due to technological progress. The suitability of technology may depend on the income level of the country. For example, a certain marketing strategy may be very effective in industrialised economies in raising the overall productivity. But if the aim is to alleviate the poverty in a less developed country, it is doubtful that marketing strategies have much relevance. It would be premature to conclude that the availability of technology is the problem from the observations that technologies and business practices are different between the rich and poor countries.

There is a general consensus in the empirical literature that the savings rate and free trade policy have positive impact on growth in less developed economies. The predictions of the three-sector AK model are consistent with these findings. Moreover, since the terms of trade is an important determinant of the income level, the model re-emphasise the importance of trade liberalization in the North for imports from the South as well as lowering trade barriers against

imports of producer durables in the South.

It would be a useful attempt to develop the model into an applied general equilibrium model. The model identifies a dynamic gain from liberalization in North-South trade. It is quite possible that such a dynamic gain is larger than suggested by studies using a static model.

The crucial assumption of the model is that production of the investment good is not subject to diminishing returns in capital. The fact that the price of capital goods relative to the price of consumption goods is falling over the years supports this hypothesis of the model. But a more direct test of this hypothesis would be a useful investigation.

It is worth noting that the AK model of Rebelo demonstrates that non-diminishing returns in the capital goods sector alone is enough to sustain long-run growth. The capital goods sector forms a relatively small part of the economy. In Brue (1993), the origin and the use of the law of diminishing returns is discussed. Brue comments that "the history of economic theory has produced an *axiomatic* acceptance of the law of diminishing returns". Empirical studies of cost functions seem to be much needed.

Unlike the two-sector model, the three-sector model has another testable implication. If the wage inequality were to be explained by the model, the traded consumption goods sector in the North would be shut. This means that products of the North are not competing with imports from the South. This appears to be consistent with observation but a detailed study on this issue is also needed.

Appendix A: The effects of tax on capital goods imports

Lee (1995) uses a variant of the two-sector AK model discussed in Rebelo (1991) to consider the effects of *ad valorem* tax on imports of capital goods. Lee's argument is correct in asserting that such tax on capital good imports has a negative effect on growth rates. However, the derivation and reasoning of the results are incorrect. The problem arises from the fact that Lee understands the model to have a transitional dynamics. However, as pointed out by Rebelo, the model has no transitional dynamics. Introduction of imperfectly substitutable capital goods does not change this property of the model.

In what follows, the notations follow those used in Lee (1995) and differ slightly from the ones I have used in this chapter so far. The model is essentially the same as the two-sector model of Rebelo (1991). The consumption goods sector is written as

$$C = (\Phi K)^{\alpha} L^{1-\alpha}, \, 0 < \alpha < 1,$$

where Φ is a faction of the capital stock employed in the consumption goods sector. The supply of labour is normalised to equal 1. Lee's model is different in that the capital goods are a composite of the domestically produced capital goods and the imported capital goods. Thus, newly produced final capital goods, I, is given by the Cob-Douglas combination of domestic and foreign capital goods:

$$I = I_D^{1-\gamma} I_M^{\gamma},$$

where I_D denotes the domestic capital goods while I_M denotes the imported capital goods. Production of the domestic capital good has the AK structure:

$$I_D = A(1 - \Phi)K,$$

where $(1 - \Phi)$ is the share of the total capital stock that is used for production of capital goods. Take the consumption goods as the numeraire and let p and p_M denote the price of the domestic and foreign capital goods respectively. The price of the foreign capital goods is given and falling at the rate $(1 - \alpha)(A - \rho)$. This is because the economy in the North is described by the two-sector AK model. Since factor markets are competitive, the following relationships

must hold:

$$\begin{aligned} pA(1-\gamma)Z^{\gamma} &= \alpha\Phi^{\alpha-1}K^{\alpha-1}, \\ p_M &= p\gamma Z^{\gamma-1}, \end{aligned}$$

where $Z = I_M/I_D$. The first of these two expressions equate the marginal product of capital in the capital goods sector and the consumption goods sector. The second is derived from the condition that the marginal product of imported capital goods is equal to its price. The expression for the interest rate can be obtained from the no-arbitrage conation $pA(1-\gamma)Z^{\gamma} + \dot{p}/p = r$. Then the growth of consumption is given by

$$\frac{\dot{c}}{c} = pA(1-\gamma)Z^{\gamma} + \frac{\dot{p}}{p} - \rho,$$

and the growth of the capital stock is

$$\frac{\dot{K}}{K} = A(1-\Phi)Z^{\gamma}.$$

From these two equation, Lee concludes that the growth rate is positively related to the share of foreign capital goods. Lee comments that "During the transitional period in which a LCD economy approaches the steady state from a low initial level of capital stock, the capital stock and per capita income rise monotonically towards their steady-state values". He also states that "Throughout the transitional period, the growth rate of income is higher in an economy with a higher ratio of imports in investment (Z)."

Both of these statements are incorrect. First, the model has no transitional dynamics. The economy is always on the balanced growth path irrespective of the capital to labour ratio. Second, the ratio of foreign to domestic capital goods is determined by the technology and does not depend of the amount of capital stock. These points can be shown as follows.

Given the demand for investment, I, the demand for domestic and foreign capital goods is given by

$$I_D = I(1-\gamma),$$

and

$$I_M = I\gamma\frac{p}{p_M}.$$

Thus, the ratio of foreign to domestic capital goods Z is given by

$$Z = \frac{p}{p_M}\frac{\gamma}{1-\gamma}.$$

Since $p_M = p\gamma Z^{\gamma-1}$, combining these two expressions gives

$$Z^{\gamma} = (1-\gamma)^{-1},$$

i.e. the ratio Z is constant. It follows that the ratio of the prices of domestic and foreign capital goods must also be constant. Lee assumes that the technology and preferences are the same in all countries. The growth rate of consumption is therefore,

$$\frac{\dot{c}}{c} = \alpha(A-\rho),$$

which is the same as the closed economy. The proportion of capital used in each sector is constant even when trade is involved (i.e Φ is constant). This can be shown as follows. The resource constraint for the consumption good is

$$Y_1 - C - p_M I_M = 0.$$

Given the expression equating marginal returns, the capital stock employed in the consumption good sector must grow at the rate $(A-\rho)$. Since Lee normalises the labour supply to one, output grows at the rate $\alpha(A-\rho)$. Given the growth rate of Y_1, C and p_M, it follows that I_M must be growing at the rate $(A-\rho)$. Since the relative demand for inputs are fixed, the demand for I_M must also be the same. This means that K_2 must also grow at the same rate as K_1 which implies that Φ is fixed.

The implication of *ad valorem tax* levied on imports of capital goods by LDC is to reduce the level of income per household but not the long-run growth rate. Lee carries out an econometric analysis in which he finds a correlation between growth rates and the share of imported capital

goods. This can be explained by the fact that tax on imported capital goods depresses the level of income. As I have discussed in this chapter, this is likely to show up as slow growth rates while "transition' takes place. But both the original model of Rebelo and the modified model of Lee predict that new equilibrium is reached instantaneously as capital is assumed be mobile between sectors.

Appendix B: Including labour in the investment good sector.

One problem with specifying the production function of the investment good sector as $Y = AK$, is that if we interpret the model literally, no labour is employed in this sector.[8] This may be seen by some as a unrealistic assumption. However, the AK formulation of the capital goods sector can be interpreted as the simplification of the following model.

Suppose that the production function for the investment good sector is linear in capital but each firm in this sector need to employ a fixed amount of labour not related to the quantity of output produced. Thus, the model has increasing returns in capital.

As before, the production functions are given by $Y_i = K_i^{\alpha} L_i^{1-\alpha}$ $i = 1, 2$ for the two consumption goods sectors and $Y_3 = AK$ for the capital goods sector. Suppose that each firm in the capital good sector needs to employ one unit of labour to produce positive output . Let m denote the number of firms producing capital goods. To simplify, I will assume that the firms are identical and produces the same amount of output, denoted by x. Then the aggregate supply of capital goods will be equal to mx. The cost function for each firm is then given by

$$C = w + \frac{Rxq}{A}, \tag{2.26}$$

$$= w + \frac{RY_3 q}{m}. \tag{2.27}$$

where R denotes the rental price and q denote the price of capital goods as before. Thus, given the demand and the price of the investment goods, the number of firms, m is determined. The amount of labour employed in the capital goods sector, denoted by L_3 is equal to m.

In the absence of tax, the average cost is equal to the price; $C/x = q$. Hence we have the following relationship:

$$q(1 - \frac{R}{A}) = \frac{w}{x}. \tag{2.28}$$

This economy grows in exactly the same way as the original model. Let n denote the growth rate of labour so that

$$\frac{\dot{L}_i}{L_i} = n, \tag{2.29}$$

[8] In Rebelo (1991), an alternative formulation is provided which assumes that K is a composite of both physical and human capital.

The growth rate of capital is then given by

$$\frac{\dot{K}_i}{K_i} = A - (\rho + \delta) + n, \tag{2.30}$$

The number of the firms in the investment good sector grows at the same rate as the growth of labour. The quantity each firm produces grows at the rate $A - \rho - \delta$. The wage grows at the rate $\alpha(A - \rho - \delta)$. It is easy to see that these growth rates will satisfy the relationship in (2.28). Therefore the balance growth rate in the original model is consistent with this modified model.

Admittedly, the micro-foundation for this specification is weak. I have simply assumed that all firms are identical. Given that technology exhibits increasing returns, this is not a trivial issue. Although a similar structure is used in the model of Salop (1979), further work is needed to provide a more sound microfoundation for this type of models.

Chapter 3

Capital Accumulation and the Total Factor Productivity Growth of East Asian Economies

3.1 Introduction

Growth experience of the East Asian economies is characterised by the rapid accumulation of capital over the past few decades prior to the financial crises in the mid-1990s. At the same time, a number of growth accounting studies have shown that total factor productivity (TFP) growth in these economies has been slower than expected. The most well-known among those are Young (1994, 1995) and Collins and Bosworth (1996). In this study, I will argue that this puzzling finding is due to mismeasurements of TFP residuals rather than actual under-performance of these economies with regard to technological progress. It is shown that two important aspects of East Asian growth, namely very high rates of investment and importing of capital goods, have both contributed to understating the measured TFP growth.

The finding in those growth accounting studies show that TFP growth rates in East Asia are modest in comparison with other countries, especially the industrialised economies. By applying the vintage models of economic growth. I will argue that two particular characteristics of East Asian economies, import of capital goods and rapid accumulation of capital, have contributed

to understating their TFP growth rates.

The vintage models differentiate capital by the date of its construction. There are two strands of the vintage models. It turns out that each of these models identifies a source of mismeasurement in standard growth accounting methodology.

The first strand of the vintage models focuses on the falling cost of capital goods relative to consumption goods.[1] This type of the vintage model was first presented in Solow (1959) and sometimes referred to as the neo-classical vintage model. The implication of this model for growth accounting is that inputs of capital should *not* be adjusted for quality improvements. However, most data sets aim to represent "real" quantities and hence are adjusted for quality changes. In this case, TFP growth residuals are not meaningful measures and it is likely that they understate the real extent of technological progress, especially in capital goods importing countries. This point is discussed in Section 3.3.

The second strand of the vintage models assumes Leontief technology. The key assumption of the model is that newer vintages of capital requires less labour for each unit of capital. The details of the model are discussed in Solow, Tobin, von Weizsäcker and Yaari (1966). The model presented in Section 3.4 is similar in spirit to this second strand of the vintage models. The model in this study assumes that substitution between labour and capital is possible but its range is limited. This model implies that growth of aggregate capital in use is constrained by the supply of labour and technology. When the rate of investment is high, a larger quantity of less productive capital is made obsolete. Hence, assuming a constant depreciation rate for capital could lead to mismeasurements in growth rates of capital. This hypothesis can account for the observed negative correlation between TFP growth rates and growth rates of capital.

In Section 3.5, numerical simulations are used to examine the quantitative aspects of the model with endogenous retirement rate of capital. The results suggest that the size of mismeasurements can be significant.

In Section 3.6, the results of growth accounting reported in Collins and Bosworth (1996) and Young (1995) are examined to see if they are consistent with the predictions of the model. A closer examination of the results of the growth accounting studies show a negative relationship between the observed TFP growth rates and the accumulation of capital.

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[1] This hypothesis is supported by empirical evidence. See Gordon (1990).

3.2 The meaning and importance of TFP residuals

The interpretations of TFP residuals

When discussing TFP residuals, it helps to be clear about the purpose of measuring TFP growth. The importance of TFP growth is in the fact that it is an indicator of the long-run growth prospect. This point can be illustrated with the following simple Cobb-Douglas production function:

$$Y(t) = A(t)K^{\alpha}L^{1-\alpha}, \tag{3.1}$$

where $Y(t)$ is output, $A(t)$ is the index of technology, K and L are inputs of capital and labour respectively. Given this production function, growth of output can be decomposed into technological improvements and growth in inputs:

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \alpha\frac{\dot{K}}{K} + (1-\alpha)\frac{\dot{L}}{L}. \tag{3.2}$$

Growth in output, capital input and labour input can be measured directly while it is not possible to quantify the rate of technological progress directly. However, the relationship in (3.2) allows the rate of technological progress to be deduced from the observable quantities. Let $\Phi(t)$ denote the TFP residual at time t. TFP residuals are defined as follows:

$$\Phi(t) = \frac{\dot{Y}}{Y} - \alpha\frac{\dot{K}}{K} - (1-\alpha)\frac{\dot{L}}{L}. \tag{3.3}$$

If the model in (3.1) is correct and the data are accurate, then the TFP residuals are equal to the rate of improvements in technology. In practice, we cannot be sure that TFP residuals are entirely due to technological progress. TFP residuals are sometimes referred to as "a measure of ignorance" for this reason. However, it seems reasonable to assume that the cause of the discrepancy between growth in output and growth in measurable inputs is likely to be technological progress in the absence of other explanations. Some authors suggest that the importance of TFP residuals is in the fact that we do not know the exact explanation for finding these residuals.[2] But this argument misses the point. By measuring TFP residuals, we are trying to quantify the technological progress taking place in the economy.

[2] The argument in Hulten (1992) seems to imply this.

This point becomes most apparent when we consider the balanced growth rate. The balanced growth path for the model in (3.1) is such that growth in income per capita is given by

$$\frac{\dot{Y}}{Y} - \frac{\dot{L}}{L} = \left(\frac{1}{1-\alpha}\right)\frac{\dot{A}}{A}. \tag{3.4}$$

The long-run growth rate in income per capita is linear in the rate of improvements in technology. Therefore, the TFP growth rate is an indicator of the economy's long-run growth prospect. If there is no technological progress, growth in per capita income eventually comes to a halt as neoclassical production functions exhibit diminishing returns in capital.

For the model like (3.1), it simple to define what mismeasurements are. If the measured TFP residuals differ from the actual growth in the parameter $A(t)$, it can be said that this is a mismeasurement. However, as we will see later, when technology is embodied in capital goods, the issue is not so straightforward. Therefore, I will rather loosely define the term "mismeasurement" to mean that TFP residuals obtained in growth accounting exercises do not reflect the economy's long-run growth prospect.

Growth accounting studies for East Asian economies

A number of growth accounting studies have shown that the TFP growth rates in East Asian economies over the past few decades have been modest. One of the early studies to examine the performance of East Asian economies' productivity growth is Young (1994). An econometric method was used to compare the TFP growth of 118 economies and examine the relative performance of the four East Asian economies (Hong Kong, Singapore, South Korea, Taiwan). The results show that even though Hong Kong has achieved one of the fastest TFP growth, the other three, especially Singapore, are much lower in the ranking.

Following on the first study, Young (1995) provides a more detailed analysis of factor accumulation and productivity growth in these four economies, and confirms that the conclusion of the earlier study. Much of the impressive growth in those East Asian economies can be attributed to the increased participation of labour, to rises in educational standards and to capital accumulation. The role technological progress has played in the growth of these economies is modest and comparable to those of OECD economies.[3]

[3] Young's estimates are 2.3% for Hong Kong, 0.2% for Singapore, 1.7% for South Korea and 2.6% for Taiwan.

More comprehensive analysis is carried out in Collins and Bosworth (1996). Their study examines seven Asian economies in detail (Indonesia, South Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand). Their findings largely confirm the results of Young. Taken as a region, TFP growth contributed only one-fourth of the per capita growth in East Asia over the past three decades. Even though East Asia has performed better than some of the other developing regions such as Africa, Middle East and Latin America, it has not done much better than the industrialised economies excluding the United States.

Many economists have argued that these economies have had opportunities to catch up with industrialised economies in terms of technology but failed to take advantage of them. Thus, they concluded that East Asian economies have been less successful in adopting advanced technology. However, the theoretical expectations for such catching-up process to take place is not as clear as they might first appear.

Theoretical expectations

Many authors have found the findings in these growth accounting studies puzzling. The underlying assumption in their argument is that there are differences in the technological level between industrialised economies and less developed East Asian economies. The increased volume of trade between these economies is likely to provide more opportunities for cross-border knowledge dissemination.[4] Even if technology is proprietary and excludable, the firms in less developed countries should be able to imitate technology developed in industrialised economies at lower costs. Another channel for technology dissemination is that trade allows less developed economies to import technology and capital goods from technologically advanced countries. Moreover, there has been large inflows of foreign direct investment into the region. It is often the case that foreign direct investment by firms based in the industrialised economies brings not only capital but also technical expertise. Hence, it is argued that technologically less advanced East Asian economies should have performed better than industrialised economies in terms of the *rate* of technological progress.

The crucial assumption is that East Asian economies were technologically less advanced at least when these economies started to grow rapidly. As I have argued in the previous chapter,

[1]For the empirical studies on knowledge dissemination, see Coe and Helpman (1995) and Coe, Helpman and Hoffmaister (1997). The validity of the findings in the former is questioned in Keller (1998).

this assumption about differences in technology is not so obvious. It is likely that there are some differences in the level of technology even today, the scale of such differences many not be as wide as implied by these authors. If broadly similar technologies are available to all countries in the first place, then there is less room for catching-up in total factor productivity to take place.

However, in the case of East Asian economies, we should expect a faster TFP growth for the following reason. It is apparent that part of technological progress is due to improvements in the quality of investment goods. This idea is known as the embodiment hypothesis. When this is the case, rapid accumulation of capital should result in greater TFP residuals. However, growth accounting studies show that contrary to such expectations, TFP growth is slower when the rate of investment is high. Thus, although there are questions over the argument based on "catching-up process", the results of these growth accounting studies do present a puzzle all the same.

It is worth considering why many authors have assumed that there is a large room for catching-up process to take place. One of the reasons is that the methods of production used in developed economies and less developed economies are clearly different. As I have discussed in Chapter 1, however, it does not necessarily follow that technology is much inferior in less developed countries.

Another reason for expecting faster TFP growth in East Asia seems to be that there is a historical precedence for apparent "catching-up" taking place. Maddison (1987) reports the TFP growth rates of six industrialised economies for the post-war period. Among those economies, the TFP growth rates of four economies (France, Germany, Japan and the Netherlands) for the period 1950-73 were clearly higher than those of the United Stats and the United Kingdom. Maddison concludes that one of the reasons for this gap is that the process of catching-up took place.

The model examined in this study questions this conclusion. It will be shown that the vintage model can potentially explain both modest TFP growth in East Asia and the apparent catching-up process in industrialised economies after the Second World War in terms of mismeasurements.

3.3 The vintage model and quality adjustments for capital

In recent years, the difficulty of adjusting output for quality improvements has been highlighted, especially in relation to the rapid progress made in information technology. If the aim of constructing the data is to measure growth in real GDP, for example, then it is natural to adjust output to take quality improvements into account. However, if the aim is to measure TFP growth and hence long-run growth prospect, the data for capital goods should *not* be adjusted for quality improvements. Using adjusted data for measuring TFP residuals is likely to result in understating technological progress especially in capital goods importing economies.

Consider the standard vintage model discussed in Solow (1959). Most data sets for output attempt to measure the change in real terms. Hence, the quantities are adjusted to allow for quality improvements. Some authors such as Hulten (1992) argue that the measurement of the capital goods as well as consumption goods should be adjusted for improvements in quality. The reason for making the adjusting is that "the failure to adjust capital for quality change when such change is actually occurring has the effect of suppressing the quality effects into the conventional total-factor-productivity residual". The point seems to be that it is undesirable to include the effects of what we know (quality improvements in capital goods) in TFP residuals. This reasoning misses the point of measuring TFP residuals discussed earlier. The importance of TFP growth is that it is an indicator of the economy's growth prospect.

To illustrate the point, consider the vintage model of Solow (1959):

$$Y(t) = A(t)J(t)^{\alpha}L(t)^{1-\alpha}, \tag{3.5}$$

where $Y(t)$ is output, $A(t)$ is the index for disembodied form of technology, $J(t)$ is effective capital and $L(t)$ is input of labour. Assume that the economy is closed. Output is used for either consumption (C) or investment (I) so that $Y = I + C$. Effective capital is given by the sum of past investment taking quality improvements in capital goods into account:

$$J(t) = \int_{-\infty}^{t} B_i I_i e^{-\delta(t-i)}\, di, \tag{3.6}$$

where $B(i)$ is the index of technology embodied in capital goods and δ denotes the constant rate

of physical depreciation. Note that output, Y, does not take quality improvements in newly produced capital goods.

First, suppose data is not adjusted for quality improvements in capital goods. In this case, the capital stock at time t is given by

$$K(t) = \int_{-\infty}^{t} I_i e^{-\delta(t-i)}\, di. \tag{3.7}$$

Let Φ_K denote the TFP residuals obtained by growth accounting using unadjusted data. TFP residuals are given by

$$\begin{aligned} \Phi_K &= \frac{\dot{Y}}{Y} - \alpha\frac{\dot{K}}{K} - (1-\alpha)\frac{\dot{L}}{L}, && (3.8)\\ &= \frac{\dot{A}}{A} + \alpha\left[\frac{\dot{J}}{J} - \frac{\dot{K}}{K}\right]. && (3.9) \end{aligned}$$

Let λ and μ represent the exogenously given growth rates of the indices $A(t)$ and $B(t)$ respectively. Then the balanced growth rate of income per capita is given by $(\lambda + \alpha\mu)/(1-\alpha)$. TFP residuals for the economy on the balanced growth path is $\Phi_K = \lambda + \alpha\mu$. Thus, TFP growth does indicate what the long-run growth rate of income per capita is.

Suppose on the other hand that capital is adjusted for quality improvements. Let $Q(t)$ denote a measure of output which is adjusted quality improvements in capital goods:

$$Q(t) = C(t) + B(t)I(t).$$

Let Φ_J denote TFP residuals obtained by using adjusted data. The growth of quality adjusted output of the economy on a balanced growth path is given by

$$\begin{aligned} \frac{\dot{Q}}{Q} &= [1-\sigma(t)]\frac{\dot{C}}{C} + \sigma(t)\left[\frac{\dot{I}}{I} + \frac{\dot{B}}{B}\right], && (3.10)\\ &= \frac{\dot{Y}}{Y} + \sigma\frac{\dot{B}}{B}. && (3.11) \end{aligned}$$

where $\sigma(t)$ represents the share of investment goods in output; $\sigma(t) = B(t)I(t)/Q(t)$. Note that when the economy grows at the balanced growth rate, the share of capital goods in output,

$\sigma(t)$, is increasing and eventually approaches one. If we use the standard growth accounting methodology with the data adjusted for quality, then TFP residuals for the economy on a balanced growth path are given by

$$\Phi_J = \frac{\dot{Q}}{Q} - \alpha\frac{\dot{J}}{J} - (1-\alpha)\frac{\dot{L}}{L}, \tag{3.12}$$

$$= \frac{\dot{A}}{A} + \sigma\frac{\dot{B}}{B}. \tag{3.13}$$

It is evident that Φ_J is not a meaningful measure since the share of investment goods $\sigma(t)$ has no relevance to the long-run growth rate. Although the share of investment goods $\sigma(t)$ is likely to be increasing, most data sets show it to be less than the income share of capital, α. It follows that the TFP growth rate obtained from quality adjusted date is smaller than the correct TFP growth rate; $\Phi_J < \Phi_K$. Moreover, for the economy which imports capital goods and export consumption goods, $\sigma(t)$ is even smaller. If all capital goods are imported, σ will be zero. In this case, TFP residuals obtained with quality adjusted data do not take account of any quality improvements of imported capital goods. Therefore, TFP growth rate of capital-goods importing East Asian economies may well look modest when compared with those of industrialised economies which export capital goods. But such a comparison is meaningless and has little relevance to the actual technological progress and the long-run growth prospect of each region.

3.4 Models with Limited Substitutability

In this section, it is shown that if the substitution possibilities between labour and capital are limited, then the retirement rate of capital is determined endogenously by increases in wages. When investment grows at a rate higher than the long-run growth rate, a larger proportion of the existing capital stock is made obsolete. Growth accounting usually uses the perpetual inventory method for estimating the capital stock and assumes that the retirement rate of capital is constant. This assumption results in overstating growth of capital input when investment rate is greater than the long-run rate. Overstating growth of capital in turn reduces TFP residuals. Hence, the model can explain the observed negative correlation between conventionally

estimated growth in capital and measured TFP residuals.

The model is similar in spirit to the vintage model in Solow, Tobin, von Weizsäcker and Yaari (1966). The vintage model in Solow (1959) assumes that the feasible range of the capital to labour ratio has no upper bound. Competitive firms will employ less labour to work with older and less productive capital allowing capital to be in use indefinitely. This is clearly contrary to casual observations. We observe that older machinery is taken out of use and replaced with new machinery even if it is still in a perfect working condition. This can be explained if there is a limit on the range of the capital to labour ratio.[5] The model used in this section incorporates this limitation by assuming that there is a minimum amount of labour needed to operate each vintage of capital. Unlike the model of Solow *et al* (1966), substitution between labour and capital is possible within a limited range. This model is used rather than the model of Solow *et al* (1966) so that the implications of the model for TFP residuals with those of the standard neoclassical production function can be compared in a meaningful way.

The model assumes that there is a minimum amount of labour that needs to be employed to work with each machinery. If the amount of labour employed were to fall below this minimum, output would be zero. Hence, production using a less productive vintage shuts down when the value of its output becomes less than the cost of employing the required minimum amount of labour. Let $Y_i(t)$ denote output from production which employs capital of vintage i at time t. The production function is given by

$$Y_i = \begin{cases} A(t)X_i^{\alpha}L_i^{1-\alpha} & \text{if } X_i/L_i \leq \eta_i, \\ 0 & \text{if } X_i/L_i > \eta_i. \end{cases} \tag{3.14}$$

This specification implies that each unit of capital X_i requires at least $1/\eta_i$ unit of labour to operate. I will refer to the increases in the parameter η_i as "labour saving technological progress". It is assumed that η_i grows at a constant rate ι:

$$\eta_i = \eta_0 e^{\iota i}.$$

[5] One worker cannot use a hundred shovels and hope to compete with a man on a bulldozer. A worker with ten typewriters cannot compete with a worker with the latest word processor and so on.

Note that the disembodied form of the technology $A(t)$ applies to all vintages. It turn out that for the economy to have a balanced growth path, the rates of technological progress are such that

$$\frac{\dot{A}}{A} = (1-\alpha)\frac{\dot{\eta}}{\eta}.$$

I assume that the two types of technological progress are related in this way. Although this is not a satisfactory assumption, it plays little role in the main argument made in this study.

Labour is assumed to be mobile within the economy which implies that the marginal product of labour needs to be the same across vintages. Let $w(t)$ denote the wage rate at time t measured in units of output. The revenue from output must at least cover the cost of employing labour. Hence the following relationship must hold for all vintages in use:

$$A(t)X_i^{\alpha}L_i^{1-\alpha} \geq w(t)L_i. \tag{3.15}$$

The constraint in (3.14) can be rewritten as

$$Y_i(t) = \begin{cases} A(t)X_i^{\alpha}L_i^{1-\alpha} & \text{if } \eta_i^{\alpha} \geq w(t), \\ 0 & \text{if } \eta_i^{\alpha} < w(t). \end{cases} \tag{3.16}$$

Let $m(t)$ denote the maximum age of capital at time t. For the oldest vintage in use, the revenue from output is just enough to cover the cost of the minimum amount of labour required:

$$\eta_{t-m(t)}^{\alpha} = w(t). \tag{3.17}$$

The aggregate output at time t, denoted by $Y(t)$, is given by

$$Y(t) = \int_{t-m(t)}^{t} Y_i(t)\, di. \tag{3.18}$$

Solow (1959) shows that the aggregate production function can be written as

$$Y(t) = K(t)^{\alpha}L(t)^{1-\alpha}; \tag{3.19}$$

where

$$K(t) = \int_{t-m(t)}^{t} X_i \, di, \tag{3.20}$$

and

$$L(t) = \int_{t-m(t)}^{t} L_i(t) \, di.$$

Suppose that the supply of labour also grows at a constant rate, n. It is easy to show that output grows at the rate $\iota + n$ on a balanced growth rate. The wage rate grows at the rate ι. The growth of the capital stock at time t can be obtained by differentiating (3.20), which gives

$$\dot{K}(t) = X_t - (1 - \dot{m}(t))X_{t-m(t)}. \tag{3.21}$$

Evidently, if investment grows at the rate greater than the long-run rate, wages also rise faster. In this situation, the constraint in (3.16) implies that the maximum age of capital in use is made shorter and a greater amount of capital is taken out of production. Hence, the growth rate of the capital stock in use is not as large as estimated by the perpetual inventory method. This discrepancy in the actual and estimated growth rates of capital could lead to understatement of TFP residuals when capital is accumulated rapidly.

Thus, we have identified a second source of mismeasurement. In this section, we have started from a reasonable assumption that capital to labour ratio for older machinery cannot be increased indefinitely. Then it is shown that this limitation can lead to mismeasurements of the capital stock. In this case, mismeasurements are such that they occur when the level of investment is high. Therefore, the model can potentially explain the negative correlation between growth in capital and TFP growth.

In the next section, numerical examples are used to assess if the possible effects of mismeasurements are large enough to affect growth accounts significantly.

3.5 Simulation results

The analysis so far has shown that the actual growth rate capital in use may differ from the rate estimated by the perpetual inventory method. It is likely that the technological progress for the aggregate economy is fairly stable over time. If this is the case, one would *theoretically*

expect a negative correlation between (conventionally measured) TFP residuals and the rate of capital accumulation. IIn fact, this is what the results in the growth accounting studies show.

However, if we are to argue that the observed negative correlation is due to mismeasurements, we need to demonstrate that the scale of mismeasurements are large enough to affect measured TFP residuals significantly. The purpose of this section is to examine the possible size of mismeasurements using numerical simulations.

Suppose that the model with the limited substitution possibilities is the "correct" model and the retirement rate of capital is determined endogenously as described in the last section. However, growth accounts are constructed using the perpetual inventory method assuming a constant depreciation rate for capital. Then the estimate of the capital stock will be different from the actual capital stock in use if the economy is not on the balanced growth path. The numerical experiments in this section aim to measure how large the resulting mismeasurements might be using a plausible set of parameters.

The numerical simulations are carried out as follows. Given the purpose of this simulation, I will use a highly stylised model. The level of investment over time is artificially constructed and this is treated as given. Then we can obtain two estimates of the capita stock in use using this investment series. One is the "incorrect" estimate that is obtained by using the perpetual inventory model. The other is the "correct" estimates (by assumption) which are obtained using the model developed in the last section. We compare these two estimates of capital to examine the size of mismeasurements and its effect of TFP residuals.

The supply of labour is assumed to grow at a constant rate n. Technological progress takes at a constant rate ι. Initially the economy is assumed to be on a balanced growth path so that investment grows at the rate $\iota + n$. Then at time t_0, investment jumps to a higher level. Thereafter, growth rate of investment falls back to the balanced growth rate . This change of investment rate is depicted in Figure 3-1. If the capital stock is estimated by the perpetual inventory method, then the change in the growth rates of the capital stock would be as shown in Figure 3-2. At time t_0 growth of capital jumps to a higher level and then gradually falls back to the balanced growth rate.

The parameters needed to describe the model are the labour growth rate, the rate of technological progress and the initial maximum age of capital at time t_0. Prior to t_0, the investment

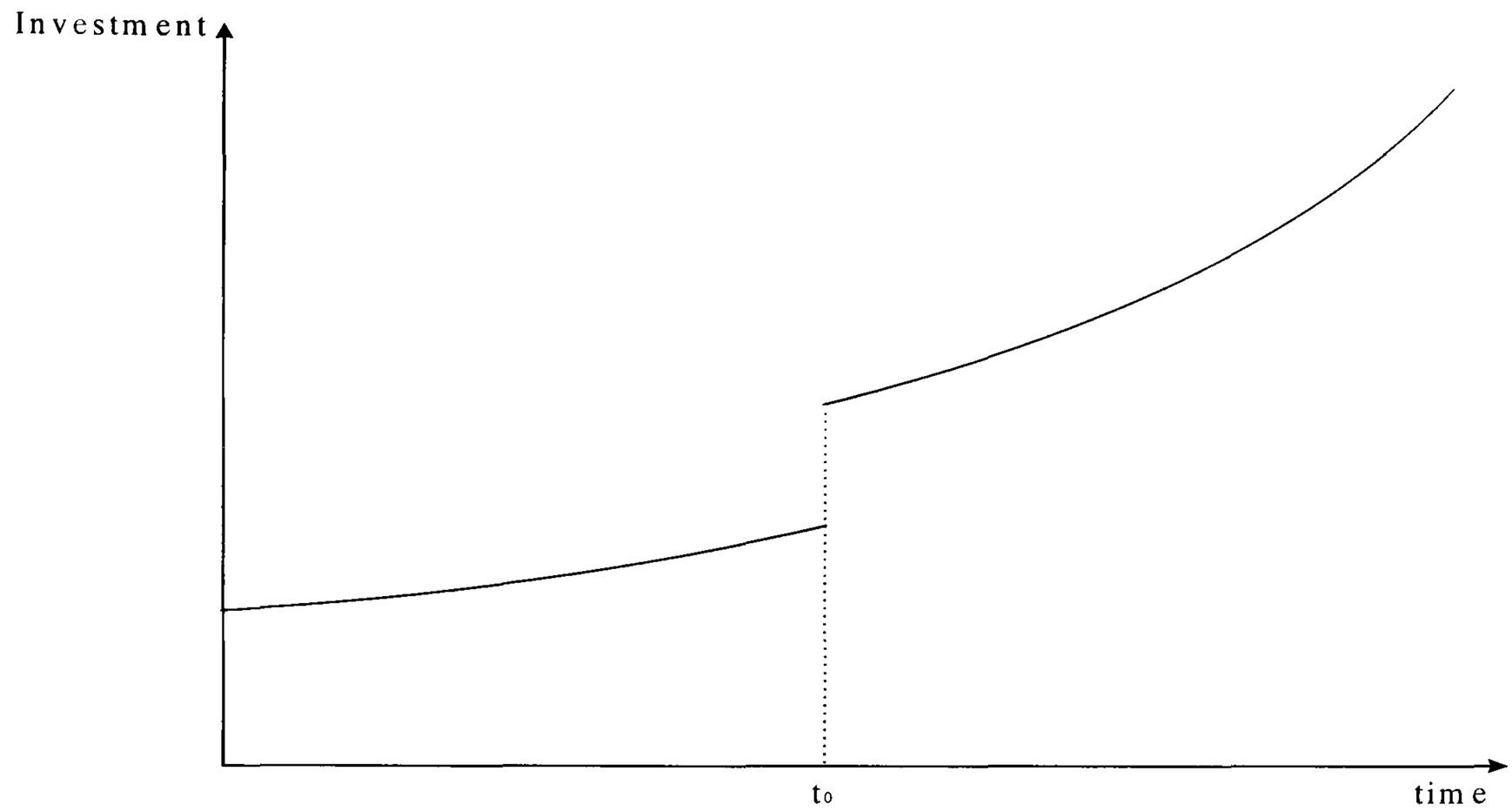

Figure 3-1: Change in the level of investment

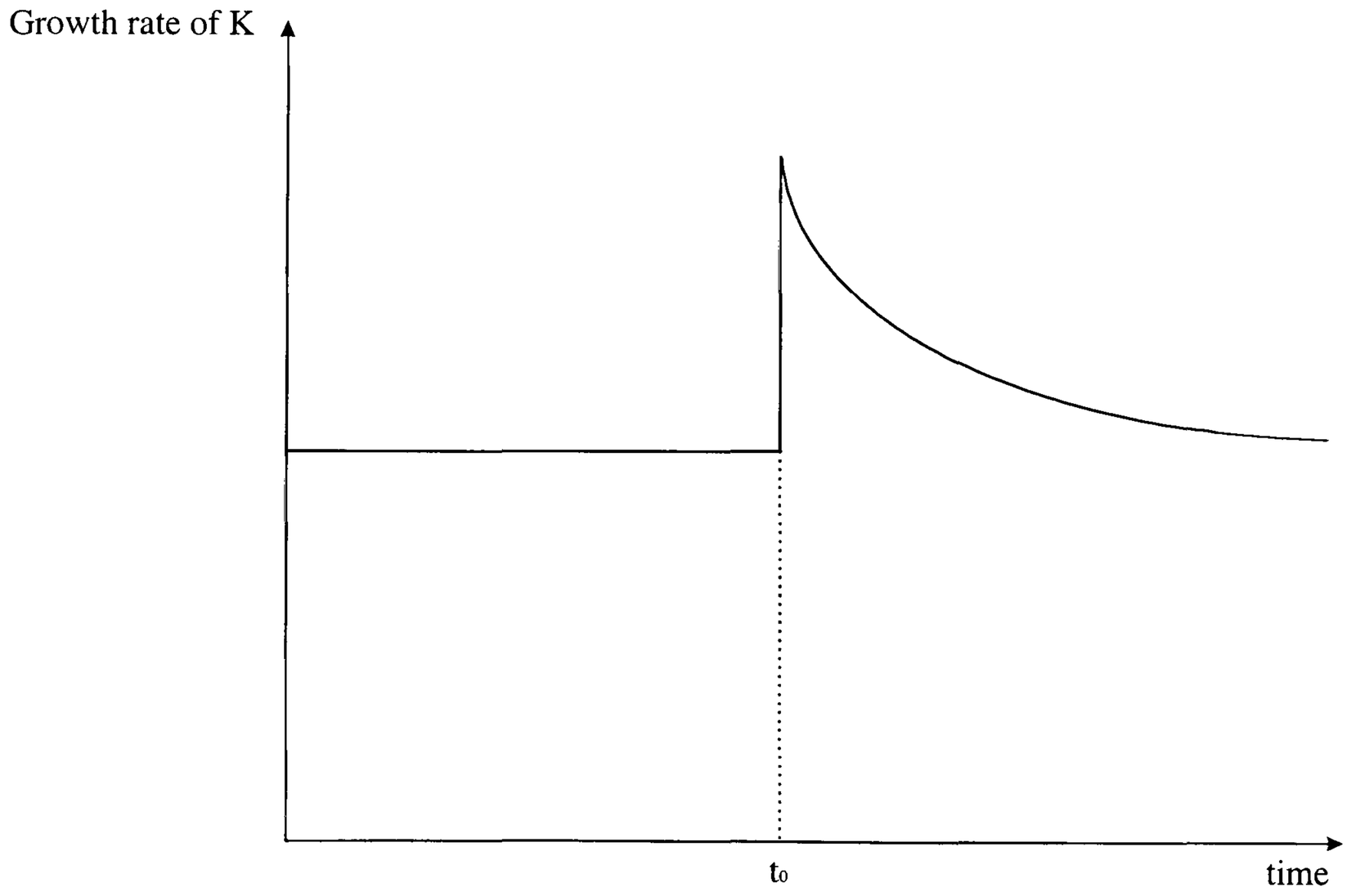

Figure 3-2: Growth rate of capital

rate is on a balanced growth rate and hence the maximum age of the capital in use is constant. After time t_0, however, the maximum age is shortened due the increased demand for labour as a result of increased investment.

The actual growth rate of capital in use implied by the model is obtained as follows. The maximum age at time t_0, $m(t_0)$, is assumed to be 20 or 25 years. Finally, the parameter for technology needs to be scaled so that the maximum age of capital in the model is as it is assumed. This can be done by using the relationship in (3.17):

$$\eta^{\alpha}_{t_0-m(t_0)} = (1-\alpha)\left[\frac{\int_{t_0-m(t_0)}^{t_0} X_i\, di}{L(t_0)}\right]^{\alpha}. \tag{3.22}$$

Since the rate of technological progress, ι, is assumed to be given, the value of η_i for other years can be obtained. The prevailing wage rate and the parameter η_i determined the range of capital in use.

The actual history of investment is obviously more complicated than what is assumed in these simulations. Different types of capital would have different maximum ages and different rates of technological progress. The purpose of the experiments in this section is simple to show that this theoretical possibility cannot be dismissed out of hand.

Simulation 1

Simulation 1 is used as the benchmark case. In this example, I will consider a case in which the average growth rate of capital approximately doubles after t_0. The annual growth rates of labour and technological progress are assumed to be 0.02 and 0.03 respectively. Hence the balanced growth rate of investment, denoted by g_I, is 0.05. At t_0, investment increases by 150growth rate of investment falls back to the balanced growth rate. This has the effect of increasing the average growth rate of capital (as measured by the perpetual inventory method) for the period 10 years after t_0 to 11% from the balanced growth rate of 5%. The results of this simulation are reported in Table 3.1.

The figures are the average of annual rates over the ten-year period. The effect on TFP residuals is obtained by multiplying the difference between actual growth rate of and estimated rate by the factor share of capital α, which is assumed to be 1/3. In Simulation 1, the negative effects of mismeasurements are 0.8% for the first 10 years and 0.5% for the next 10 years. These

Table 3.1: Simulation 1

$g_I = 0.05$
$n = 0.02$
$\iota = 0.03$
$m(t_0) = 25$

	Actual growth of K	Estimated growth of K	Effects on TFP residuals
Prior to t_0	0.05	0.05	0
Between t_0 and t_{10}	0.0879	0.1124	−0.0082
Between t_{10} and t_{20}	0.0501	0.0664	−0.0054

The maximum age is in years. All other figures are in annual growth rates.

effects are significant in comparison with the commonly observed TFP growth rates. Therefore, although this is a crude experiment, this example confirms the theoretical possibility pointed out in the last section could have significant effects on the results of growth accounting.

In the other three examples, the values of the parameters are varied to investigate the effects of mismeasurements further.

Simulation 2

In the second simulation, the maximum age of capital at time t_0 is changed from 25 years to 20 years. The other parameters are the same as Simulation 1. The results are reported in Table 3.2. The negative effects of mismeasurements are 1.0% for the first 10 years and 0.6% for the next 10 years.

When the maximum age is shorter, the effects of mismeasurements are larger. When capital turning obsolete is newer, there is a relative more quantity of it in relation to the total capital stock in used since the balanced growth is assumed for the period before time t_0. Hence, if the maximum age at the time investment increases to above the balanced growth level is shorter, the magnitude of mismeasurements is larger.

Simulation 3

In Simulation 3, the annual growth rate of labour supply is assumed to be 1% and hence the balanced growth rate of investment is changed to 4%. Other parameters are the same as in Simulation 1. The results are reported in Table 3.3. The negative effects of mismeasurements are 0.9% for the first 10 years and 0.5% for the next 10 years.

Table 3.2: Simulation 2

$g_I = 0.05$			
$n = 0.02$			
$\iota = 0.03$			
$m(t_0) = 20$			
	Actual growth of K	Estimated growth of K	Effects on TFP residuals
Prior to t_0	0.05	0.05	0
Between t_0 and t_{10}	0.0797	0.1125	−0.0109
Between t_{10} and t_{20}	0.0488	0.0664	−0.0059

The maximum age is in years. All other figures are in annual growth rates.

Table 3.3: Simulation 3

$g_I = 0.04$			
$n = 0.01$			
$\iota = 0.03$			
$m(t_0) = 25$			
	Actual growth of K	Estimated growth of K	Effects on TFP residuals
Prior to t_0	0.04	0.04	0
Between t_0 and t_{10}	0.0741	0.1005	−0.0088
Between t_{10} and t_{20}	0.0416	0.0579	−0.0054

The maximum age is in years. All other figures are in annual growth rates.

When the supply of labour grows slowly in relation to the increase in capital stock, increases in wages will be faster. If the growth rate in wages is higher, more capital is made obsolete. The slight increase in the effect of mismeasurement in comparison with Simulation 1 is for this reason.

Simulation 4

In Simulation 4, the annual growth rate of technology is assumed to be 2% and the growth rate of labour is assumed to be 2% as before. Hence the balanced growth rate of investment is 4%. The results are summarised in Table 3.4. The negative effects of mismeasurements are 1.1 % for the first 10 years and 0.6% for the next 10 years.

The results show that the effects of mismeasurements are greater than the case in which

Table 3.4: Simulation 4

$g_I = 0.04$			
$n = 0.02$			
$\iota = 0.02$			
$m(t_0) = 25$			
	Actual growth of K	Estimated growth of K	Effects on TFP residuals
Prior to t_0	0.04	0.04	0
Between t_0 and t_{10}	0.0675	0.0992	−0.0106
Between t_{10} and t_{20}	0.0396	0.0579	−0.0061

The maximum age is in years. All other figures are in annual growth rates.

the rate of technological progress is lower. This is explained by the fact that slower rate of technological progress means that more capital needs to be made obsolete to accommodate the increases in wages.

Varying the values of the parameters will lead to changes in the size of mismeasurements. It is clear, however, that if the model is correct, then using the perpetual inventory method to estimate the capital stock leads to quantitatively significant mismeasurements. Although detailed modelling of the actual economies are beyond the scope of this study, the results in this section show that the effect mismeasurements is a possible explanation for the negative correlation between growth of capital and TFP growth.

3.6 Evidence from the results of growth accounting studies

The model predicts that when there is a large amount of new investment relative to growth of labour, the perpetual inventory method overstates growth of the capital stock and hence understates the TFP growth rates. If the actual rate of technological progress is stable over time, we expect a negative correlation between the observed TFP growth and the growth in per capita physical capital. In this section, I will plot the observed TFP growth rates and the estimated growth rates of capital to see if there are discernible patterns.[6] It turns out that the results reported in Young (1995) and Collins and Bosworth (1996) are largely consistent with

[6]Given the nature of analysis, detailed statistical analysis seems to be of little value.

this prediction of the model.

Before discussing the results in Young (1995), it is worth noting the method of estimating the capital stock at the beginning of the data series for investment. Young estimates the capital stock using the standard perpetual inventory method which requires an estimate of the capital stock at the beginning of the series. He considers the capital stock reported in various surveys inadequate. Therefore, Young initialises the capital stock series by assuming that the growth rate of investment in the first five years of the investment series is representative of the investment growth prior to the beginning of the series. Young recognises that this method is fairly crude and therefore focuses his analysis on the post-1966 period to leave enough time after the beginning of the series. Therefore, I similarly discard the results for the period before 1966. Moreover, Young comments on Singapore that "Given the IIP's questionable (i.e., non-existent) deflators, these estimates are clearly inaccurate". Therefore, I will not include the results for Singapore in the analysis.

The annual TFP growth rates are plotted against the difference in the growth rates of labour and capital. For Hong Kong, Young considers only the aggregate economy. The number of the observations are admittedly few but Figure 3-3 shows a clear negative relationship between the TFP growth rates and the growth rates in the per capita capital. It is noted that if we include the period 61-66, this period turns out to be a clear outlier.

For South Korea, the economy is disaggregated into Manufacturing, Other Industries and Services. There is a clear negative relationship in the growth rates of TFP and the per capita capital stock as shown in Figure 3-4. The Taiwanese economy is also disaggregated into the same three categories. The relationship in Taiwan is less clear as can be seen in Figure 3-5.

Thus, the findings in Young's growth accounting are consistent with the hypothesis that the rate of technological progress has been stable and the variations in TFP residuals are due to the errors in estimating the capital stock.

In Collins and Bosworth, the results for only three periods are reported for each economy. In most cases, the pattern follows the predictions of the model. When the growth in the per capita capital growth is greater, TFP growth rates tend to be lower. It is evident that what is depressing the average TFP growth rate of East Asian economies over the period from 1960 to 1994 is the particularly slow growth phase between 1973 and 1984. However, this

Table 3.5: Annual Growth Rates in Hong Kong

	Capital (1)	Labour (2)	(1)-(2)	TFP
61-66	0.169	0.032	0.137	0.035
66-71	0.075	0.025	0.05	0.023
71-76	0.075	0.033	0.042	0.039
76-81	0.093	0.051	0.042	0.022
81-86	0.078	0.019	0.059	0.009
86-91	0.062	0.005	0.057	0.024

Source: Young (1995, TABLE V)
Growth rates of the per capita capital is given by (1)-(2).

Table 3.6: Annual Growth Rates in South Korea

	Capital (1)	Labour (2)	(1)-(2)	TFP
Manufacturing:				
60-66	0.105	0.115	-0.01	0.013
66-70	0.205	0.104	0.101	0.048
71-75	0.133	0.084	0.049	0.053
75-80	0.207	0.047	0.16	-0.007
81-85	0.075	0.019	0.056	0.051
85-90	0.147	0.069	0.078	0.008
Other industry:				
60-66	0.188	0.082	0.106	-0.012
66-70	0.258	0.165	0.093	-0.033
71-75	0.104	0.006	0.098	0.028
75-80	0.180	0.051	0.129	0.010
81-85	0.131	0.051	0.080	0.014
85-90	0.058	0.040	0.018	0.066
Service:				
60-66	0.052	0.040	0.012	0.007
66-70	0.142	0.079	0.063	0.014
71-75	0.124	0.043	0.081	0.022
75-80	0.14	0.033	0.107	0.009
81-85	0.107	0.034	0.073	0.016
85-90	0.096	0.060	0.036	0.025

Source: Young (1995, TABLE VII)
Growth rates of the per capita capital is given by (1)-(2).

Table 3.7: Annual Growth Rates in Taiwan

	Capital (1)	Labour (2)	(1)-(2)	TFP
Manufacturing:				
60-70	0.207	0.078	0.129	0.031
70-80	0.145	0.100	0.045	0.001
80-90	0.078	0.012	0.066	0.028
Other industry:				
60-70	0.177	0.100	0.077	-0.020
70-80	0.165	0.063	0.102	0.013
80-90	0.058	0.012	0.046	0.027
Service:				
66-70	0.145	0.018	0.127	0.040
70-80	0.134	0.049	0.085	0.029
80-90	0.094	0.036	0.058	0.039

Source: Young (1995, TABLE VIII)
Growth rates of the per capita capital is given by (1)-(2).

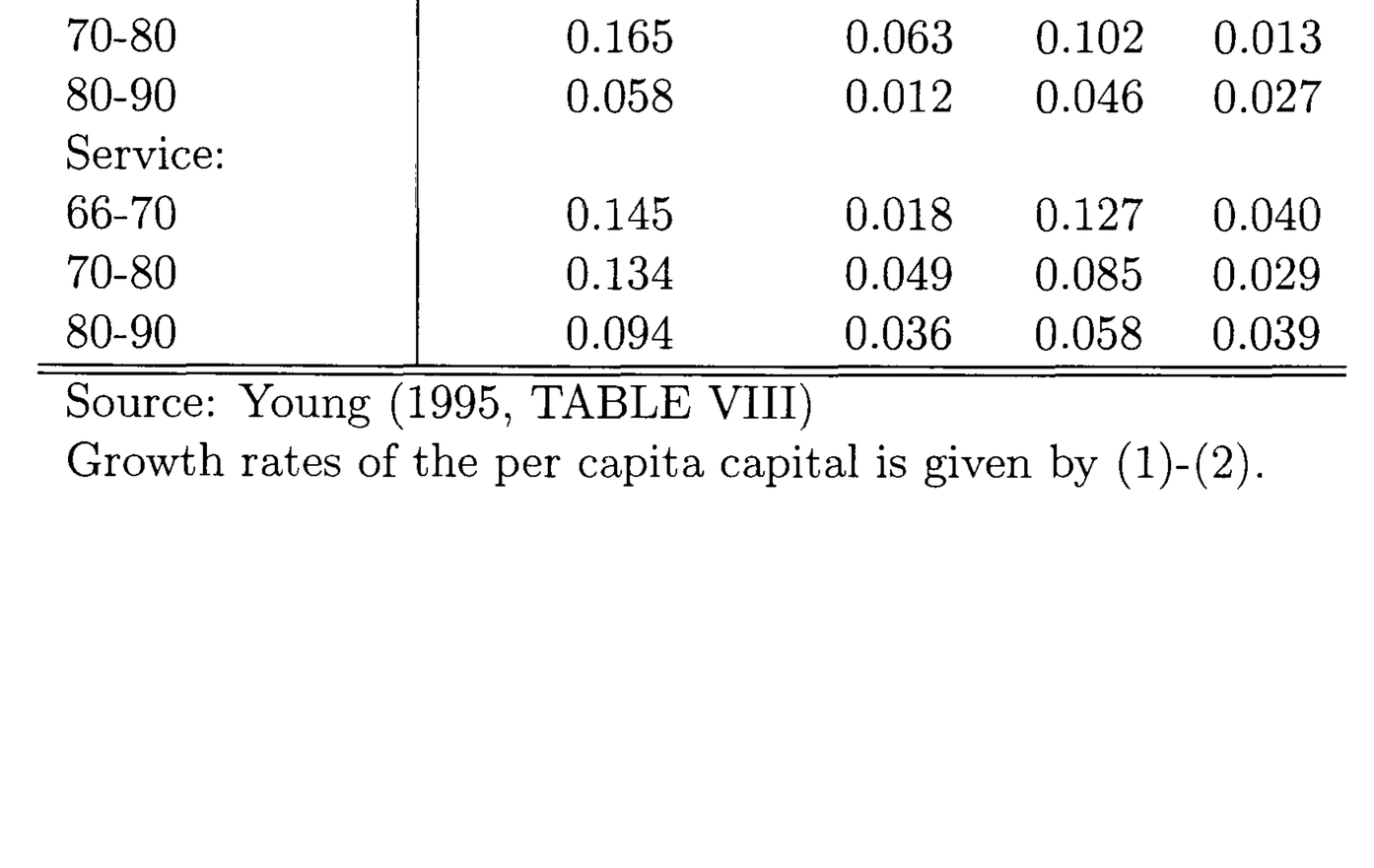

Figure 3-3: Growth in TFP and capital per worker in Hong Kong.

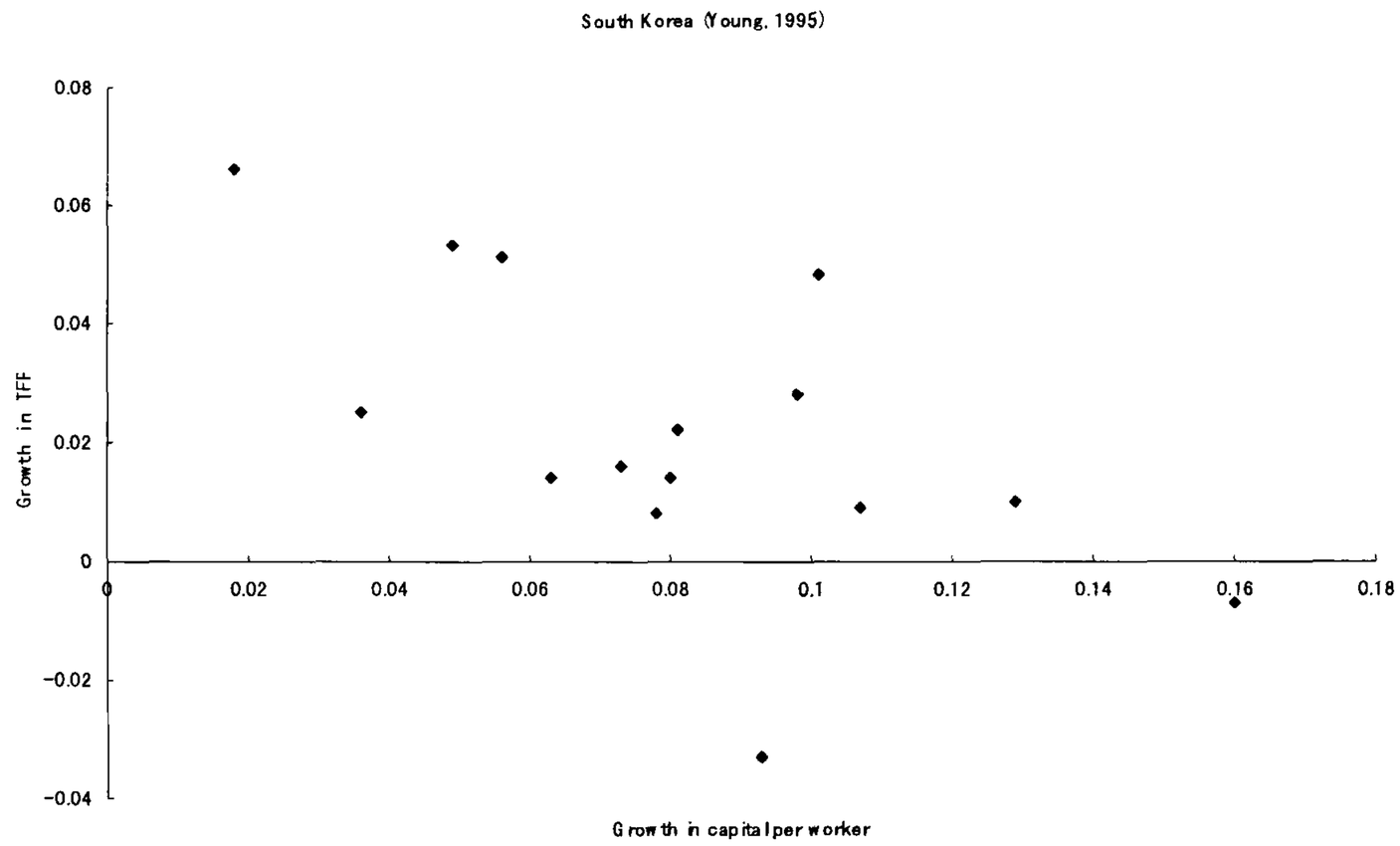

Figure 3-4: Growth in TFP and capital per worker in South Korea.

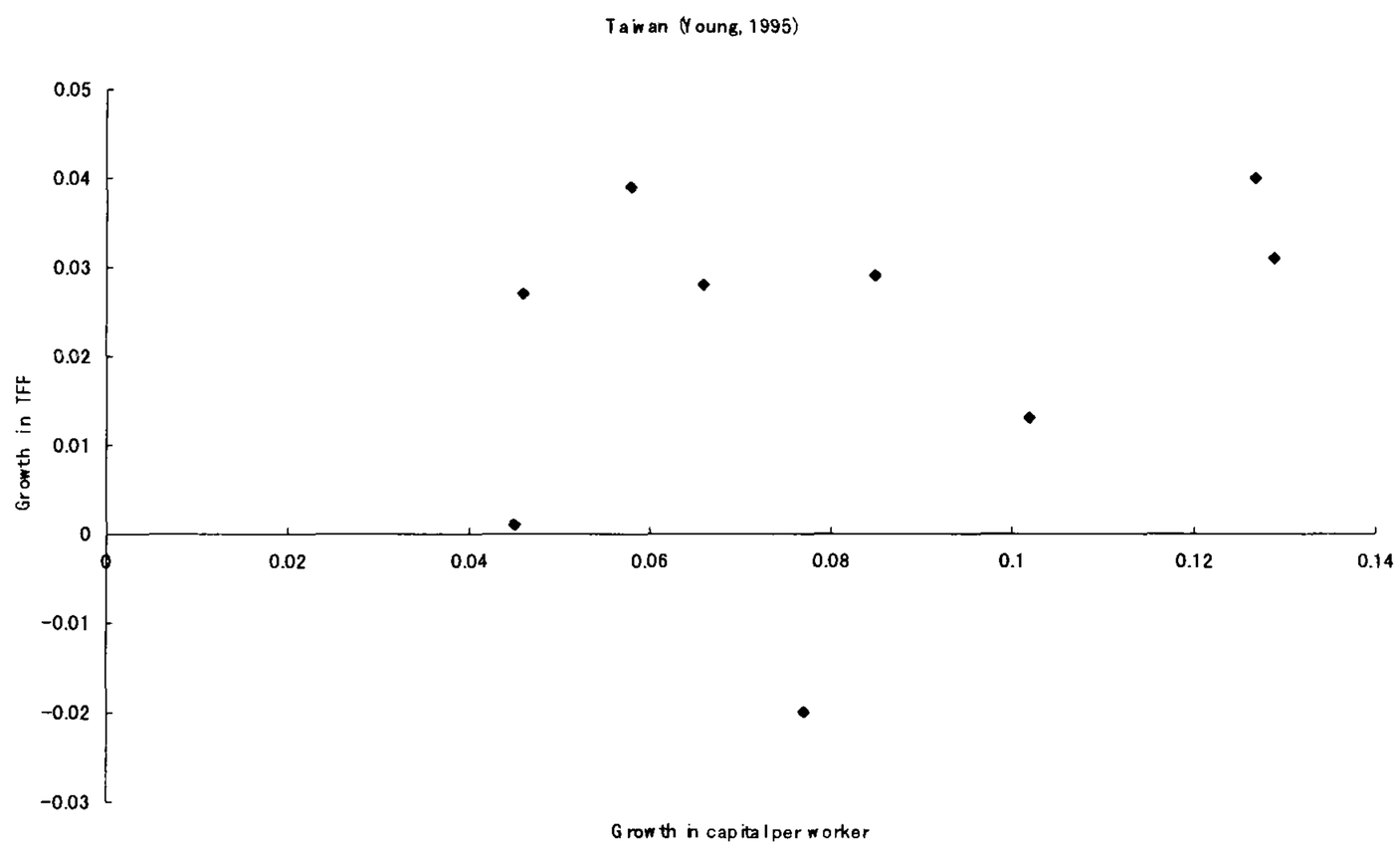

Figure 3-5: Growth in TFP and capital per worker in Taiwan.

period coincides with the time in which capital per worker grew (as estimated by the perpetual inventory method) fast. Therefore, it seems likely that mismeasurements of the capital stock has played a role in the finding that TFP growth in East Asia has been modest.

The model can also provide a potential explanation for the fast TFP growth rates observed in some of the industrialised countries after the Second World War. Maddison (1987) provides a detailed growth accounting study for six industrialised economies. The methodology is different from that of Collins and Bosworth and therefore simple comparisons are not helpful. But a number of interesting observations can be made. Apart from the United States, TFP growth rates in industrialised economies were significantly higher in the period 1950-73. Four of the six economies, France, Germany, Japan and the Netherlands experienced especially high TFP growth while the TFP growth rates of the other two were more modest. Maddison attempts to explain TFP growth in terms of nine supplementary factors such as changes in economic structure and the effects of catching-up.

The model with endogenous retirement rate of capital presented in this study also offers a simple explanation for faster TFP growth in the period immediately after the Second World War. Maddison quotes the war damage to the fixed capital stock from various sources. These figures are reproduced in Table 3.9.

It shows that the damage was much larger in the four economies which experienced very high TFP growth in the period 1950-73. This is consistent with the predictions of the model. If a large amount of capital is removed from the economy, then the technological constraint that causes older capital to turn obsolete ceases to bind until enough capital is accumulated. When the constraint is not binding, no capital is made to retire apart from those due to wear and tear. Therefore, the actual retirement rate would be low and assuming a constant rate of physical depreciation for the capital stock results in understating the growth of the capital stock and hence overstating the observed TFP growth rates.

The effect of war damage may also explain another puzzle mentioned in Collins and Bosworth. They find a modest correlation between TFP growth and growth of capital per worker (the sum of physical capital per worker and education per worker) before 1973 but finds no evidence of a relationship after 1973. Some of the industrial economies which had large war damage could have accumulated physical capital without causing more capital to retire since removal of capital

Table 3.8: Growth in physical capital per worker and TFP

Country and period		Physical capital per worker	TFP
Indonesia			
	1960-73	0.9	1.1
	1973-84	3.3	0.5
	1984-94	2.3	0.9
Korea			
	1960-73	3.2	1.4
	1973-84	3.4	1.1
	1984-94	3.3	2.1
Malaysia			
	1960-73	2.4	1.0
	1973-84	2.7	0.4
	1984-94	1.8	1.4
Philippines			
	1960-73	1.3	0.7
	1973-84	2.0	-1.3
	1984-94	0.2	-0.9
Singapore			
	1960-73	4.6	0.9
	1973-84	3.1	1.0
	1984-94	2.3	3.1
Thailand			
	1960-73	3.2	1.4
	1973-84	2.0	1.1
	1984-94	2.6	3.3
Taiwan			
	1960-73	3.9	2.2
	1973-84	3.0	0.9
	1984-94	2.3	2.8

Source:Collins and Bosworth (1996, Table 6).
Figures are in percentage points per year.

Table 3.9: TFP growth and the war damage.

Country	War Damage (%)	TFP Growth		
		1913-50	1950-73	1973-84
France	8	1.42	4.02	1.84
Germany	13	0.86	4.32	1.55
Japan	25.7	1.10	5.79	1.21
Netherlands	15	1.25	3.35	0.81
U. K.	3	1.15	2.14	1.22
U.S.	n.a.	1.99	1.85	0.52

Source: Maddison (1987, Table 10 and Table 11)

would lower the real wages allowing less efficient capital stock to be used longer. If a constant rate of depreciation is assumed, then it would have resulted in faster observed TFP growth for some years after the Second World War but as capital accumulation continued, the constraint on the capital to labour ratio would have began to bind again turning more capital obsolete.

3.7 Concluding remarks

In this chapter, I have presented two hypothesis to account for slow TFP growth rates found in growth accounting studies for East Asian economies.

The first is related to the nature of technological progress and the problems with constructing the data set. It is shown that inputs of capital should not be adjusted for quality improvements. Using *real* data is not appropriate for the purpose of growth accounting. An implication of the model is that this will understate the TFP residuals of capital-goods importing economies more than capital-goods exporting economies. Krugman argues that "If technology is embodied in capital, this can lead to an exaggeration of the 'residual' component of growth." This argument is correct only if the data set for capital inputs are not adjusted for quality improvements. Hence, when trade in capital goods plays an important role in accumulation of capital, a simple comparison of the TFP residuals for industrialised countries and less developed economies may be misleading.

The second hypothesis is that new investment has the effect of replacing the old capital stock in which case assuming a constant rate of physical depreciation overstates the growth

of the capital stock in use. This hypothesis is motivated by the observation that there is a negative correlation between TFP growth rates and growth in capital per worker, contrary to the predictions of growth models. Perhaps this negative correlation is more puzzling than the apparent slow TFP growth in East Asia. The vintage model limited substitution possibilities can account for this puzzling finding.

The overall conclusion from this study is that it is premature to conclude that technological progress in East Asia has been slow. In this study, I have attempted to show that there are enough grounds to doubt the findings in the growth accounting studies of East Asian economies. Although TFP growth is a important indicator, given the problems in measuring the relevant quantities, its results need to be interpreted with caution.

Chapter 4

Open Regionalism

4.1 Introduction

The purpose of this chapter is to show that if two asymmetric countries agree to adopt a policy of open regionalism, such an arrangement may result in worsening the welfare of one economy while improving the other's. Furthermore, if the countries are not freely able to choose the partners for forming a trade bloc, some economies may have to accept welfare-worsening open regionalism as the least worst alternative. It is commonly thought that an open regionalism agreement is a "benign" form of regionalism and does not hinder the progress towards global free trade. The findings in this study are in sharp contrast to this conventional view.

The emergence of regional trading blocs in recent years has raised the concern that such agreements are not only globally welfare-worsening but also prove to be an obstacle to further multilateral trade liberalization towards global free trade.[1] Faced with such criticism, proponents of regional trade agreements point to the relative success of trade liberalization at regional levels in contrast to the slow pace of multilateral negotiation at the WTO. Moreover, some of them argue that the potential threats regional agreements pose for multilateral trade liberalization can be avoided to a large extent if the trade bloc adopts a non-discriminatory policy called "open regionalism".

There is some confusion as to the exact meaning of the term "open regionalism". In this

[1] Bhagwati and Panagariya (1996).

study, open regionalism is defined as follows. A trade liberalization measure adopted by a regional bloc is in accord with open regionalism if it is non-discriminatory with regard to non-member countries. Given this definition, a number of different trade liberalization measures come under the label of open regionalism. This study focuses on the policy rule by which trade liberalization measures agreed within the bloc are unconditionally extended to cover trade with non-member countries. This policy is sometimes referred to as "unconditional MFN" and considered to be the purest form of open regionalism.

Before preceding further, it is worth mentioning other regional trade agreements which could be described as open regionalism. First, trade blocs may adopt a limited form of unconditional MFN by which the member economies liberalize trade in *selected* sectors on an MFN basis.[2] If the member economies dominate the world market in those selected sectors or transport costs allow only limited competition from non-member economies, liberalizing trade without reciprocal measures from non-member economies would have little further effects. Another interpretation is that of an "open membership" rule by which any outside economy wishing to join the bloc will be accepted provided that it satisfies the non-discriminatory entry criteria.[3] In this study, the term "open regionalism" only refers to the policy of unconditional MFN.

The advantages of open regionalism over PTAs

There are two forms of preferential trade agreements (PTAs). Countries participating in a free trade area (FTA) removes tariffs on imports from other member countries while retaining the right to set their own tariffs rates on imports from non-members. In a customs union (CU), countries set a common tariffs rates on imports from outside countries. Preferential trade agreements clearly violate the MFN principles. Open regionalism (OR) as defined above is clearly not a preferential trade agreement since it is non-discriminatory. Bergsten (1990) points out that unconditional MFN has a number of advantages over PTAs.

First, it avoids the problem of trade diversion altogether. The concepts of "trade diversion" and "trade creation" have been central to the discussions of the relative merits of forming preferential trade areas. The members of a PTA gain from trade created by internal liberalization. However, setting discriminatory tariffs as a result of forming a PTA may give advantage to

[2] Frankel and Wei (1995).

[3] Open regionalism discussed in Yi (1996) is open membership.

less efficient producers based within the PTA over more efficient outside producers. Open regionalism does not involve introducing discriminatory trade barriers and therefore avoids trade diversion while allowing the countries to benefit from trade creation.

The second advantage of open regionalism is that it would avoid the problem of "trade deflation" and the related issue of defining the rules of origin. This problem, which is specific to FTAs, arises when the member economies wish to impose different tariffs rates on imports from outside economies. From the policy maker's point of view, the advantage of FTA over CU is that each economy retains control on tariffs for imports from non-member countries. However, if the movement of goods among the member economies is completely free and transportation costs are small, then imports from non-member economies would enter the trade bloc through the member economy with the lowest tariff rate and then distributed to the other economies within the FTA. This is often referred to as trade deflation. If this is permitted, any tariffs higher than the lowest rate among the member countries would be ineffective. To avoid this problem, FTA agreements often stipulate the "rules of origin" to determine when goods qualify for tariff-free treatment. However, problems could easily arise as production of goods is increasingly globalised. For example, if a firm within the trade bloc is own by foreigners (of non-member countries), what is the origin of the firm's product? Or when goods produced within the trade bloc contains intermediate goods imported from non-member countries, does it qualify for tariff-free treatment? As production becomes increasingly globalised, such arbitrary rules could prove to be a costly restriction for producers. Open regionalism is much simpler to administrate in this respect.

The third advantage of open regionalism is its effect on the process of global trade liberalization. PTAs may give the member economies a welfare level greater than what they would obtain under global free trade at the expense of countries outside the PTA. If so, member countries of the PTA have little incentive to take part in the further multilateral trade liberalization. Thus, PTAs may turn out to be an obstacle to the goal of achieving global free trade. It is argued that since open regionalism does not provide the member countries any incentives to hinder the multilateral liberalization, it cannot be an obstacle to multilateral trade liberalization. However, I will demonstrate in this study that this is not always the case.

There are, however, disadvantages to open regionalism, too. Although open regionalism

does not reduce incentives to pursue multilateral trade liberalization for member countries, its consequences for non-member countries are different. The post-war trade liberalization process at the GATT/WTO has been negotiated on a reciprocity basis. Participating economies make "concessions" to remove trade barriers in certain areas in return for other participants at the negotiation doing likewise. Unconditional MFN means that the trade bloc is giving away this "leverage" without requiring reciprocal trade liberalization from non-member countries. Hence, unconditional MFN provide trading partners with the opportunity to "free-ride" on the benefits of market access while using tariffs to manipulate the terms of trade in their favour. Therefore, open regionalism policy may perversely slow down the process of trade liberalization.

Despite the potential problem concerning the incentives for non-members, open regionalism is regarded as a good practice according to this conventional view. The point about the disadvantage of open regionalism suggests that the trade bloc that adopts open regionalism policy is making unilateral concessions. In fact, whether or not open regionalism means making unilateral concessions partly depends on the motives for having tariffs on imports in the first place.

The motives for protection

The assessment of the relative merits of open regionalism policy depends on the reason for imposing tariffs in the first place. First, consider the case in which the economy is so small that a change in its demand for imports by use of tariffs has no impact on international prices. Tariffs are imposed because of mercantilist influence on the policy making process. Suppose that the influence of the producer lobbyists on policy making is such that trade liberalization at home requires opening of export markets in exchange. Then a policy maker may find it easier to sign up to an open regionalism agreement with a smaller subset of its trading partners (i.e. countries participating in the open regionalism agreement) rather than remove tariffs unilaterally. Even though tariffs are removed on all imports according to the open regionalism agreement, there are gains for producer lobbyists in the form of the opening up of other members' markets. In terms of the welfare, any trade liberalization is good for small economies provided that there are no other distortions in the economy.[4] Hence, adopting an unconditional MFN policy

[1]As in standard models, welfare under consideration is determined by consumption bundles of homogeneous residents in the economy. The issue of distribution is left aside.

does not constitute making any concessions in terms of the economy's welfare. In this case, open regionalism can be interpreted as a policy device to achieve welfare improving trade liberalization at home.

Suppose, on the other hand, that economies are large enough to have monopoly power in the goods market and tariffs are used to influence the terms of trade in their favour. In this case, removing the tariffs without reciprocal liberalization is likely to lead to a fall in welfare. Hence, unconditional MFN does often mean that the economies are making concessions.[5]

Most of the literature on this issue is concerned with the latter case. The proponents of open regionalism often talk of minimising the negative effect arising from the lack of reciprocal trade liberalization. The underlying premise is that countries that adopt open regionalism are making sacrifices for the sake of global good. This must imply that tariffs are assumed to be levied in the context of strategic trade policy interactions among economies.

However, this argument neglects the possibility that some countries in the trade bloc may actually gain if the bloc adopts open regionalism policy. The aim of this study is to point out that if the economies in a trading bloc are asymmetric, some countries could obtain a higher welfare level than under other arrangements despite the fact that they are giving away the right to impose retaliatory tariffs. Furthermore, it is possible that some of the participants to open regionalism agreement obtain a higher welfare level than they would under global free trade. This can happen for the following reason. A commitment to open regionalism by member countries is likely to make non-member countries more aggressive in setting tariffs on imports from the countries adopting open regionalism. Tariffs carry external effects in that the resulting lower price benefits all other countries which import the goods. If the countries in the bloc are asymmetric, some countries may gain from this externality effect. Hence, open regionalism may serve the self-interest of some countries, contrary to the popular perception that they are making unilateral concessions for global good. Moreover, it will be shown that these countries that could gain from open regionalism may succeed in forcing other countries in the bloc to adopt open regionalism policy.

The rest of this chapter is organised as follows. In the next section, I will discuss in detail

[5]However, if the trade bloc is an FTA, the benefits from doing away with the rules of origin may be considerable, though.

how open regionalism policy may be motivated by self-interest, contrary to the conventional view. It is also shown that there are situations in which open regionalism policy is an equilibrium outcome. In Section 4.3, the model and procedures for numerical simulations are described. In Section 4.4, the results of simulations are discussed. The results show that open regionalism could dominate other possible outcomes. Concluding remarks are given in Section 4.5.

4.2 Open regionalism and the external effects

The results of this study are derived using numerical examples as the model is analytically intractable. However, the intuition behind those results is relatively easy to see. In this section, I will discuss the mechanism by which some countries could gain from joining an open regionalism agreement.

Consider a pure exchange economy consisting of three countries. The countries are labelled A, B and C. There are three types of goods and they are numbered as good 1, good 2 and good 3. The patterns of endowments are such that in equilibrium each country exports one good while importing the other two goods. Goods are labelled so that the export of country A is good 1, the export of country B is good 2 and the export of country C is good 3. The pattern of trade is shown in Table 4.1 where a "+" sign indicates that the country is exporting the good while the "−" sign shows that the country is importing the good.

Table 4.1: The patterns of trade

		Goods		
		1	2	3
Country	A	+	−	−
	B	−	+	−
	C	−	−	+

Countries are large enough to influence the international prices by use of tariffs. Countries may set tariffs individually or coordinate the policy by forming a trade bloc with others. Suppose that country A and B agree to adopt open regionalism policy. In this three-country model, an open regionalism agreement amounts to removal of tariffs by countries A and B irrespective of the actions taken by country C. In many situation, this open regionalism policy would give

countries A and B a lower welfare level than they could obtain by forming a PTA and levy tariffs on imports from country C. In some cases, however, an open regionalism agreement gives a higher welfare level than PTAs to one of the countries participating in the agreement.

To see the mechanism by which one of the countries gains from joining in an open regionalism agreement, suppose that country B obtains a higher welfare level with an open regionalism than under other regimes. Country B always has the option of removing tariffs unilaterally on its own or within an FTA. Therefore, if country B benefits more from an open regionalism agreement, it must be due to the fact that the other participants to the agreement also remove tariffs on imports from non-participating economies. In general, tariffs affect welfare levels thorough changes in world prices and through the revenues tariffs generate. In this case, any increase in welfare must be due to a change in the price of goods since economies A and B are removing all of their tariffs and therefore have no tariffs revenues. In terms of international prices of goods, economy B gains from a fall in the price of the imports, goods 1 and 3, and loses out from a fall in the price of its export, good 2. The commitment by countries A and B to remove tariffs on imports from country C is likely to make country C to set higher tariffs, which would have the effect of depressing the prices of good 1 and good 2. The welfare of country B could increase if the loss of welfare from the fall in the price of good 2 is smaller than the benefits from the fall in price of good 1. In effect, country B is receiving the benefits of the externality effect due to the country C's increased tariffs on imports from country A. Open regionalism agreement prevents country A from retaliating to country C and in a sense helps country C win a "trade war" over country A.

Thus, if the two countries in an open regionalism agreement are not symmetric, one of them could gain at the expense of another. Numerical simulations demonstrate that such an situation could indeed arise. The next question is whether open regionalism agreement could ever be an equilibrium. Each country has the right not to participate in any trade agreements. If an policy of open regionalism policy is welfare-worsening, then why should country A agree to such an arrangement? It turns out that in some situations, open regionalism is the least worst outcome for country A and hence country A will choose to join in an open regionalism agreement to avoid even worse outcomes being realised.

A PTA consisting of countries B and C is likely to be welfare-worsening for country A.

If countries B and C form free trade area, the consumers in those countries substitute away from the export of country A to the import from the PTA partner. Moreover, countries B and C may form a customs union which tends to be more aggressive in setting external tariffs. Therefore, country A would opt for an open regionalism agreement with country B if doing so is less welfare-worsening than letting economies B and C form a PTA. Country B on the other hand might agree to such an arrangement, if it can obtain a better welfare level by choosing country A as its partner rather than country C. The loss of welfare incurred to country A as a result of agreeing to open regionalism can be seen as a retainer country A has to offer to country B in order to avoid a greater loss.

Moreover, it is possible that country B obtains a greater welfare level under an open regionalism agreement with country A than under global free trade. Since economy C is free to levy any tariffs without the fear of retaliation, it is also likely to obtain relatively high level of welfare. If one country in the trade agreement (i.e. country B) and the country outside (i.e. country C) find open regionalism better than free trade, there is little incentives in the system to pursue multilateral trade liberalization. Hence, open regionalism could be an obstacle to achieving the goal of global free trade.

Thus, the mechanism by which open regionalism agreement could arise is rather simple. However, showing the result is analytically is not possible. Therefore, I will use numerical simulations in the following sections to demonstrate the effects of an open regionalism agreement on welfare and that it can be an equilibrium outcome.

4.3 The Model

In this section, I will describe the model and the methodology used for the numerical simulations. A pure exchange economy consisting of n countries and m types of goods are used for the numerical simulations. The subscript i $(i = A,\ B,\ C, ...)$ is used to index the countries and the subscript j $(j = 1,\ 2,\ 3, ...)$ is used for the types of goods. Let X_{ij} denote the aggregate consumption of good j in country i. Preferences for the representative consumer in country i

are described by the utility function,

$$u_i = \left(\sum_{j=1}^{m} \beta_{ij}^{\frac{1}{\sigma}} X_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{4.1}$$

where

$$\sum_{j=1}^{m} \beta_{ij}^{\frac{1}{\sigma}} = 1, \tag{4.2}$$

and σ denotes the elasticity of substitution. Let p_j denotes the world price of good j. Aggregate demand, X_{ij}, can be written as

$$X_{ij} = u_i \left(\frac{\beta_{ij}}{[p_j(1+t_{ij})]^{\sigma}} \right) p_{iu}, \tag{4.3}$$

where

$$p_{iu} = \left(\sum_{j=1}^{m} \beta_{ij} [p_j(1+t_{ij})]^{1-\sigma} \right)^{\frac{1}{1-\sigma}}. \tag{4.4}$$

The representative consumer in economy i is endowed with ω_{ij} units of good j. The revenue from tariffs is returned to the consumer. The aggregate income for the consumer in economy i, M_i, is therefore given by

$$M_i = \sum_{j}^{m} (\omega_{ij} p_{ij} + X_{ij} t_{ij} p_{ij}), \tag{4.5}$$

and the budget constraint is given by

$$M_i = u_i p_{iu}. \tag{4.6}$$

Finally, the aggregate supply of goods must be equal to aggregate demand in equilibrium;

$$\sum_{i}^{n} \omega_{ij} = \sum_{i}^{n} X_{ij}. \tag{4.7}$$

Using this model, I will examine five types of trade agreements, which are No Agreement, Customs Union, Free Trade Area, Open Regionalism and Global Free Trade. These trade arrangements are defined as follows.

In the No Agreement case, each country individually sets tariffs rates on imports to maximize

its own welfare taking the tariffs rates of trading partners as given. Thus, this is a Nash equilibrium with no cooperation between any of the economies. In the case of CU, the countries which participate in the customs union will remove the tariffs on imports from other member countries in the union. Common external tariffs rates are levied on imports from non-member countries. The rates are set to maximize the simple sum of the utility levels of the member countries given in (4.1). The use of the simple sum is justified since identical utility functions are used for all countries. In the case of FTA, tariffs on the imports from member countries are removed as in the case of CU. However, each country sets its tariffs rates on imports from non-member to maximize its own welfare. If a policy of open regionalism is adopted, then the participating countries agree to remove all tariffs. Only the non-participating countries set tariffs. In the case of global free trade, all the tariffs in the system are removed.

The methods of the simulations corresponding to each of the trade agreements are as follows. In the No Agreement case, the tariffs rates of country A, t_{1j}, are chosen to maximize the utility of country A while the tariffs rates levied by other countries are held constant. Then the utility of country B, C,...up to country n is sequentially maximised in the same way. This procedure is iterated until a Nash equilibrium in tariffs rates is found. The same procedure is applied for the case of FTA except that tariffs rates for imports from other member countries are always set at zero in the iterative procedure. In the case of a customs union, joint utility is maximised by varying the common tariffs rates on imports from non-member countries. [6] In the open regionalism case, member countries set all the tariff rates at zero and only non-member country imposes tariffs to maximize its utility.

4.4 Can open regionalism dominate free trade?

When discussing the possible trade arrangements, it needs to be noted that the possibility of transfer payments between countries are ruled out. This assumption is necessary for the following reason. In the absence of externalities or distortions other than tariffs, the aggregate welfare is maximised under global free trade. Suppose that countries in the system liberalise

[6] Other studies take a different approach. Riezman (1999), for example, computes two equilibria for the external tariff set by a customs union of two countries. Each equilibrium is obtained by maximizing the utility of one of the two countries. It is assumed that the customs union chooses an external tariff rate which gives each country the average of these two equilibrium utility levels.

Table 4.2: The possible coalitional arrangements

n	Coalitional Arrangement	Trade Policy
1	$\{A\}$ $\{B\}$ $\{C\}$	No Agreement
2	$\{A, B\}$ $\{C\}$	CU between A and B
3	$\{A, B\}$ $\{C\}$	FTA between A and B
4	$\{A, B\}$ $\{C\}$	OR between A and B
5	$\{A\}$ $\{B, C\}$	CU between B and C
6	$\{A\}$ $\{B, C\}$	FTA between B and C
7	$\{A\}$ $\{B, C\}$	OR between B and C
8	$\{A, C\}$ $\{B\}$	CU between A and C
9	$\{A, C\}$ $\{B\}$	FTA between A and C
10	$\{A, C\}$ $\{B\}$	OR between A and C
11	$\{A, B, C\}$	Global Free Trade

trade completely. Then it is always possible to find a set of transfer payments which makes all countries better off than they would be under other trading arrangements. Furthermore, this pattern of transfer payments can be replicated by a set of tariffs. If transfer payments and equivalent tariffs measures are not ruled out, the countries will always agree to these measures. Hence, the studies on regional trade agreements presuppose that such transfer agreements are not possible and we will do so in this study as well.

The policy coordination considered in this study are customs union, free trade area, open regionalism agreement and global free trade. In a scenario with three countries, there are eleven possible coalitional arrangements. These combinations are shown in Table 4.2. Countries in the bracket { } are in the same coalition.

Arrangement 1 is the case in which there are no agreements and each country sets tariffs to maximize its own welfare. In arrangement 2, 3 and 4 countries A and B are in a coalition and country C remains outside. In arrangement 5, 6 and 7, countries B and C form a coalition leaving country A out. Similar trade arrangements are possible between countries A and C which leaves country B as shown in arrangement 8, 9 and 10. Finally, arrangement 11 is the case in which there are not restrictions to trade.

We can obtain the welfare levels of the countries under different trading arrangements using numerical simulations described in the previous section. Given the possible outcomes, we can determine which trading arrangement will actually be implemented using the concept of the "core" as in Riezman (1985).

It is possible to obtain a set of equilibrium goods allocation for each of coalitional arrangement. This equilibrium allocation of goods gives the welfare levels for each economy associated with different arrangements. Given these welfare levels, we may deduce which coalitional arrangement will result as an equilibrium trade agreement. A coalitional arrangement is blocked if there is another arrangement which results in the allocation that makes the countries in the coalition no worse off and some of them better off. For example, No Agreement blocks Global Free Trade if any one of the three countries obtains a higher welfare level under No Agreement than under Global Free Trade. Similarly, coalitional arrangement 1 (i.e. a customs union between A and B) would block No Agreement if both countries A and B could obtain a higher welfare level in the customs union than under No Agreement. A trading arrangement is in the core if it is unblocked by any other possible arrangement. When there is more than one arrangement in the core, the theory offers no prediction as to which arrangement will be the actual outcome. It is possible that any one of the arrangements in the core turns out to be the actual outcome. Numerical examples in this study show that open regionalism could be in the core along with other arrangements.

Finally, I will assume that there are restrictions to the possible coalitional combinations. Riezman (1985) considers the effects of banning bilateral trade agreements, which means that some of the coalitional arrangement are ruled out. In this study, I will introduce a different kind of restrictions. Rather than restricting the forms of trade policy coordination, I will restrict the possible combination of countries. For example, if the policy coordination between countries A and C is ruled out, then coalitional arrangements 8, 9 and 10 are taken out of the consideration.

This restriction may seem arbitrary but it is not hard to imagine that some countries are not able to form a trade bloc together due to political, cultural and historical reasons. For example, the geographical proximity and the vast differences in relative factor endowments mean that there are large potential gains in the trade between Japan and Russia. However, political considerations make it very unlikely that the two countries agree to a bilateral preferential trade agreement. The North and the South Korea are another example. Similarly, it is implausible that the United States and any of the countries it calls "terrorist states" come together to form a preferential trade agreement.

The numerical examples carried out in the following section shows that when there are

restrictions on possible coalitional arrangements, it is often the case that open regionalism agreement is in the core.[7]

In what follows, four simulation exercises are carried out. The first is carried out to illustrate the point that when two countries form a PTA, optimal tariffs on imports from the outside country may become lower. However, this does not mean that these countries adopt a policy of open regionalism. The second simulation shows a simple example in which a PTA between asymmetric countries may lead to adopting open regionalism. The third and fourth examples show that an country may participate in an open regionalism agreement to avoid formation of a PTA that excludes it. This means that one country may have to accept a welfare-worsening open regionalism agreement.

Simulation 1

This simulation shows an example in which the formation of a CU results in a lower external tariffs rate than in the case of No Agreement. The tariff lowering effect of a PTA is pointed out in Syropoulos (1999). In general, a formation of a customs union and the introduction of the common external tariffs give the customs union a greater market power. Moreover, the benefits of the lower price as a result of levying tariffs by one country are internalised in the union. Therefore, when countries form a customs union, the common external tariffs tend to be higher than a pre-union tariffs rates of member countries. However, formation of a customs union could result in lowering the tariffs for the following reasons.

In this simulation, countries A and B form a customs union and set a common external tariff on good 3 which is the good imported from country C. Before the formation of the union, country A's tariffs on imports from country C has the effect of increasing the revenue from tariffs on imports from country B. Since goods are assumed to be substitutes for one another, a higher price of good 3 results in greater demand for good 2, which is imported from country B. With the formation of a customs union, this revenue increasing effect of tariffs disappears. Therefore, the formation of a customs union by A and B removes one incentives for imposing higher tariffs on imports from country C.

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[7]One disadvantage of relying on numerical simulations is that we cannot say for sure if such restrictions are necessary for open regionalism agreement to be in the core. There may be a pattern of factor endowments which leave open regionalism in the core without any restrictions imposed.

Table 4.3: Simulation 1

The endowments												
		1	2	3								
	A	3.0	0	1.0								
Country	B	0	3.0	1.0								
	C	1.0	1.0	3.0								
Eq.	Country	Utility	Tariffs			Prices	Consumption			Trade		
	A	1.307	0	0.547	0.407	1.000	1.929	0.806	1.306	1.071	-0.806	-0.306
NA	B	1.307	0.547	0	0.407	1.000	0.806	1.929	1.306	-0.806	1.071	-0.306
	C	1.600	0.187	0.187	0	0.864	1.264	1.264	2.388	-0.264	-0.264	-0.612
	A	1.348	0	0	0.237	1.000	1.380	1.380	1.285	1.620	-1.380	-0.285
CU	B	1.348	0	0	0.237	1.000	1.380	1.380	1.285	-1.380	1.620	-0.285
	C	1.592	0.174	0.174	0	0.838	1.239	1.239	2.430	-0.239	-0.239	-0.570
	A	1.343	0	0	0.083	1.000	1.340	1.340	1.348	1.660	-1.340	-0.348
FTA	B	1.343	0	0	0.083	1.000	1.340	1.340	1.348	-1.340	1.660	-0.348
	C	1.618	0.217	0.217	0	0.921	1.320	1.320	2.305	-0.320	-0.320	0.695
	A	1.336	0	0	0	1.000	1.313	1.313	1.383	1.687	-1.313	-0.383
OR	B	1.336	0	0	0	1.000	1.313	1.313	1.383	-1.313	1.687	-0.383
	C	1.637	0.243	0.243	0	0.975	1.373	1.373	2.234	-0.373	-0.373	0.766
	A	1.349	0	0	0	1.000	1.249	1.249	1.561	1.751	-1.249	-0.561
GFT	B	1.349	0	0	0	1.000	1.249	1.249	1.561	-1.249	1.751	-0.561
	C	1.623	0	0	0	0.894	1.502	1.502	1.877	-0.502	-0.502	1.123

The price in the row for country A corresponds to the price for good 1 and similarly row B is for goods 2 and row C is for good 3.

In term of welfare, the following takes place. Suppose, for the purpose of illustration, that the tariffs rate on the imports from country C is fixed at the pre-union level. In country A, trade liberalization with country B makes the price of the imported good from country B cheaper than the imports from country C. Since different types of goods are substitutes for one another, country A imports more from country B and less from country C. Expansion of import from country B must be balanced by the expansion of exports to country B. Suppose that the pre-union tariffs rate of country A on imports from country B is relative high while the tariffs on imports from country B is low so that the internal price of imports from C is already relatively high comparted to the imports from country B. In this case, the scope for substitution from imports from country C to imports from country B as a result of trade liberalization may be little. As a consequence, country A gains little from trade creation while it loses tariffs revenues. Therefore, formation of a PTA removes tariffs revenue while exacerbating the loss from trade diversion which results from the tariffs on the imports from country C. If countries A and B lower the tariffs from country C, the negative effects from trade diversion can be made smaller and could result in overall welfare gains. This argument equally applies to the case of free trade area. Since the formation of free trade are does not does not give the member economy a greater market power or internalise the externality, it is more likely that the member countries of a FTA reduces the external tariffs rate.

The results of simulations show that when countries A and B form a customs union or free trade association, these countries lower tariffs on imports from the third country compared with the No Agreement case. The external tariffs rate is higher in case of CU than FTA. This is due to the fact that in the case of FTA, the benefits of tariffs shared by the FTA partner is not regarded as internal.

It is noted that the countries A and B lose when they move to OR from CU or FTA. As discussed in Johnson (1954), countries will impose tariffs on imports unless the offer curve of the trading partners is a straight line. In this case, if the countries do adopt the policy of open regionalism, they are making unilateral concessions to country C.

Simulation 2

This simulation is an example in which one member country prefers open regionalism to PTA. This is due to the fact that the patterns of endowments between the potential PTA

partners are such that one of them is the symmetric to the outside economy.

As before, there are three countries in this example. To illustrate the point in a simplest way, I will assume that trade policy coordination is possible only between country A and country B. Then there are five possible coalitional arrangements in this example; No Agreement, CU between A and B, FTA between A and B, Open Regionalism between A and B and Global Free Trade. All other arrangements are ruled out.

The numerical simulations show that OR between countries A and B gives country B the highest welfare level of all the possible outcomes. The result is trivial since country B does not trade with country C. Therefore, having no tariffs on imports from country C does not harm country B at all. However, country B does gain from the removal of tariffs its trade bloc partner, country A, levies on imports from country C for the following reason. If country A joins in an open regionalism agreement, country C sets tariffs rate on imports from country A more aggressively. This has the effect of depressing the price of the export from country A which is imported not only by country C but also by country B.

We can deduce from the utility levels associated with the coalitional arrangements that No Agreement is blocked by OR as both countries A and B are better off with OR than No Agreement. Country B finds No Agreement preferable to CU and therefore CU is also blocked. Therefore, open regionalism agreement and FTA are the outcomes in the core. Country A prefers FTA but country B prefers open regionalism. We cannot say which trade arrangement will be the actual outcome but open regionalism is clearly a possibility. The country B's utility level obtained in the case of OR is greater then the level it can achieve under global free trade. The outside country, country C, is also better off under open regionalism of countries A and B than with the global free trade. Therefore, once countries A and B sign up to an open regionalism agreement, two countries in the system have little incentive to move to global free trade. Therefore, open regionalism in this case may prove to be an obstacle to the multilateral trade liberalization process.

Simulation 3

In this example, the possibility that smaller countries use the threat of forming a trade bloc of their own will force another large country to sing up to an open regionalism agreement.

There are four countries in the system and they are labelled as A, B, C and D. There are

Table 4.4: Simulation 2

The endowments												
		1	2	3								
	A	3.0	0	0								
Country	B	1.0	4.0	3.0								
	C	1.0	3.0	4.0								
Eq.	Country	Utility	Tariffs			Prices	Consumption			Trade		
	A	1.022	0	0.374	0.374	1.000	1.406	0.853	0.853	1.594	-0.853	-0.853
NA	B	2.607	0.268	0	0.080	0.934	1.797	3.310	2.836	-0.797	0.690	0.164
	C	2.607	0.268	0.080	0	0.934	1.797	2.836	3.310	-0.797	0.164	0.690
	A	1.103	0	0	0.154	1.000	0.991	1.265	1.063	2.009	-1.265	-1.063
CU	B	2.593	0	0	0.154	0.855	2.328	2.973	2.498	-1.328	1.027	0.502
	C	2.573	0.197	0.055	0	0.837	1.681	2.762	3.439	-0.681	0.238	0.561
	A	1.075	0	0	0.144	1.000	1.009	1.281	0.948	1.991	-1.281	-0.948
FTA	B	2.608	0	0	0	0.887	2.241	2.874	2.758	-1.241	1.153	0.242
	C	2.595	0.237	0.088	0	0.902	1.750	2.872	3.294	-0.750	0.128	0.706
	A	1.069	0	0	0	1.000	0.935	1.188	1.093	2.065	-1.188	-1.093
OR	B	2.611	0	0	0	0.887	2.283	2.901	2.667	-1.283	1.099	0.333
	C	2.604	0.248	0.100	0	0.925	1.782	2.911	3.240	-0.782	0.089	0.760
	A	1.122	0	0	0	1.000	0.891	1.248	1.248	2.109	-1.248	-0.248
GFT	B	2.587	0	0	0	0.845	2.054	2.876	2.876	-1.054	1.124	0.124
	C	2.587	0	0	0	0.845	2.054	2.876	2.876	-0.502	0.124	1.124

The price in the row for country A corresponds to the price for good 1 and similarly row B is for goods 2 and row C is for good 3.

restrictions in the possible coalitional arrangements and only five coalitional arrangements are possible; No Agreement, CU between countries A and B, CU between countries A, B and C, Open Regionalism between countries A, B and C and finally Global Free Trade. As shown in Table 4.5, if three countries were to form a larger customs union, it would give all the three countries higher welfare levels than in the case of the smaller union between A and B or under No Agreement. Therefore, the large customs union blocks No Agreement and the small customs union. However, the welfare levels of countries A and B will be higher still if the three countries agree to adopt open regionalism policy. It is evident that this higher welfare level is achieved at the expense of country C. In this case, therefore, OR and the large CU are in the core.

Is the outcome of OR possible? The negotiating strategy of countries A and B would be to offer country C two alternative; OR among the three countries or else they will form a small customs union between the two countries. The threat to form a small customs union may not appear to be credible since countries A and B would obtain lower welfare levels than in the case of a customs union consisting of three countries. However, if the small customs union is formed, country C loses out considerably. The welfare of country C becomes worse than it is under No Agreement. Thus, to avoid the small customs union being formed, country C may agree to open regionalism policy with countries A and B. Open regionalism agreement between countries A, B and C give the highest welfare levels not only to countries A and B but also country D which is not involved in trade bloc formation proposals at all. Therefore, although the utility level of country C is highest under global free trade, other three economies do not have incentives to negotiate further if the three economies adopt open regionalism policy.

Simulation 4

In this example, one country forces its trade partner to accept a welfare-worsening open regionalism agreement by the use of threat to form an alternative PTA with an outside country.

There are three asymmetric countries labeled as A, B and C. It is assumed that two larger countries, A and C, are unable to form a trade bloc for political or other reasons. The smallest country, B, may form a PTA with one of the larger countries. Country A is relatively large and achieves a high welfare level in the case of No Agreement. For country B, No Agreement gives the lowest utility but its trading partner, country A has no incentives to form a PTA with country B. Both CU and FTA consisting of countries A and B give a lower utility level for

Table 4.5: Simulation 3

The endowments

		1	2	3	4
	A	4.0	1.0	0	4.0
Country	B	1.0	4.0	3.0	4.0
	C	1.0	3.0	4.0	2.0
	D	4.0	4.0	4.0	10.0

Eq.	Country	Utility	Tariffs				Prices	Consumption			
	A	2.803	0	0.501	0.508	0.325	1.000	2.523	1.822	3.548	3.965
NA	B	2.803	0.501	0	0.508	0.325	1.000	1.822	2.523	3.548	3.965
	C	2.868	1.233	1.233	0	1.227	0.433	1.808	1.808	6.716	3.567
	D	5.209	0.155	0.155	0.473	0	0.429	3.847	3.847	6.188	8.503
	A	2.839	0	0	0.499	0.141	1.000	2.225	2.225	3.384	4.007
CU	B	2.839	0	0	0.499	0.141	1.000	2.973	2.498	3.384	4.007
{A, B}	C	2.777	0.189	0.189	0	1.189	0.395	1.725	1.725	6.787	3.451
	D	5.248	0.146	0.146	0.521	0	0.420	3.825	3.825	6.444	8.534
	A	2.870	0	0	0	0.261	1.000	2.007	2.007	4.472	3.733
CU	B	2.870	0	0	0	0.261	1.000	2.007	2.007	4.472	3.733
{A, B, C}	C	2.899	0	0	0	0.261	0.383	2.097	2.097	4.516	3.770
	D	5.239	0.101	0.101	0.433	0.381	0.381	3.749	3.749	6.539	8.763
	1	2.879	0	0	0	0	1.000	2.057	2.057	4.434	3.900
OR	2	2.879	0	0	0	0	1.000	2.057	2.057	4.434	3.900
	3	2.852	0	0	0	0	0.383	2.037	2.037	4.392	3.864
	4	5.294	0.180	0.180	0.531	0	0.449	3.850	3.850	6.739	8.335
	A	2.847	0	0	0	0	1.000	2.043	2.043	4.086	4.086
GFT	B	2.847	0	0	0	0	1.000	2.043	2.043	4.086	4.086
	C	2.984	0	0	0	0	0.420	2.142	2.142	4.284	4.284
	D	5.254	0	0	0	0	0.420	3.722	3.722	7.543	7.543

CU{A, B} refers to the customs union between economy A and B. CU{A, B, C} refers to the customs union between economy A, B and C.

country A. However, if countries B and C were to form a customs union, the welfare of country A decreases considerably. This threat to form a customs union between countries B and C is credible because both of these countries obtain a higher utility level in the union than in the No Agreement case. Given such a threat, country A has the incentive to form a trade bloc with country B. Even though such an arrangement would decrease the utility level of country A, it would still be better off than being left out of a customs union between countries B and C. If countries A and B were to form a CU or an FTA or adopt open regionalism policy, the welfare of country B will be higher than the case of No Agreement or CU between B and C. Therefore, country B will choose to form a trade bloc with country A.

It is evident that No Agreement and FTA between countries B and C are blocked by CU between B and C. A customs union between B and C is in turn blocked by CU, FTA or OR between countries A and B. Hence, the three possible forms of trade bloc between countries A and B and Global Free Trade are in the core.

The preferences for country A would be Global Free Trade, CU, FTA then Open Regionalism in the descending order. For country B, the order of preferences are Open Regionalism, FTA, Global Free Trade then CU. If the outcome is Open Regionalism, then countries B and C both prefer Open Regionalism to Global Free Trade. Hence if open regionalism is adopted, it could prove to be an obstacle to multilateral liberalization in this case also.

Country B obtains a higher welfare level under Open Regionalism than under FTA or CU with country A for the two reasons. First, the price of its export, good 2, relative to the price of good 1 increases and this will benefit country B. Unlike Simulation 2, country B is the exporter of good B to country C also. It is noted that although country B gives up the welfare improving retaliatory tariffs on imports from country C, it still ends up with a higher welfare level. Secondly, country B is an importer of good 3 under FTA but the trade pattern changes under Open Regionalism and it becomes an exporter of good 3 as well. Together with the higher price of good 3, this change also benefits country B. Although it is not shown in this example, the increase in the price in the price of good 2 relative to the price of good 1 alone should be enough to have a situation in which country B does better under OR than under PTAs.

Table 4.6: Simulation 4

The endowments												
		1	2	3								
	A	14.0	4.0	3.0								
Country	B	1.0	8.0	5.0								
	C	1.0	6.0	13.0								
Eq.	Country	Utility	Tariffs			Prices	Consumption			Trade		
	A	7.264	0	0.619	0.662	1.000	10.014	5.946	6.163	3.986	-1.946	-3.163
NA	B	4.418	0.182	0	0.102	0.802	2.651	5.763	5.187	-1.651	2.237	-0.187
	C	6.152	0.304	0.185	0	0.767	3.335	6.291	9.651	-2.335	-0.291	3.349
CU	A	6.984	0	0.534	0.596	1.000	10.539	5.218	5.749	3.461	-1.218	-2.749
{2, 3}	B	4.481	0.418	0	0	0.927	2.285	5.349	6.381	-1.285	2.651	-1.381
	C	6.228	0.418	0	0	0.848	3.176	7.434	8.869	-2.176	-1.434	4.131
FTA	A	7.289	0	0.610	0.676	1.000	10.000	5.798	6.398	4.000	-1.798	-3.398
{2, 3}	B	4.449	0.122	0	0	0.927	2.661	5.031	6.020	-1.661	2.969	-1.020
	C	6.142	0.195	0	0	0.848	3.339	7.171	8.582	-2.339	-1.171	4.418
CU	A	7.262	0	0	0.317	1.000	7.412	7.736	6.660	6.588	-3.736	-3.660
{1, 2}	B	4.588			0.317	0.979	4.682	4.887	4.207	-3.682	3.113	0.793
	C	6.214	0.290	0.124	0	0.801	3.906	5.377	10.133	-2.906	0.623	2.867
FTA	A	7.112	0	0	0.223	1.000	7.471	7.731	6.185	6.529	-3.731	-3.185
{1, 2}	B	4.646	0	0	0.004	0.983	4.280	4.429	5.255	-3.280	3.571	-0.225
	C	6.367	0.348	0.169	0	0.899	4.249	5.840	9.560	-3.249	0.160	3.440
OR	A	7.043	0	0	0	1.000	6.877	7.098	7.156	7.123	-3.098	-4.156
{1, 2}	B	4.647	0	0	0	0.984	4.538	4.683	4.722	-3.538	3.317	0.278
	C	6.512	0.383	0.206	0	0.980	4.585	6.219	9.123	-3.585	-0.219	3.877
	A	7.264	0	0	0	1.000	6.359	7.154	8.347	7.641	-3.154	-5.347
GFT	B	4.598	0	0	0	0.943	4.025	4.529	5.283	-3.025	3.471	-0.283
	C	6.414	0	0	0	0.873	5.615	6.317	7.370	-4.615	-0.317	5.630

The price in the row for country A corresponds to the price for good 1 and similarly row B is for goods 2 and row C is for good 3.

4.5 Concluding remarks

The two main objections to PTAs are that it creates trade diversion and may also reduce incentives for the member countries to take part in further multilateral trade liberalisation. If a trade bloc adopts the policy of open regionalism, it will avoid creating trade diversion since the policy is non-discriminatory. Moreover, the commonly held view in the literature is that although open regionalism may reduce incentives for non-member countries to liberalise trade, this is not a problem for countries in the trade bloc. When this is the case, open regionalism can be seen as a collective action to mitigate the loss from unilateral reduction in tariffs.

However, the findings in this study show that there are situations in which open regionalism could actually benefit some member countries in the bloc at the expense of the other members. In effect, these countries benefits from restricting the tariff imposing power of its trading partners in the bloc. This is due to the external effect of the tariffs imposed by the non-member countries. The results of numerical simulations suggest that it may become even harder to pursue further multilateral trade liberalization.

This finding is in sharp contrast with the commonly held view in the literature. The skepticism in the literature about the proposed open regionalism policy is usually that although the term "open regionalism" is used, the actual policy proposal in fact involves discriminatory practice. This study shows that even if the policy proposal is unconditional MFN to the letters, it may still have adverse effects.

An obvious question to ask is how likely it is that open regionalism becomes obstacle to the process of multilateral trade liberalisation. One possible way to answer this question is to carry out simulations varying the set of endowments in a systematic manner. Then one could obtain the likelihood of open regionalism being left in the core. However, I am skeptical about the value of such an exercise. The model used for numerical simulations is a very simple one. It is doubtful that the quality of debate on the merits of open regionalism is raised by finding the likelihood of open regionalism being in the core in this simple framework.

A similar point can be made with regard to the assumptions made while carrying out simulations. All examples considered in this study assume asymmetry and restrictions for the possible coalitional arrangements. In the real world, these factors are the norm rather than exceptions and therefore the situation described in this study may well arise. However, it is

meaningless to discuss how likely the real world situation agrees with these assumption.

All this type of study can hope to achieve is to demonstrate and confirm that open regionalism may prove to be an obstacle to the goal achieving global free trade. Hence, when the policy makers contemplate adopting an element of unconditional MFN in a regional trade agreement, the possible adverse effects pointed out in this study should be considered. If we were to examine the relevance of this problem to the real policy debate, it would require reasonably detailed applied general equilibrium model. This is beyond a scope of this study.

Finally, it needs to be noted that there are other reasons for which some countries could pursue open regionalism policy to serve their self-interest. One possibility is that the exported goods from the countries in an open regionalism agreement are complements. Consider the following situation. There are three countries labelled A, B and C. Countries A and B form a free trade area. Suppose that the consumers' demand in country C is such that the exports from countries A and B are complements. Hence, a rise in country C's demand for the good imported from country A is accompanied by a rise in demand for the good imported from country B and vice versa. If the volume of trade between countries A and C is reduced as a result of a tariff war between these two countries, country B's export to country C is also likely to suffer. If country C consume the export from country A less, then it is likely that the export of country B is consumed less due to the complementarity of these two goods. Therefore, the interest of country B may be best served by an increased volume of trade between countries A and C. It is possible that the volume of trade between countries A and C is greater when country A is constrained from levying any tariffs under open regionalism agreement than when it imposes tariffs as allowed by a free trade area agreement. In this case, country B would want to pursue open regionalism. Detailed analysis of this possibility is left for future work.

Chapter 5

Comments on Policy Implications

Persistent disparity in income levels across countries has led to the argument that poorer countries ought to be given help in adopting advanced technology. The findings that technological progress in East Asian economies has been modest is interpreted by some authors as supporting this view of technology. Theoretically, this view has found an expression in the form of models of innovation.

In models of innovation, devoting more resources to the innovation activities promote growth. An implication of this is that protection of such "innovative sectors" is necessary in order for less developed countries to raise their living standards. It is in this context that the findings in this thesis have relevance to the policy debate.

This thesis suggests that one cannot read too much into the finding that TFP growth in East Asian economies has been slow. It is noted that there are a number difficulties with measuring TFP residuals in a meaningful manner. Increasing importance of trade in capital goods and foreign direct investment makes the task even harder. If we were to measure the extent of technological progress as intended by Solow accurately, we would have to deal with issues such as transfer pricing, embodiment of technology in imported capital goods, varying retirement rates of capital among others.

The three-sector AK model in this thesis demonstrates that the observed pattern of factor prices can be explained while assuming that technology is a public-good. Two conclusions may be drawn. First, it is by no means clear that technology is the cause of North-South disparity. Second, even if poor countries had exactly the same technological level as the industrialised

countries, the return on investment in those countries might not be as high as suggested by some models. Thus, we should not necessarily expect convergence. Convergence could take place, however, in those poorer countries that have a higher saving rate and a favourable terms of trade with richer countries.

It would surely be absurd to suggest that poorer countries should spend a large share of its resources on R&D activities in order to catch up with richer countries. If we accept the public-good model of technology, justification for protecting the so-called high-tech sectors becomes much weaker. On the contrary, this study suggests that trade barriers especially those against imports of capital goods would have negative effects on growth as confirmed by a number of empirical studies. The model implies that having a higher savings rate and a lower rate of the population growth is the key to raising the living standard in poorer countries. Incidentally, these two issues are not unrelated. Studies suggest that falling birth rates tend to raise the savings rate.[1] Furthermore, although it is not addressed in the model, allocative efficiency is likely to play an important role. These "traditional" policy agenda that have been discussed in the context of the neoclassical model remain important.

In recent years, the issue of protecting intellectual property rights has received a high profile in the trade policy debate. The firms in industrialised countries, most notably the pharmaceutical companies, have sought to protect their monopoly power that international patent rights would allow. Protection of patent rights has become an important international trade issue because it is evidently quite easy to imitate the advanced technology in developing countries. It seems therefore that where the yields are high enough, adoption of technology is not such a problem for developing countries.

Although I have argued against laying too much emphasis on the role of technology in accounting for North-South inequality, technology is, of course, very important especially at micro-levels. International dissemination of knowledge should take place relatively easily, but there may be instances where assisting this process yields good returns. Moreover, the geography and climate of poorer countries may present technological challenges that cannot be met by the existing technology. In such cases, one could imagine that the technological resources in industrialised countries can usefully deployed for finding new solutions.

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[1] For a discussion of this issue, see Higgins and Williamson (1996).

In terms of trade policy, these studies confirm the importance of "getting the basics right". In order to narrow North-South inequality, trade liberalisation in the North as well as the South is important. In practice, this would mean that the industrialised countries need to liberalise its agricultural markets and perhaps more importantly, the developing countries should liberalise trade in manufactured goods, especially capital goods.

Moreover, this study also emphasise the importance of multilateral trade liberalisation. Open regionalism policy may appear to be innovative at first sight. However, although it is non-discriminatory and does not involve those much discussed problems with regional trade agreements, it may still hinder the multilateral trade liberalisation towards global free trade. If policy makers are wary of such a proposal, the findings in this thesis suggest that they are right to be so.

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