Structural Changes in East Asia: Factor Accumulation, Technological Progress and Economic Geography

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by

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Abstract

This thesis deals with understanding the rapid industrial change in East Asia between the mid 1970s and the mid 1990s. The countries analysed are South Korea, Taiwan, Hong Kong, Singapore, Malaysia, Indonesia, Thailand and China.

Patterns of industrial development are studied across the region in depth. We calculate industrial and regional specialisation indices to obtain an idea of the trends being witnessed. A more formal analysis of the mobility which can be observed is then conducted. Measures of mobility and persistence are obtained for the movement of industries in the region. The nature of industrial growth and decline in the region points to the possible importance of a number of theoretical explanations.

We subsequently analyse whether the patterns of change in industry seen indicate similarity in paths of development across countries. We investigate the industrial structure of pairs of countries in the region over time. We find that there is similarity in the development paths of industry in East Asian countries, with factor endowment considerations not the sole explanators.

We next examine possible theoretical explanations of the industrial change seen. We test for Heckscher-Ohlin and Ricardian effects in a neo-classical framework. We find discernible patterns and significance in terms of factor endowment effects. Technology is seen to be less important but still plays a considerable part in explaining manufacturing change.

A further theoretical explanation considered is that of economic geography. We analyse various statistics for industrial change related to economic geography. We also test a specification comparing factor endowments and economic geography. The contribution of economic geography to change in the region is measured and seen to be discernible but small and declining in importance when compared to comparative advantage forces.

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Chapter 1

Introduction

1.1 Introduction

This thesis studies structural change of industry in the rapidly developing economies of East Asia. We are interested in change in the dynamics and composition of industry in these countries, with a specific interest in any common themes which can be located. The countries which we analyse are the East Asian nations which have experienced rapid industrialisation at different points in the post-war era. The point of take-off in industrialisation of the countries was Japan first in the 1950s; followed by Hong Kong, Singapore, Korea and Taiwan in the 1960s; Malaysia, Thailand and Indonesia in the 1980s; and finally China in the 1990s. We are keen to explore whether there was any connection in the reasons behind the industrial change witnessed. We believe that national data disaggregated to an industrial level and measured over the period of a number of decades offers a rich and previously thinly explored source of information on this issue. It allows us to discuss similarities between experiences in each country with a higher degree of rigorousness as compared to more aggregate level data.

Our analysis offers evidence of similarities in the pattern of industrial structure among the countries. We subsequently investigate the reasons behind the common industrial structure pattern seen. This is done through studying the applicability of Heckscher-Ohlin, Ricardian and economic geography theory predictions for the industrial change seen in the region.

The tradition of analysing international patterns of industrial development is a well-established one. Kuznets was a pioneer in the field in the 1960s (eg Kuznets (1965), Kuznets (1966)) with his cross-sectional study of the connection between income levels and structure of production. The subsequent and extensive work of Chenery (eg. Chenery and Taylor (1968), Chenery (1975)) added more information and analysis to the issue. Large groups of countries were studied at a somewhat disaggregated level of economic sectors over time in order to draw conclusions as to the form and degree of similarity in structure of countries at the same stage of development. It was generally concluded that a number of particular paths of development could be traced internationally. Stable relationships were obtained between income and degree of industrialisation for distinct groups of countries. Grouping was related to natural-resource endowments and size of country. These factors would determine which would be early or late industrialisation countries. The availability of natural resources would delay the point at which it was worthwhile for an economy to industrialise. This work was mainly at an intersectoral level considering agriculture, manufacturing and services. We explore a similar idea for East Asia of attempting to draw out similarity in the pattern of development among countries. We differ in that we consider data at an intrasectoral level within manufacturing industry.

The work of Leamer (1987) extended that of Chenery by increasing the sophistication of the model used. Land was added as an extra factor to the existing implied Heckscher-Ohlin ones of capital and labour, allowing for a richer set of theoretical development outcomes. The innovation allowed for countries to be in particular 'triangles of diversification' based on their combinations of endowments of the particular factors. Leamer was able to explain differences in industrial structural patterns seen by those such as Chenery on a more firm theoretical footing. More disaggregated data at the three-digit ISIC code level was also studied. Leamer found some backing for his general predictions in the data, with his strongest finding being that there could be a clear difference in the industrial development paths of land-scarce and land-abundant countries. Industrial development paths in a two factor, multiple good framework have been analysed through the work of Schott (1999). He utilises the characteristics of the Heckscher-Ohlin framework to discuss the concept of 'cones of diversification'. Countries' capital-labour endowment ratios determine which cone they belong to with each cone only producing a subsector of all possible goods depending on the goods' factor intensity properties. Countries therefore display different industrial structure characteristics based on their relative endowment position at the time, with particular goods increasing and declining in importance as countries pass through different cones. We wish to see if similarity in paths of industrial change can be found among our sample countries given their diversity of initial factor endowment mixes and our consideration of multiple goods.

Similarities in the pattern of industrial development in East Asia have been a subject of considerable discussion in the last few decades. It is useful to outline how this discussion developed to indicate what issues have already been addressed by the literature on the region and what remaining questions we hope to explain in our work. Research interest was initially raised by the stellar development performance of the Newly Industrialising Economies (NIEs)- Singapore, Hong Kong, Korea and Taiwan- from the 1960s onwards. The contentious issue for analysts was the seeming difference in initial conditions and internal policies of the countries. Hong Kong and Singapore were both city-states with no agricultural hinterland. They both also pursued policies of considerable openness towards foreign trade and investment. Korea and Taiwan were larger countries and significantly more closed towards foreign investment. They were also far more involved in their economies in terms of creating new industries and directing investment into them. Nevertheless the fact that all the countries were industrialising at a similar time led to the thinking that certain common forces were at play among them. The subsequent industrialisation of the non-Singapore ASEAN countries- Malaysia, Thailand and Indonesia- led to further interest in the reasons behind industrialisation spreading in virtuous turn across the region. It should be noted that these countries displayed complex industrial policy mixes just as observed in the NIE case. The countries were not united in a free-market approach to industry. Malaysia and Indonesia were both keen to 'pick winners' by using incentives to promote particular industrial sectors (see World Bank (1993)). For example, the state-owned Heavy Industries Corporation of Malaysia was formed in the early 1980s to focus public investment on a heavy industrialization push. Indonesia created a domestic automobile and aircraft industry through protection and support. Nevertheless the countries displayed similar openness and emphasis on encouraging exports.

In view of these experiences the phenomenon was suggested of industrialisation moving in waves from Japan to the NIEs to ASEAN (eg Yamazawa (1992) and Kwan (1994)), often referred to as the "flying geese". The concept developed on the work of Akamatsu (1962) who discussed the regional spread of a particular industry- textiles. The flying geese idea was an exposition of a form of dynamic trade theory. It suggested that trade and investment flows could integrate economies and create a virtuous cycle of development based on evolving comparative advantage. For example, an economy in a region marked by such integration would import raw materials from less developed neighbors and capital goods from more developed neighbors, causing its stock of capital to expand more rapidly than its supply of labor: in other words, shifting its relative factor endowments. This economy would thus be induced to move gradually out of labor-intensive manufacturing and into more capital-intensive production. As this process continued, and capital goods continued to be imported, the economy would move further up the value-added chain. Drawn on a chart, the process takes a "V" shape, like geese flying in formation with a small group of forerunners leading a larger group of followers. Evidence offered included the increasing role played by exports and manufacturing as a proportion of the countries' output. Furthermore, attention was drawn to the nature of industrialisation changing in each of the groups over time with more capital-intensive manufacturing increasingly becoming more important. Support was provided in broad empirical terms through industrial data at high levels of aggregation for the idea of changes in industrial structure during the process of the countries' development. The idea differs from the direct concept of factor endowments resulting in an industrial structure in a particular country through the suggestion that patterns of change in factor endowments are similar across countries at different points in time, leading to their similar development paths. We consider in our work whether a similar predicted pattern and order of industrial development can be found in the region but do this through a study of the structure of disaggregated industry between countries. There is little empirical work to date in this area.

contribution

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We then explore the empirical importance of the Heckscher-Ohlin model in explaining differing industrialisation patterns in East Asia as compared to a number of other specifications. Traditional empirical work with Heckscher-Ohlin theory has been mainly using trade data. However there has been recent work considering the Heckscher-Ohlin model from the production side. Harrigan (1995) uses OECD data and finds factor endowments to be important in explaining manufacturing production structure. Harrigan and Zakrajsek (2000) use a panel of both OECD and non-OECD countries and also find an important role for factor endowments in determining production levels. An alternative explanation for industrial structure is the Ricardian model of industry-specific technological differences. This predicts that countries will produce in industries in which they have a technological advantage relative to other countries. Harrigan (1997) considers both Ricardian and Heckscher-Ohlin forces in a formulation for OECD data, finding that industry-specific technological differences are also important in explaining industrial output variation. We apply a similar analysis of factor endowment and technology effects to industrial production data in East Asia to see if there are any common forces which explain change across countries in the region. There has been no exploration to our knowledge of these explanations for industrial change using production data across the region and very limited work at the country level (eg. Kee (2001) for Singapore).

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A more recent theoretical attempt to explain such a regional pattern in industrial development has been through the concepts of economic geography (eg.Krugman (1991a), Krugman and Venables (1990, 1995)). It discusses how industrial change results in a region through the decision of firms to move between countries or remain on the balance of 'push' and 'pull' forces. The 'pull' forces are the desire to be close to suppliers (forward linkages) and to customers (backward linkages). The 'push' forces are related to increases in factor costs, representable as wage increases, through the entry of new firms. It has been posited (Puga and Venables (1996)) that development patterns in East Asia are a possible candidate to be explained by such a model. Though there has been a considerable amount of theoretical work done in this field, empirical work has only emerged recently on testing its applicability. This has been due in part to the need for sufficiently tractable versions of the model. There has been empirical work conducted with respect to international data (eg. Redding and Venables (2001)), the OECD (Davis and Weinstein (1997)) and Europe (Midelfart-Knarvik et al. (2001)), though none to date considering East Asia. We therefore apply an adaptation of one of the specifications (Midelfart-Knarvik et al. (2001)) which enable us to compare the relative importance of factor endowments and a number of economic geography variables in explaining East Asian industrial change.

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1.2 The Thesis

We now lay out the chapters which compose this thesis and preview their findings. In the second chapter we study trends in the composition of industrial production and comparative advantage across the region. It is useful to quantify the degree to which industry is localised in the East Asian region. This provides us with evidence of the degree to which industry has agglomerated in different parts of the region, rather than industry being evenly spread throughout the region. Therefore we obtain an idea as to whether industry characteristics influence country choice by firms. The empirical measure used is the Krugman (1991b) index of regional specialisation. We find fairly high specialisation by

extent of
① localisation

② specialisation

most sample countries. We then study the evolution of comparative advantage in the region. We are interested in evidence of significant mobility in industrial sectors and the details of which industries are moving at particular stages of development of a country. A derivative of the Revealed Comparative Advantage measure of international specialisation of Balassa (1965) is utilised. Industrial composition is seen to change rapidly as countries develop with movements in line with a constant increase in industrial technological sophistication. A more formal measure of the mobility observed is then attempted. This is done by means of techniques used by Quah ((1993), (1996a) and (1996b)) to analyse income convergence in the cross-country growth literature. The chapter points to considerable persistence in country specialisation as well as discernible trends in industrial mobility. Heckscher-Ohlin forces through endowments of labour and natural resource endowments, appear to influence the strongest tendencies toward comparative advantage. Nevertheless the change witnessed in other industries highlight the possible role played by technological and economic geography type effects.

Chapter 3 looks in more depth at whether the patterns of change in comparative advantage seen indicate similarity in paths of industrial change across countries. Our manner of investigation is to compare the industrial structure of pairs of countries in the region through use of an industrial structure measure derived from Krugman (1991b). We do this first by seeing how each of the countries' industrial structure compares to its compatriots in terms of time precedence or lag. What emerges from this discussion is that there is a discernible pattern of progression in terms of structural similarity between the sample countries. Countries' structure continuously evolve towards those of countries more developed than them. The least developed countries are the perennial followers with the middle income developing countries of Malaysia and Thailand coming next, and the most developed countries being in the leading group. We then measure more precisely the dynamic characteristics of similarities in industrial structure. The connection between industrial structure and developmental stage is studied through an econometric specification. The GDP this is not a measure of distance

per capita ratio between countries is used as an approximation to their relative developmental positions at each point in time. The bilateral GDP per capita ratio and fixed effects as a proxy for differences in initial conditions between countries are used as explanators for changes in bilateral industrial structure correlation. It is found that GDP per capita differences are negative and highly significant in terms of explaining differences in industrial structure. This corroborates our earlier findings. We explore the components of the relationship by estimating a regression comparing developmental stage and industrial structure with the inclusion as additional variables of differences in some factor endowments measures among countries. It is seen that the additional variables are not enough to explain the patterns of similarity in industrial structure in the East Asian countries along their development path. It is therefore important to investigate factor endowments in more depth as well as alternative theories as explanations for the common pattern of industrial change seen in the region.

Chapters 2 and 3 discuss the nature and extent of similarity between the industrial change of the East Asian countries. Chapters 4 and 5 analyse possible explanations which the countries may have in common to explain their industrial change. Chapter 4 considers Heckscher-Ohlin and Ricardian forces in the region. We investigate the relative endowment positions of the countries between each other to see if this provides pointers as to their relative industrial change compared to their neighbours. The chapter then studies factor endowment and technological change explanations of disaggregated manufacturing patterns observed in the region. The work is important because of its original empirical attempt to consider the importance of Heckscher-Ohlin and Ricardian specifications in a comparable manner with respect to East Asian industry. This is done by adaptation of a theoretical specification developed by Harrigan (1997) allowing us to derive separate empirically estimatable constructs for factor endowments effects and factor endowments considered together with technology. We find discernible patterns and significance in terms of factor endowment and technology effects. Standardized coefficients indicate that skilled labour and capital are the most economically significant variables for the greatest number of industries. Technology is seen to be less important but still plays a role in explaining manufacturing change in all sectors. Industrial change in each of the sample countries is better explained by a specification which includes technology.

The fifth chapter considers the importance of economic geography in explaining industrial changes in the region. We apply a testable theoretical model comparing economic geography to its most common theoretical alternative the factor endowments approach. This is important because there is very little empirical work on economic geography in East Asia, a region to which the theory seems fairly well suited as discussed above, and none testing for factor endowments at the same time. The analysis has been made possible by acquisition of recently published data on comparable input-output statistics at a disaggregated level across East Asia. It is very likely, as we see in earlier chapters, that change in the region will involve some role for factor endowments. This approach allows us to compare the relative importance of the two theories in a concrete manner. Its consideration of cross-sections of industry at different points in time also allows us to draw out the time aspects of comparative advantage forces which are subsumed in earlier consideration of disaggregated industries across time. Our method has a number of shortcomings which may cause measurement error and so our results should be treated with sufficient caution. Increasing returns to scale in industries is not accounted for and some information has had to be proxied. We find our empirical results follow theory in indicating the positive and often significant effect of comparative advantage forces. Agriculture abundance is generally the most significant, skilled labour grows and then declines in significance, and capital increases rapidly in significance. Economic geography variables exhibit little significance individually, with forward linkages being the most significant initially but declining over time while transport cost effects and backward linkages are latterly increasing in significance. When considered as a group, we find that economic geography considerations do not explain a statistically significant degree of the industrial change seen in any of the periods. We check for goodness of fit of the specification for countries and industries and see that it generally does better at explaining the latter in East Asia. The contribution of economic geography to explaining change in the region is measured and seen to be discernible but small and declining when compared to comparative advantage forces. We offer a number of suggestions for why our specification does not find economic geography forces to be significant in the region in the sample period, related to the particularities of our specification and method of measurement as well as to the nature of the region´s industrial change

Chapter 2

An Empirical Investigation of the Changing Structure of East Asian Industry

2.1 Introduction

This chapter seeks to conduct a wide-ranging examination of the changing structure of East Asian industry over the last three decades. The period has clearly been one of tremendous development and change in the region with the resulting transformation in the industrial landscape. An understanding of the precise nature of this industrial change in terms of factors such as time precedence and persistence and mobility of industries is useful as a first step in the evaluation of competing theories. Our work follows on from a number of papers which seek to explore the industrial development of different regions in terms of existing theory. Examples include Kim(1996) with US regional data, Amiti (1997) and Brulhart (1998) with EU national data, Davis and Weinstein (1999) with Japanese regional data and Ruhashyankiko (1998) with international data.

Our sample group in the region includes China, Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan and Thailand. Industrialisation has spread in the region rapidly over the last 40 years. What is seen in the region is industry spreading in a series of waves- starting from Japan, spreading first to Korea, Taiwan, Hong Kong and Singapore, then to Malaysia, Indonesia and Thailand, and latterly to China and Vietnam. This can be seen from Figure 2-1, which displays the change in percentage of labour force employed in manufacturing for Japan and two aggregate group of countries. The aggregates are of countries in the two separate waves of industrial change. We see the differing rates and directions of change reflect the different phases of the groups' industrial change. Some countries are reducing their labour force´s involvement in manufacturing while others are employing increasingly more of their people in it. Japan is generally moving downwards from an intermediate level, the first wave of Hong Kong, Singapore and Taiwan are decreasing rapidly from a high level while the second wave of Indonesia, Thailand and Malaysia are increasing equally rapidly from a low base.

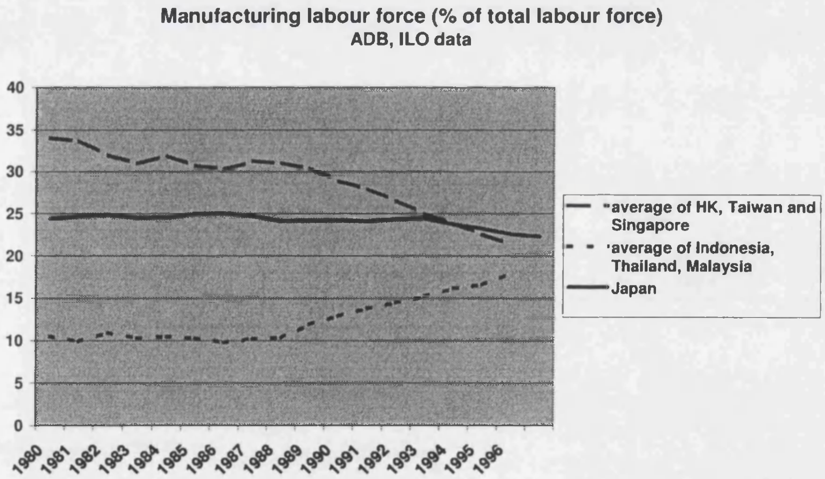


Figure 2-1: Manufacturing labour force (as % of total labour force)

There has been a considerable amount of work done on studying patterns of industrial change in various regions. We discuss what the findings have been regarding specialisation across countries and industries and how our work relates to it. We subsequently present measures for specialisation based on the

Krugman (1991b) regional specialisation index and Balassa (1965)'s industrial revealed comparative advantage (RCA) index. Patterns and anomalies across the region are highlighted in an effort to motivate further work to examine theoretical causes behind the observations. Certain trends emerge fairly clearly which raises questions as to which of a number of theories are the most appropriate for the region.

The layout of the chapter is as follows. Section 2.2 provides a theoretical framework for the empirical analysis to follow. Section 2.3 provides calculations of an index of regional specialisation. Section 2.4 provides measures of relative comparative advantage for industries in each of the East Asian countries in our sample over time. Section 2.5 provides a formal analysis of the dynamics of comparative advantage across countries over time. Section 2.6 maps some of the dynamics observed. Section 2.7 concludes.

2.2 Theoretical Framework

Our work builds on previous work by a number of authors who have studied patterns of intercountry industrial specialisation and national intraindustry comparative advantage. A substantial amount of empirical analysis of intercountry specialisation has been conducted with respect to Europe. Specialisation is considered in terms of either production or exports, with the former generally seen to be rising in the region and the latter decreasing. Examples include Sapir (1996), Amiti (1999), Haaland et al (1999), Midelfart-Knarvik et al. (2000) and Brulhart (2001). For example, Amiti (1999), using production data, finds more countries with increase rather than decrease in specialisation in the region. Similar work has been done on specialization patterns within the US economy such as Dumais et al. (1997), Hanson (1998), Kim (1995), and Krugman (1991). Kim (1995) analyses the US regional specialization pattern over a long time series, 1860-1987, showing that regions were more specialised when the US was becoming an integrated country before the First World War, although since the interwar years specialisation has been falling. Specialisation in the US and EU have been compared by Krugman (1991), Midelfart-Knarvik et al. (2000) and Aiginger et al (1999). Regional specialisation is seen to be higher in the US than in the EU. Our work is similar in that it considers industrial data across countries, but applies such analysis to East Asia.

National intraindustry comparative advantage is often considered through variants of the export-based measure of Revealed Comparative Advantage (RCA) suggested by Balassa (1965). Numerous applications have been made of the measure to analyse industrial change within countries over time. Examples include Aquino (1981) and Crafts et al. (1986). The question of whether a production or trade based measure should be used to calculate RCA is an important one. Both have been suggested with theoretical justification as both production and the pattern of trade are affected by the economic conditions which determine the international pattern of comparative advantage. Ballance et al. (1987) tested numerous RCA measures for consistency between each other. They find that the empirical distinction between industries that enjoy comparative advantage and those that do not is not too sensitive to the choice of RCA index. We will use a trade-based RCA measure.

Another issue with RCA is that it utilises post-trade prices to make judgements about comparative advantage which refers to pre-trade relative prices. Hillman (1980) analyses this issue and concludes that the RCA measure is applicable to cross-country comparisons and is consistent with the empirical nature of individual country and world trade given certain conditions. These are that the country's exports of a particular good are simultaneously neither overly prominent in its total exports nor overly prominent in total world trade in that good. An underlying assumption is that the reference countries have identical homothetic preferences.

We utilise a variant of a RCA measure, first looking at change in the relative importance of "named" industries over time within countries. Subsequently we attempt to draw out information about patterns of mobility across industries within countries. This is done by means of techniques used by Quah ((1993), (1996a) and (1996b)) to analyse income convergence in the cross-country growth literature. This methodology is useful because it utilises both time-series and cross-section variability in the data. Proudman and Redding (1998) also use these methods to find the RCA mobility pattern for the G5 countries. We apply their methodology to East Asian data and extend it by considering dynamics not only via transition matrices, but also via stochastic kernels.

2.3 A Regional Specialisation Measure

It is useful to quantify the degree to which industry is localised in the East Asian region. This provides us with evidence of the degree to which industry has agglomerated in different areas, rather than industry being evenly spread throughout the region. The countries in our sample are Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand.

The measure we use is from Krugman (1991b) as stated in Kim (1996) and is expressed as:

$$SI_{jk} = \sum_{i=1}^{n} \left| \frac{E_{ij}}{E_j} - \frac{E_{ik}}{E_k} \right| \tag{2.1}$$

where E_{ij} is the level of employment in industry $i = 1, ..., n$ for country j and E_j is the total industrial employment for country j and similarly for country k. An index value of 0 indicates that the industrial structure of region j is identical to that of region k. The other extreme is an index value of 2, indicating that the regions are completely different in structure. This therefore gives us a measure of differences in industrial structure, and so regional specialisation as well.

Using the sample of 8 countries and at the 2-digit ISIC industry level, we obtain 28 bi-regional indices over time. We can then obtain aggregate indices for each country as well as an aggregate regional index. The country aggregate index for country j is made up of the average of the sum of SI_{jk} for all k. The aggregate regional index is the unweighted average of all the country aggregate indices. The results are presented in Figure 2-2 in graphical form. The index is stable over the period 1974 to 1991 between 0.60 to 0.69. This indicates that the degree of regional specialisation is between 30% (i.e. 0.60 divided by 2) to 35%. When compared with a maximum value of 43% and a minimum value of 23% in the American Midwest over the considerable time period 1860 to 1987 (see Kim (1996)), the East Asian region can be argued to have a reasonable amount of regional specialisation. However, it is important to note that the aggregate index numbers obtained depend on the sample of countries which are compared to each other. We have utilised a subset of the world which we feel has some unique characteristics and therefore differences within them are interesting. The ideal case though would be to compare the region with the world.

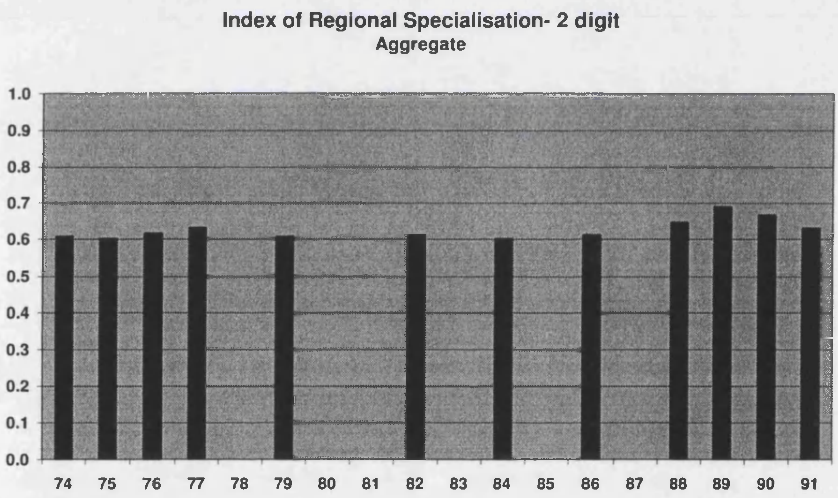


Figure 2-2: Aggregate Index of Regional Specialisation- 2 Dig ISIC Code

It is perhaps more useful to analyse differences between individual country index numbers to remove some of the issues associated with considering an aggregate regional index. We therefore disaggregate to a national level to look for variations in specialisation between the sample countries (Figure 2-3). There is a considerable difference in industrial structure with Singapore and Hong Kong being by far the most specialised countries with index numbers on an increasing trend between 0.7 and 0.8. Korea is clearly the least specialised with a value staying stable around 0.4. Taiwan and Thailand are notable for showing a sharp pattern of increase rising from around 0.5 to 0.7 before falling to around 0.6. Indonesia also stands out for its roughly stable and substantial specialisation level of 0.7. To some extent the difference for Singapore and Hong Kong will lie in the fact that they are geographically small, non-resource-rich economies. Their small populations would make them less likely to attract market-seeking industries. The countries' lack of agricultural production and natural resources also make them less attractive to manufacturing industries which utilise such raw materials. There is thus a smaller range of sectors in which the countries potentially produce, resulting in them being more specialised. Korea as the largest economy in the region may be the least specialised for this reason too. These criteria do not however apply as much to the other sample countries.

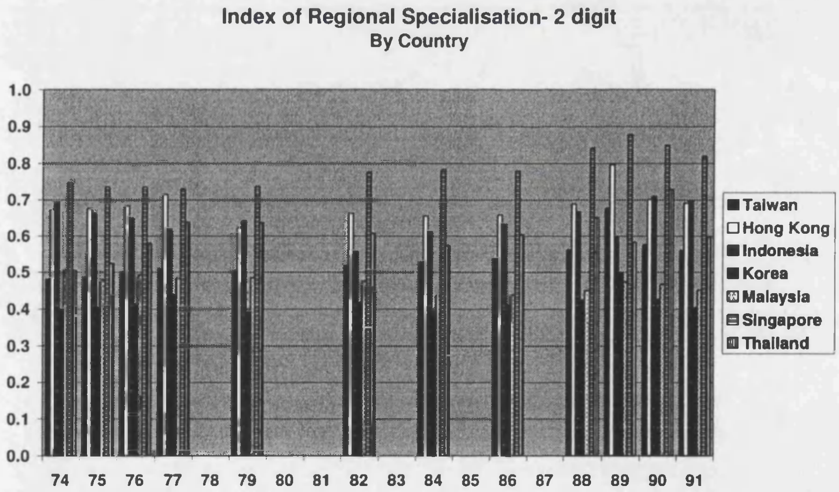


Figure 2-3: National Indices of Regional Specialisation- 2 Dig ISIC Code

We conduct a more formal analysis of whether the countries differ significantly in terms of their specialisation level. There is evidence of first-order non-independent observations within some of the sample country time series, as measured by Durbin-Watson statistics. We therefore take observations from every other year for each country to manage this source of autocorrelation. We perform runs tests on each of these country samples and find no evidence of non-randomness. Analysis of the country samples' residuals also indicates that the specialisation measure is not normally distributed. We therefore conduct a Kruskal-Wallis non-parametric test of similarity of means between the sample countries. We obtain significance at the 0.01% level indicating that the mean specialization levels of the countries are different.

It is worthwhile enquiring as to whether the qualitative nature of the index values is sensitive to the level of disaggregation at industry level. We recalculate all of the above measures at the 3-digit level of ISIC industry classification (Figure 2-4). We find that the pattern of the regional aggregate index is also stable, having a range of between 0.76 and 0.83.

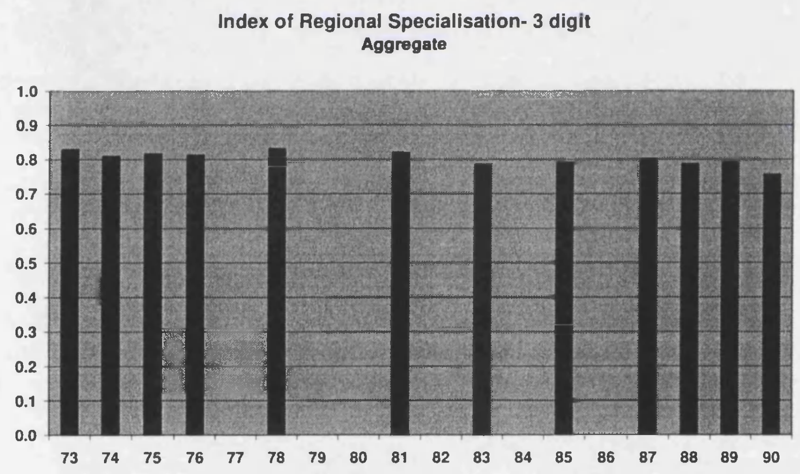


Figure 2-4: Aggregate Index of Regional Specialisation- 3 Dig ISIC Code

At a national level, similar trends to the previous analysis are seen (Figure 2-5). Hong Kong and Singapore remain the most specialised, though their trend is gradually downwards instead of upwards. Indonesia is also closer to the two leaders than in the previous analysis. We repeat the statistical test for difference in country specialization levels undertaken at the two-digit level. Autocorrelation is found in the country results as in the two-digit case, and is managed in the same manner with resulting non-significant runs tests. The Kruskal-Wallis test of similarity of means again provides very significant results at the 0.01% level, indicating difference in specialization levels of the sample countries.

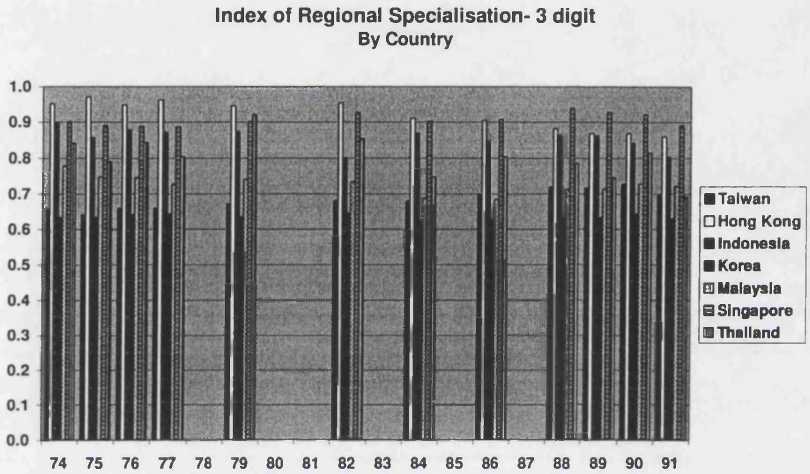


Figure 2-5: National Indices of Regional Specialisation- 3 Dig ISIC Code

It is not surprising (as mentioned by Kim(1995)) that the average values in the 2-digit specification are lower than those at the 3-digit level as greater specialisation can be expected to be observed when industries are more specifically defined. However, the question of note is whether disaggregation leads to a different pattern of results. Here it seems that the stable nature of the results over time remains.

In terms of the data we see fairly high specialisation by most sample countries. In comparison, Midelfart-Knarvik et al. (2000) analyse 13 countries across 36 industries for the period 1970-1997 and obtain Krugman specialisation indices ranging from 0.201 to 0.779. This is lower than the 3-digit specialisation indices range that we obtain which is between 0.623 and 0.971. We find that the degree of specialisation is highest for Hong Kong and Singapore in our sample. The proviso should be borne in mind, as mentioned earlier, that small countries tend to display higher index numbers. Differing specialisation results among the countries may be influenced by a number of other reasons as well. The degree of trade barriers is pinpointed in the theoretical literature as being important. This is because a reduction in tariffs allows the easier separation of production from consumption. Hong Kong and Singapore are known for having the freest trade structures in the region. Korea, Indonesia, Malaysia and Thailand all have trade barriers of various levels for different goods and this may well play some part in the lower specialisation patterns observed.

It is important to note that while the overall extent of specialisation remains relatively constant across countries, which industries a country specialises in may change dramatically over time as we go on to show and discuss. An analysis of regional specialisation along with industrial specialisation serves to provide a rounded picture of the different forces at work in regional industrial change.

2.4 Mobility of Comparative Advantage

We now study the evolution of comparative advantage in East Asia. We are interested in evidence of significant mobility in industrial sectors over the relatively short sample period of 1970 to 1994 and the details of which industries are moving at particular stages of development. The approach and methodology of the following two sections is adapted from the work of Proudman and Redding (1998) who applied the techniques to EU data.

The index often used for such calculations is the Revealed Comparative Advantage measure of international specialisation of Balassa (1965). RCA of economy i in sector j is defined as the ratio of share of world exports of economy i in sector j to share of total world exports of economy i in all sectors. The Balassa index is a relative measure of specialisation as it conditions for country size. This is through its weighting of the export figures in a particular industry by the country's overall share of world exports. Such an idea is sensible if one is concerned about a country's comparative advantage. This allows us to understand what factors determine the location of an industry across countries. However, to understand theories such as new economic geography, it is also useful to think about absolute measures of industry specialisation. These are measures not conditioned by country size. We then obtain an idea of which industries tend to be more concentrated within a region than others, allowing us to consider theories of what determines these industry characteristics. At present, we will consider a relative specialisation measure but a later investigation of absolute specialisation would be of some interest.

The problem with the Balassa measure is that the mean value of RCA is not necessarily equal to one due to the numerator not being weighted for the proportion of exports accounted for by sector j. At any point in time, one may thus not have a true reflection of the deviation from the mean of a reading. Furthermore, over time the mean may exhibit movement leading to loss of comparability for different data points.

We use instead the alternative RCA measure of Proudman and Redding (1997) which compares the export share of sector j for country i to average export share of country i in all manufacturing sectors N. This provides a logical measure of the relative export strength of a given industry while ensuring through construction that the mean value is constantly one. The measure is as follows,

$$RCA = \frac{Z_{ij}/\sum_i Z_{ij}}{\frac{1}{N}\sum_j (Z_{ij}/\sum_i Z_{ij})} \tag{2.2}$$

Values range from zero to above with a value greater than one indicating a sector in which the country is relatively strong in terms of exports. We study the export composition of manufactures for each sample country over time using trade data for 21 industries obtained from the OECD Bilateral Trade Database (BTD) (as outlined in Appendix 2.8.1). Sample countries used are China, Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan and Thailand.

The data considers exports from these countries to the 23 OECD economies presented in the OECD BTD. The data therefore leaves out intra-country trade between the East Asian sample countries. There is the possibility that an accurate reading of the export structure of the countries, and consequently their structure of comparative advantage, is not being obtained. In this case we would be obtaining an estimation of the changing structure of the part of a country's industry involved in extra-regional exports. The use of the data source is not ideal but acceptable for a number of reasons. First, intra-East Asian exports account for a minority of exports in the countries and period concerned. For instance, Bank of Japan (2000) analyses intra-East Asian exports between South Korea, Taiwan, Singapore, Hong Kong, Indonesia, Malaysia Philippines, Thailand and China. It is seen that in the time period 1985-87 intra-regional exports as a percentage of total exports were 17% for the group of South Korea, Taiwan and Singapore, 24% for the group of Thailand, Malaysia, Philippines and Indonesia, and 34% for the group of China and Hong Kong. Another point of concern is the possibility that intra-regional exports may have been increasing significantly during the period analysed. This could lead to the data analysis mistakenly concluding the quantity of exports to have changed for a country when they have actually merely been redirected from extra-East Asian to intra-East Asian destinations. Kreinen and Plummer (1994) analyse intra-East Asian manufacturing exports between South Korea, Hong Kong, Singapore, Thailand, Malaysia, Indonesia and the Philippines in 1981 and 1990. This group does not include China which is discussed separately below. It is seen for the group of Malaysia, Thailand, Philippines and Indonesia that intra-regional exports remained stable at 24.8% from 1981 to 1990. For the group of Singapore, South Korea and Hong Kong intra-regional exports decreased slightly from 14.8% in 1981 to 14.5% in 1990. It may be therefore reasonable to assume that there had not been much change in intra-regional trade in the region during a large part of the time period considered in the analysis.

We have also been keen to use OECD data as the partner countries represent relatively stable export markets. We are using trade data to give us an insight into production changes within the East Asian sample countries. We would therefore like this data to be explaining changes within our sample rather than changes within the partner countries. A number of non-OECD countries to which the sample countries export have undergone changes in their tariff regimes, particularly China. This would affect the amount exported to them by our sample countries, but would not be because of changes in conditions within the sample. Though we see above that intra-East Asian trade for the sample group except for China remained fairly stable over much of the sample period, this is not so much the case if we include China. Mckinnon and Schnabel (2002) see that for the latter group intra-East Asian trade increases from 21.7% in 1980 to 32% in 1990, whereas without China the corresponding figures are 18.9% and 22%. Chinese imports of intermediate manufactured goods rose by 80% between 1984 and 1991, while consumer manufactured goods imports increased by 999% (World Bank (1994)). The average import tariff in the country fell from 55% in 1982 to 45% by 1994 (Landy (2001)), and quotas and licenses which were applicable to 46% of all tariff lines in the late 1980s were applicable to 18% of tariff lines by 1992. In comparison, the average weighted tariff rate for the OECD between 1980 and 1990 stayed relatively stable at 8-9% (World Bank (2001)).

At each point in time we see the make-up of RCA, and across time we study its evolution. To smooth out shocks we consider five year RCA averages. We obtain 5 sets of RCA figures for each country covering the periods 1970-74, 1975-79, 1980-84, 1985-89 and 1990-94. The results are listed in Appendix 2.8.2.

Sectors are ranked in order of increasing RCA for the first period. In subsequent periods, the initial order of ranking is maintained while displaying the new RCA values. This provides an indication of how RCA is changing compared to the starting date. In each graph, RCA is displayed around the mean value of one. It is clear that there is a substantial degree of RCA mobility for every country in the sample. This is seen most directly if one compares the RCA ordering in the final period to the first period. A grouping of the gains and losses of RCA for each country between the two periods is also instructive as seen in Table 2.1.

CHINA		**HONG KONG**	
Gain	Loss	Gain	Loss
Comm, semicond	Stone, clay	Computers	Fabricated metal
Electrical machinery	Food, drink	Instruments	
Rubber, plastics		Electrical machinery	
INDONESIA		**KOREA**	
Gain	Loss	Gain	Loss
Rubber, plastics	Chemicals	Shipbuilding	Wood, cork
Textiles, leather		Computers	
Wood, cork		Electrical machinery	
MALAYSIA		**SINGAPORE**	
Gain	Loss	Gain	Loss
Computers	Food, drink	Computers	Chemicals
Rubber, plastics	Non-ferr metals		Wood, cork
TAIWAN		**THAILAND**	
Gain	Loss	Gain	Loss
Computers		Computers	Non-ferr metals
Fabricated metal		Comm, semicond	
Electrical machinery		Rubber, plastics	

Table 2.1: RCA gains and losses per country 1970-1994

Most countries have similar ratios of gains to losses. However Thailand is notable for gains in four sectors the largest of the group, whereas Singapore only gains in one sector the lowest of the sample countries. Singapore, Malaysia and China also stand out for losing two sectors, whereas the others lose one or none in the case of Taiwan. A closer look at the composition of gains and losses is highly instructive and raises many possible questions. The computer industry is gained by all the countries except China and Indonesia. It seems that only the two poorest countries in the sample fail to gain this industry. The widespread distribution of the industry could be explained by the fact that when industries spread to new countries they do not abandon their previous host but instead maintain some resources there. Singapore, for instance, has gradually lost many lower-end high-technology operations while maintaining top-end production, R&D and headquarters divisions.

Newer developing countries such as Indonesia, Malaysia, Thailand and China have gained less-skilled sectors such as rubber, plastics, wood and cork whereas their more developed neighbours have not gained operations of as great a labour-intensity. Indeed, Singapore and Korea lost sectors such as wood and cork over the period. This matches the expectations of factor endowments theory. It also chimes with new trade theory models which foresee labour-intensive industries with no great agglomeration forces being the first to move between countries as wage cost pressures are critical to them. However, a model such as Young (1992) also fits the data with countries gradually moving up the technological ladder. To establish the more relevant model, tests of the causes of regional industry movement analysing factor endowments, technology and economic geography need to be undertaken.

In addition to an actual gain or loss of RCA, there are substantial changes in the degree of RCA for a sector. This is seen by a change in the height of columns. For example, while Taiwan did not lose its RCA in textiles and footwear, its degree was dramatically reduced from 2.85 to 1.08 (remembering that 1 is the mean). Therefore the changes expected by theory such as movement of industries to lower-wage countries are often occurring but not to a great enough degree to show up as a change in the direction of RCA.

We can obtain an idea of the overall extent of specialisation in a country by looking at a graph of RCA for the final period 1990-94 displayed in increasing order. We do not find systematically higher RCA figures in specific sectors and smaller RCA in others when comparing their evolution with the first period 1970-74. This would exhibit itself as more concentrated end-points of the graph in the final period compared to the first one.

2.5 Measuring Mobility

A more formal analysis of the mobility which can be observed from the above graphical analysis is now attempted. This is done by means of techniques used by Quah ((1993), (1996a) and (1996b)) to analyse income convergence in the cross-country growth literature.

Considering RCA for an industry in a country as x, distribution of its values across industries at a point in time is referred to as $G(x)_t$. If we assume for simplicity that the behaviour of RCA follows a first-order autoregressive process, the behaviour of RCA over time can be modelled as,

$$G(x)_{t+1} = A.G(x)_t \tag{2.3}$$

where A is a vector term which describes the mapping of the previous distribution of RCA to the current distribution of RCA in the country. RCA distribution at any point further ahead in time can be considered in the same manner by an iteration of the above process forward. We thus have,

$$\begin{aligned} G(x)_{t+m} &= (A.A......A).G(x)_t \\ &= A^m.G(x)_t \end{aligned} \tag{2.4}$$

The above formulation taken to a point forward m of ∞ provides the expected long run behaviour of RCA if we believe that changes in RCA behave in a first-order autoregressive manner. This allows us to see whether RCA in the long run displays increasing specialisation, equivalent to understanding the evolution of the external shape of the RCA distribution rather changes within it. The division of the space of possible values of x into a number of discrete cells w (in our case four) allows us to obtain a transition matrix of the probabilities of annual RCA observations remaining the same or moving to another of the value spaces w. These probabilities are measured by counting the number of entrants and leavers with respect to a particular cell (which for us represents a particular range of RCA). This provides us with a measure of mobility of RCA from its lower to higher regions. Measures of movement in the RCA distribution as time tends to ∞ are also obtained and referred to below as the ergodic distribution. The cells in all cases were calculated to provide a roughly equal number of industry-year observations in each. All calculations were undertaken with Quah's TSRF econometrics package.

Transition matrices were obtained using annual RCA data for each of the sample countries and the tables are presented in Appendix 2.8.3. As a guide to reading the tables, we use the example of the pooled sample which is presented in Table 2.2. The pooled sample is also very useful as a guide against which the individual country matrices are compared to check for differences. The numbers in the first column represent the number of industry-year observations beginning in the relevant cell (1112, 937,1001 and 998). The top numerical row numbers are the upper end-point RCA values of the relevant cells (0.04, 0.22, 0.99, ∞). The subsequent numerical rows have the following interpretation. They provide the probability of leaving a particular state of RCA and moving to each of the other possible RCA states. For example, the third numerical row shows the probability of remaining in the lower-intermediate RCA state (0.81) or moving to either the lowest (0.08), higher-intermediate (0.11) or highest (0.00) RCA states. The sixth numerical row provides the ergodic distribution.

Pooled	*UpperEndpoint*			
Number	0.04	0.22	0.99	∞
(1112)	0.89	0.10	0.01	0.00
(937)	0.08	0.81	0.11	0.00
(1001)	0.00	0.07	0.84	0.08
(998)	0.00	0.00	0.06	0.93
Ergodic	0.156	0.195	0.289	0.360

Table 2.2: Pooled sample transition matrix

To see if the assumption of a first-order process is valid in the long run, we check for the degree of similarity between the one-year transition matrix iterated five times and the five year transition matrix. If the evolution of RCA was fully characterised by a first-order time-homogenous model we would expect both sets of results to be identical. This comparison is conducted for the pooled sample as shown in Table 2.3. We see that there are differences between the two, indicating that the evolution of RCA is not exactly characterised by a first-order autoregressive process. The probabilities of persistence for the five year transition matrix are higher than the one-year transition matrix iterated five times. Nevertheless the order of the probabilities of moving between states is very similar in both cases. In addition to the one year iterations listed in the tables in Appendix 2.8.3, we calculate five year iterated transition matrices for each of the sample countries as an approximation to medium-term patterns of movement between states.

5 Year Pooled	*UpperEndpoint*			
Number	0.10	0.42	1.29	∞
(144)	0.73	0.23	0.04	0.00
(117)	0.07	0.63	0.29	0.01
(114)	0.01	0.18	0.65	0.17
(129)	0.00	0.00	0.15	0.85
Ergodic	0.062	0.201	0.340	0.397
	1x transitions iterated 5x			
	0.61	0.28	0.10	0.01
	0.22	0.44	0.28	0.06
	0.03	0.17	0.50	0.25
	0.00	0.03	0.19	0.73

Table 2.3: Five year transition matrix

The main diagonal for each table shows the probability of remaining in any particular state as opposed to all other states. The probability of mobility from each state is therefore one minus the probability of persistence in the state. Analysing this, we see in the transition matrices in Appendix 2.8.3 that the range between lowest and highest probabilities of moving states from a particular state is 8%-22% (China), 6%-19% (Hong Kong), 5%-35% (Indonesia), 6%-14% (Korea), 6%-16% (Malaysia), 6%-31% (Singapore), 7%-23% (Taiwan) and 6%-26% (Thailand). The lowest probability of moving states is very similar between countries while the highest probability of moving states displays a considerable range. Still, all of the highest probability figures are substantial enough to support our belief of considerable mobility in all sample countries. We can confirm our belief that there is substantial mobility by looking at the values for the one year transition matrix iterated five times. This gives us an approximate idea of outcomes in a longer time frame. We obtain much higher mobility values as compared to one-year transitions, of 30%-49% (China), 24%-55% (Hong Kong), 19%-52% (Indonesia), 33%-46% (Korea), 23%-49% (Malaysia), 23%-69% (Singapore), 27%-61% (Taiwan) and 24%-65% (Thailand). There appears to be a rather substantial tendency to move between RCA states over the longer term.

It is highly instructive to look into the details of the transition matrices. It is seen that in all cases the lowest probability of leaving a state is when RCA is highest. This seems to indicate that a sector in which an economy is clearly highly specialised does not change easily. A more informal view by means of studying the RCA graphs provides further detail of this phenomenon. The industries at the highest RCA level in the initial period for most countries (Hong Kong, Thailand, Singapore, Korea and China) tend to be seen near the top in the reordered final period graph as well. Examples include textiles (China, Hong Kong and Thailand), petroleum refining (Indonesia) and wood (Malaysia).

The probability of remaining in the lowest RCA state is second only to that of remaining in the highest state. This is true for all countries except Indonesia.

The inference is that the sectors where a country has a great disadvantage remain constant over time. This could apply, for instance, to a lack of sufficient capital endowment for heavy industry or lack of market size to attract industries with increasing returns to scale and high transport costs. Examples include shipbuilding (Thailand) and motor vehicles (Singapore and Indonesia).

Within the two middle RCA states, the lower-intermediate stage displays a greater mobility than the higher-intermediate one for all countries except Korea where it is equal. It is interesting to note that there is a greater probability for RCA to move in a positive direction than a negative one from the lower-intermediate stage for all countries barring Hong Kong. Similarly, there is a greater probability of RCA moving in a negative direction than a positive one from the higher-intermediate stage for all countries except Korea and Indonesia. The differences between moves in the positive and negative direction are not however very substantial for either of the RCA stages so no great theoretical significance can probably be drawn.

The finding that the greatest mobility is found in the middle two quadrants of the respective matrices matches the findings of Proudman et al. (1997) obtained with respect to some European countries. Examples in East Asia include the growth of the computers (Taiwan, Hong Kong, Singapore, Korea), and plastics (Thailand, Malaysia, China) industries, decline in the plastics (Hong Kong), textiles (Taiwan), wood (Singapore, Korea), and non-ferrous metals (Malaysia, China) industries. There are indications from this that a country's inherent comparative advantage is difficult to change being linked to characteristics such as natural resource or labour endowments. There is however considerable possibility of development through change in comparative advantage in many other sectors which are not as tied to strong country advantage or disadvantages.

The iterated matrices for each country, providing an approximation to the pattern of moving between cells over 5 years, confirm the above findings. We see that persistence in the top RCA range is highest for all countries. Indonesia is prominent amongst the sample countries for its particularly high reading. On the other hand, the persistence of the countries in staying in the lowest RCA state is second highest among the four possible states. It is interesting that when one is taking a longer time perspective, there is not as great a difference in persistence between the first, second and third states. Indeed in some cases there is nearly as great a chance of remaining in the middle two states as the first one. We find that the likelihood of remaining in the lowest RCA state is less apparent when given considerable time as compared to our analysis of one year transitions.

We can now consider changes in the external shape of RCA, in other words whether a country is increasingly specialising in a limited subset of industries. Given that the mean of all industry RCAs is one, we could either see a concentration of extreme RCA values in a few industries or RCA spread fairly evenly over industries. We find that all countries except Taiwan, Hong Kong and China exhibit increasing specialisation in the highest RCA state. However all countries except Hong Kong exhibit lower specialisation in the lowest RCA state. Though the standard deviation as a whole has declined this is because of the impact of the greater decline in the lower RCA range as compared to the increase in the higher RCA range. So now we see greater detail to the pattern of specialisation. The fact that as a whole the standard deviation of RCA has reduced is an indication that there is a less skewed distribution of export shares across industries within a country (Ruhashyankiko (1998)). Agglomeration in the sample countries seems to have declined. We do not obtain the predictions of the new economic geography models which imply a polarisation of the RCA distribution to extreme values over the sample period.

The pattern of specialisation confirms what we found through the more ad-hoc analysis of RCA graphs. This is that most East Asian countries gain more sectors of RCA advantage than they lose. Though this was clear earlier in terms of the observed gains from negative to positive (ie. RCA below 1 to greater than 1), we now have clearer proof that this trend is present even for industries already starting above an RCA of 1. These results suggest that a country's inherent comparative advantage, for example through labour or natural resource endowments, remain important though other factors such as gain in technological capability contribute to the considerable movement in industry witnessed in the region. The latter effect is seen, for example, through the gain in more advanced countries of the electrical machinery and computer industries over time.

2.6 Mapping Mobility

We are able to remove one of the artificial constructs of the above analysis by considering the probability of movement of RCA in industries to new values in a precise manner instead of into a number of discrete ranges of RCA. The ranges were previously arbitrarily chosen so as to provide a roughly equal number of industry-year observations in each grouping. We can remove this arbitrariness by letting the states be all possible intervals, including infinitely small ones. The transition probability matrix is replaced by a stochastic kernel. The kernel is like a transition probability matrix with a continuum of rows and columns. TSRF calculates the kernel when provided with the RCA data. It also constructs a contour map of the kernel which highlight the kernel's critical features. The results are presented in Appendix Figures 2-54 and 2-55.

To interpret the kernel, stand at any point on the period t axis. Looking across the kernel parallel to the $t+1$ axis, observe the shape of the surface of the kernel. This line is a probability density, and it is non-negative and integrates to 1. The more likely is a transition probability, the higher the point.

As with a transition matrix, the 45- degree diagonal indicates persistence, therefore the higher the surface along the diagonal the more persistence in the distribution. When clusters appear along the 45-degree diagonal, they represent dynamics that are absorbing- after entering such an RCA state, one encounters persistence.

Unfortunately we can only construct the kernel and contour for the pooled data. This is the only sample for which we have enough observations per year. A number of general trends emerge from the diagrams. There is considerable persistence with a number of clusters along the diagonal. Persistence is highest i.e. everywhere?

at the lowest, middle and high RCA values. This is useful as we obtain further detail as to the exact nature of persistence along the diagonal. Previously we have seen that there is lower persistence in the middle as compared to the extremes. Now we obtain detail that the persistence in the middle is observed most at a particular area in the center. Mobility is seen between the three peaks with the tendency being a downwards movement. This implies an RCA other than at the cluster points along the diagonal has a tendency to fall gradually in the next period. The analysis poses the question of why there is a likelihood of considerable persistence at intermediate values of RCA. These and other questions outlined above highlight the many issues which arise from this study of industrial movements across the region and which require further analysis to understand change in the area.

2.7 Conclusion

This chapter attempts to make a contribution to the empirical literature on international specialisation by considering a case study of East Asia. We point out a number of discernible trends across the region as well as discrepancies across countries. A study of the pattern of regional specialisation confirms a reasonable level of specialisation throughout the region coupled with differing levels of specialisation across countries. This suggests that it is worthwhile to study industrial change across the region as countries face considerably different circumstances with consequent variation in industry response, leading to a rich data source of economic forces.

We see that the RCA results display a combination of persistent advantage in some sectors and mobility or “churning” in other industries. It can be seen that the mobility in industries is not random. The nature of change in comparative advantage is fairly clear from the type of sectors where RCA is being gained by countries as compared to lost, though the absolute magnitude of RCA in these sectors is not as great as traditional areas of RCA advantage or disadvantage. The finding that there has been considerable increase in exports in technology or knowledge driven industries in East Asia has been noted also by various other studies (eg. Sheehan et al. (1996)).

The fact that change in industrial composition in the region exists alongside fairly stable country specialization results is due to a number of factors. One is that there is still considerable persistence in the comparative advantage of selected sectors in the sample countries. Persistence in these sectors serve to offset churning in other sectors. Industries linked to natural resources, such as wood in Malaysia and petroleum refining in Indonesia, display persistent comparative advantage.

A second group of sectors which have displayed persistent comparative advantage are those in "retainable industries", as outlined by Gomory and Baumol (2000). These are industries with increasing returns to scale due to high start-up costs in specialised learning and equipment. Once a country has been able to overcome such start-up costs and enter an industry it is difficult for other countries to enter and compete in these sectors as the earlier entrant will already be gaining productivity through technological advance. There is a role for government in overcoming entry costs as the benefits of acquiring a retainable industry for a country are greater than those which accrue only to the relevant firms involved. Industrial policy in a number of East Asian countries attempted to pick industries through incentives (see World Bank (1993)). A number of countries were successful in some industries and this is reflected in our results. We see rubber, plastics and shipbuilding in Korea, petroleum refining and shipbuilding in Singapore, rubber and plastics in Taiwan, and computers in both Taiwan and Singapore from later in our sample period. The fact that there has been considerable movement in comparative advantage in other industries in our sample follows to some degree the concept of them being "non-retainable industries". These are industries which are easy to enter for countries as they are assembly-type operations depending on moderate non-specialised skills coupled with low wages.

Another reason for the country specialisation and mobility of industrial structure results is that the change in industrial structure towards the new industries has been similar across countries in the region. Therefore countries are becoming no more different and perhaps closer to each other in industrial structure. Furthermore, the change in structure towards such industries has been a relatively recent phenomenon in our sample period. Singapore, Hong Kong and latterly Malaysia and Thailand, have been most prominent in these areas in the 1980s and 1990s, whereas Indonesia is only emerging now. Therefore the full effect of dynamism in comparative advantage in these sectors is not reflected in the sample period considered, and so traditional areas still dominate some of the results in terms of sectors of greatest advantage.

Our findings highlight stylised facts which fit certain theories better than others. Heckscher-Ohlin forces through endowments of labour and natural resource endowments may influence the strongest tendencies toward comparative advantage. Nevertheless the growth and change witnessed in other industries highlight the possible role played by technological and economic geography type effects. The subsequent steps are to establish to what degree the industrial movements seen are common across the region and subsequently to conduct formal tests of the main theoretical candidates using appropriate data from the region.

2.8 Appendix

2.8.1 Data Description

Source for Figure 2-1: Total labour force and manufacturing labour force data for all countries except Japan obtained from Asian Development Bank online statistics database. These are collected by the Bank from the national statistical agencies of the respective countries. Aggregates were obtained as the arithmetic averages of the summation of the countries' percentages of labour employed in manufacturing. Japanese data from the International Labour Organization.

Data for calculation of the Krugman index of regional specialisation was obtained from the UNIDO Industrial Statistics (3 digit level). This provides employment data divided into 3-digit industrial sectors as classified by ISIC code. Sample countries are Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand. Missing data points are interpolated using available data points, or extrapolated when necessary using a five year linear trend from available data points.

Data for the Relative Comparative Advantage measures were obtained from the Bilateral Trade Database (BTD) of the OECD. This provides data for imports and exports between the 23 OECD countries and 15 partner economies. Data is provided for the 21 manufacturing sectors described in the BTD Database. The partner economies consist of Argentina, Brazil, China, Czech and Slovak Republics, Hong Kong, Hungary, India, Indonesia, Malaysia, Mexico, Philippines, Singapore, South Korea, Taiwan and Thailand. Together the data accounts for 90-95% of world trade. Sample countries used are China, Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan and Thailand. Exports of each of the countries were calculated as the summation of imports by each of the 23 OECD countries. We have had to leave out intra-East Asia trade due to limitations in the data. However, we obtain a reasonable approximation of evolution of comparative advantage (see discussion above). The manufacturing sectors considered are:

ISIC Code- Sector

31- Food, drink & tobacco

32 - Textiles, footwear & leather

33- Wood, cork & furniture

34 - Paper, print & publishing

35- Chemicals

353+354- Petroleum refining

355+356- Rubber & plastic products

36- Stone, clay & glass

371- Ferrous metals

372- Non-ferrous metals

381- Fabricated metal products

382-3825- Non-electrical machinery

3825- Computers & office machinery

383-3832- Electrical machinery

3832- Communicat. equip. & semiconductors

3841- Shipbuilding

3842+3844+3849- Other transport equipment

3843- Motor vehicles

3845- Aerospace

385- Instruments

39- Other manufacturing

2.8.2 Revealed Comparative Advantage (RCA) Tables

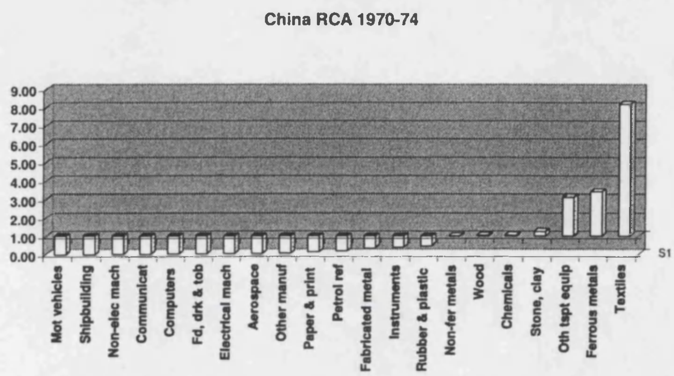


Figure 2-6: China RCA 70-74

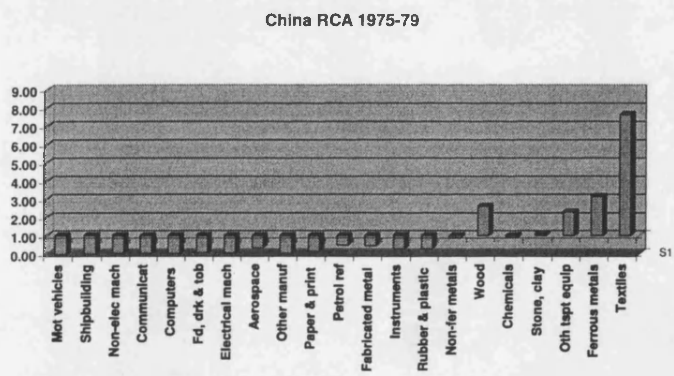


Figure 2-7: China RCA 75-79

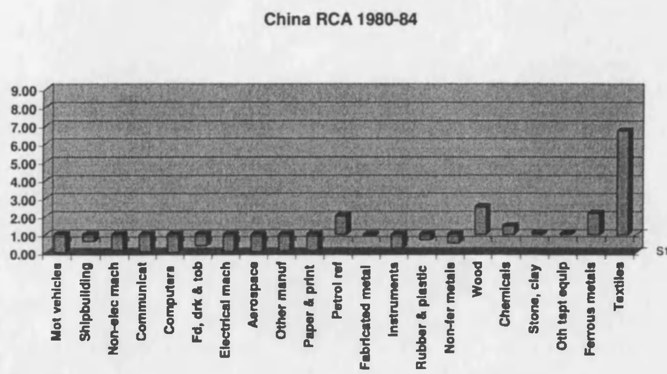


Figure 2-8: China RCA 80-84

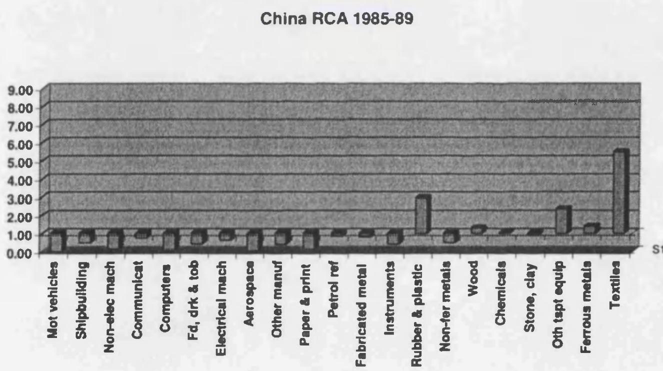


Figure 2-9: China RCA 85-89

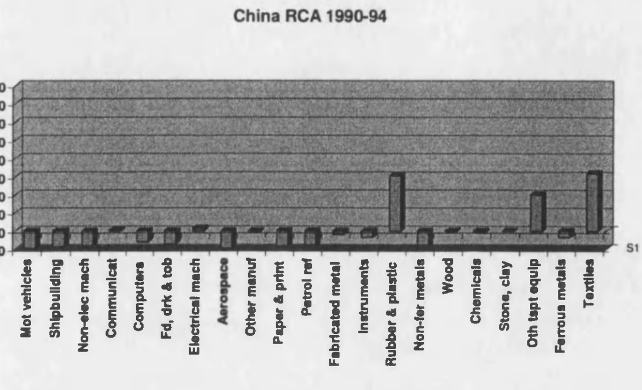


Figure 2-10: China RCA 90-94

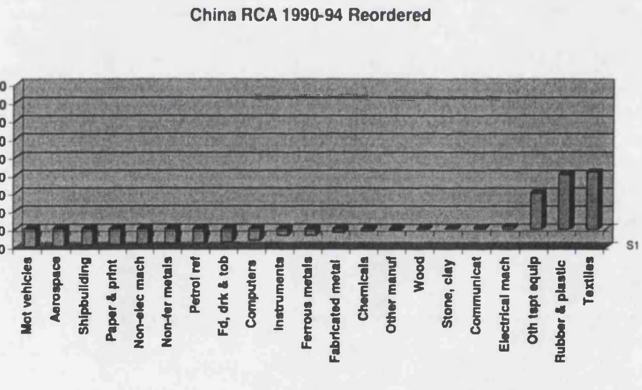


Figure 2-11: China RCA 90-94 Reordered

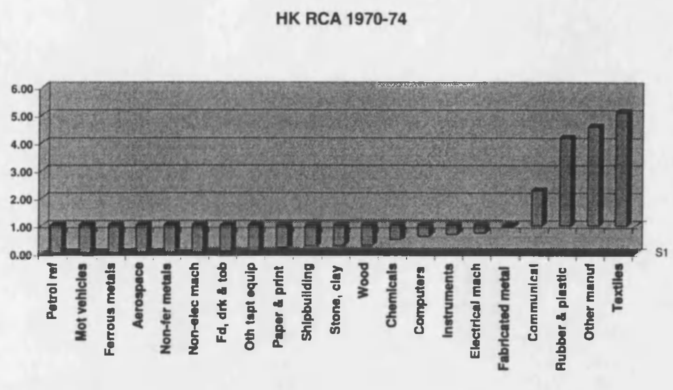


Figure 2-12: HK RCA 70-74

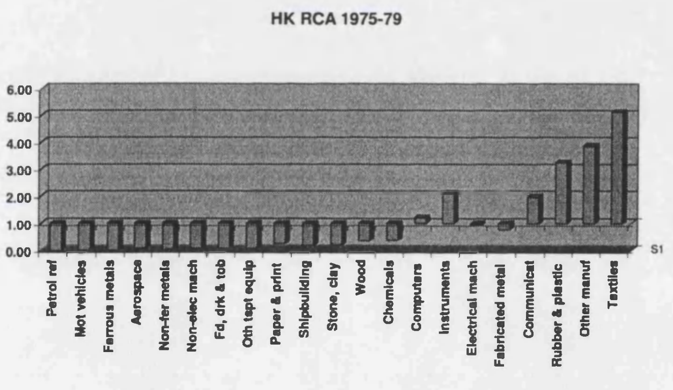


Figure 2-13: HK RCA 75-79

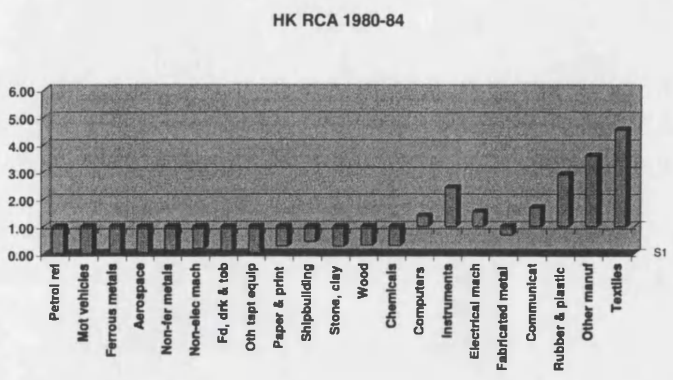


Figure 2-14: HK RCA 80-84

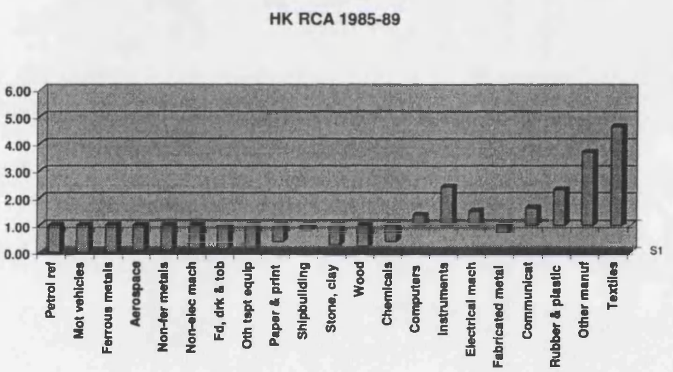


Figure 2-15: HK RCA 85-89

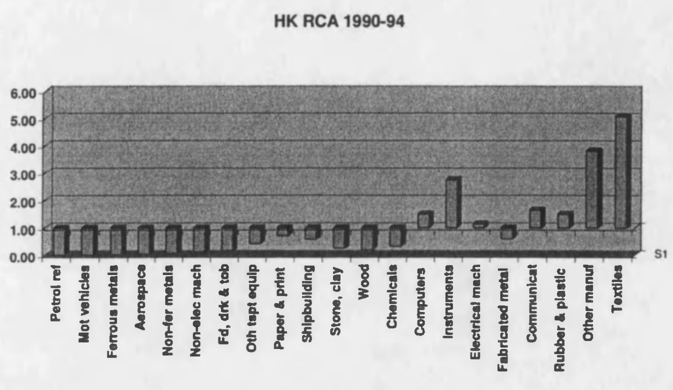


Figure 2-16: HK RCA 90-94

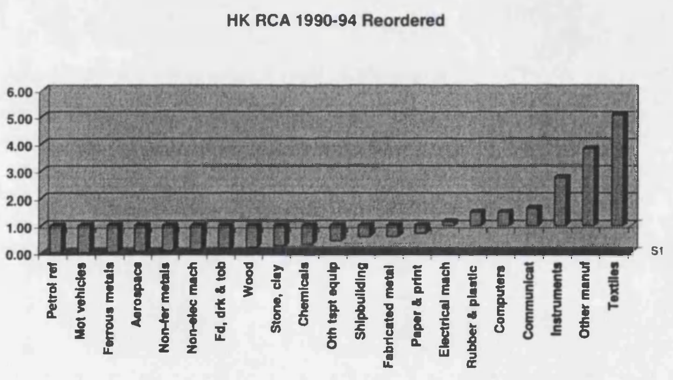
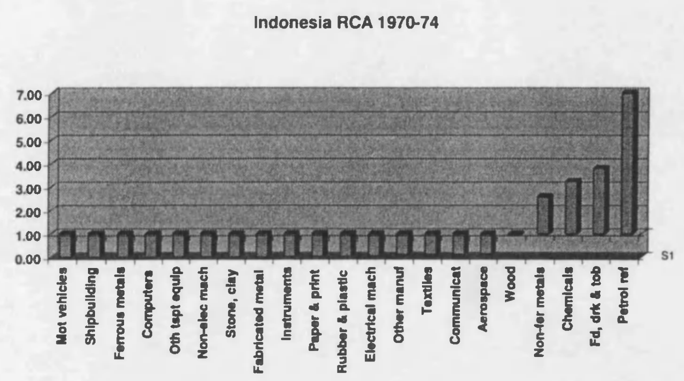


Figure 2-17: HK RCA 90-94 Reordered



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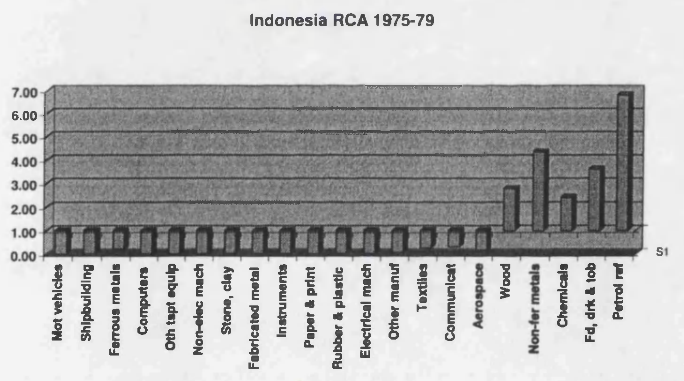

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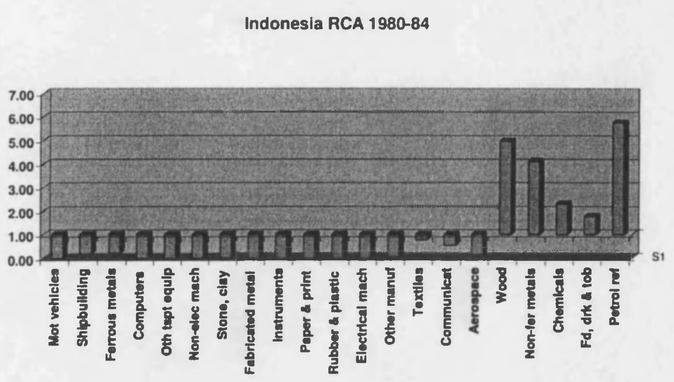
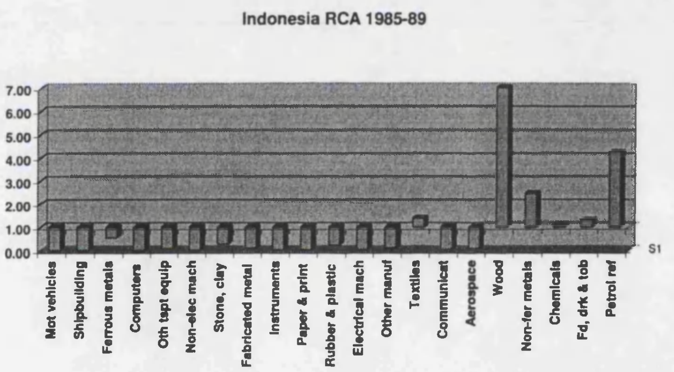


Figure 2-20: Indonesia RCA 80-84



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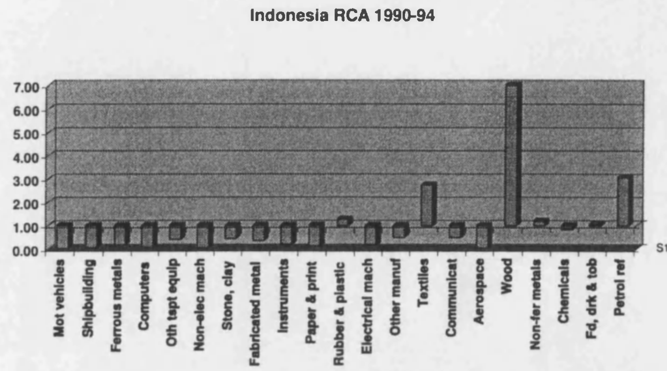

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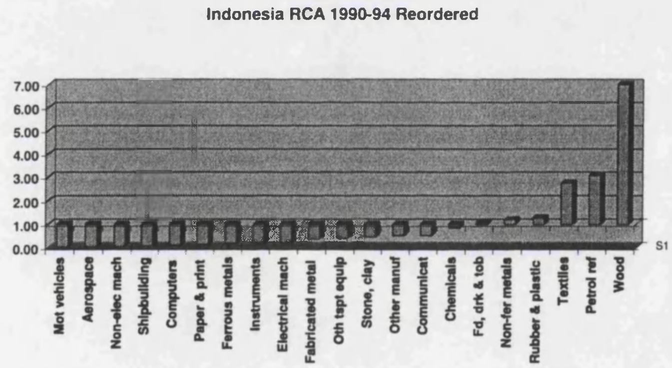


Figure 2-23: Indonesia RCA 90-94 Reordered

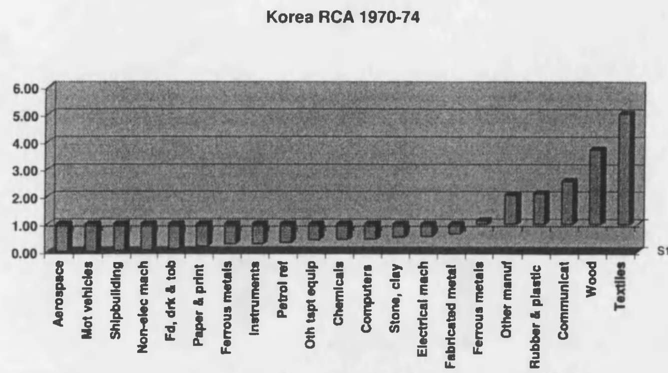
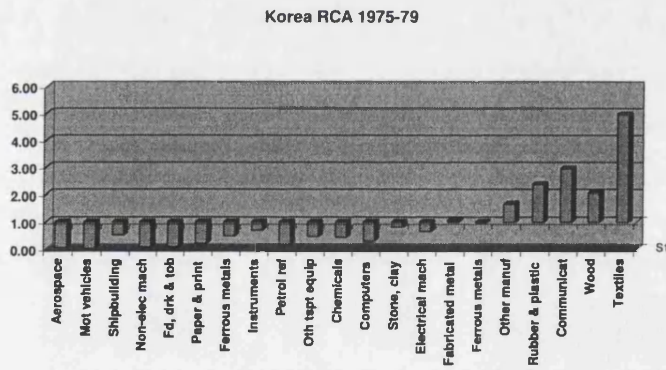


Figure 2-24: Korea RCA 70-74



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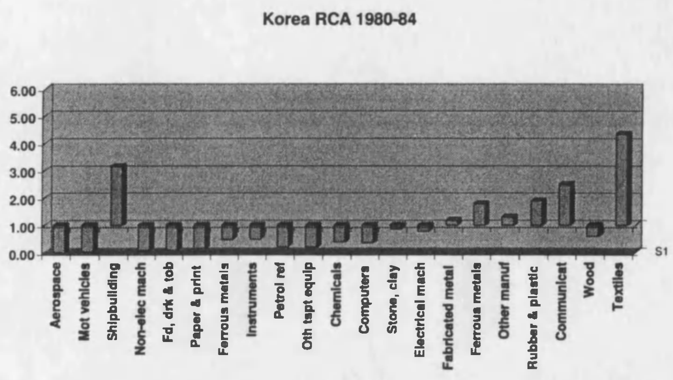
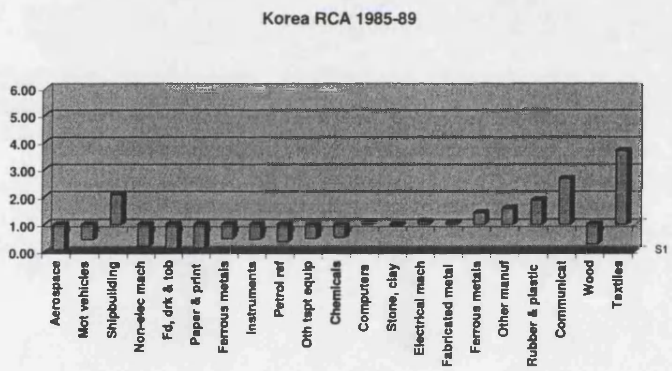


Figure 2-26: Korea RCA 80-84



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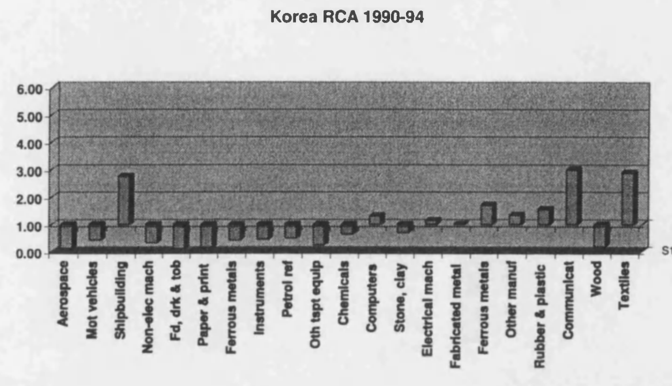

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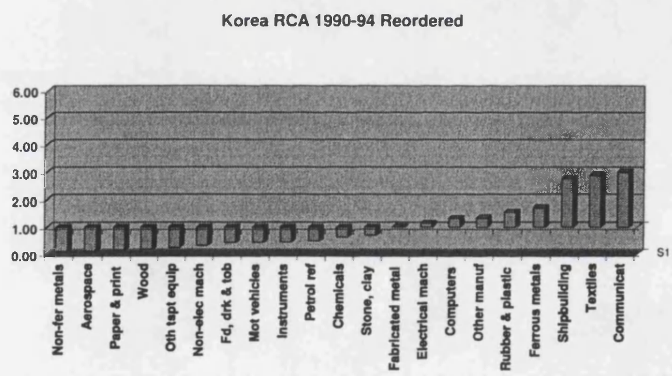


Figure 2-29: Korea RCA 90-94 Reordered

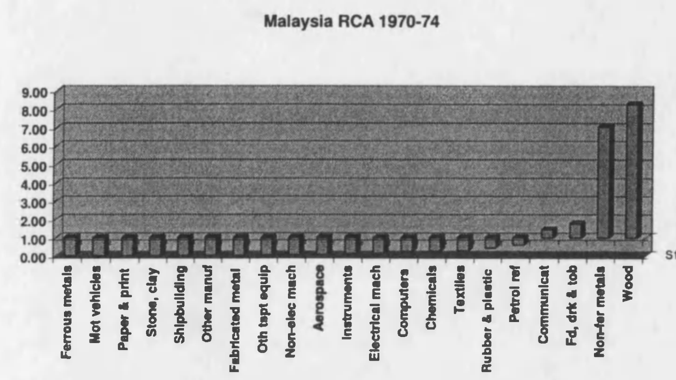
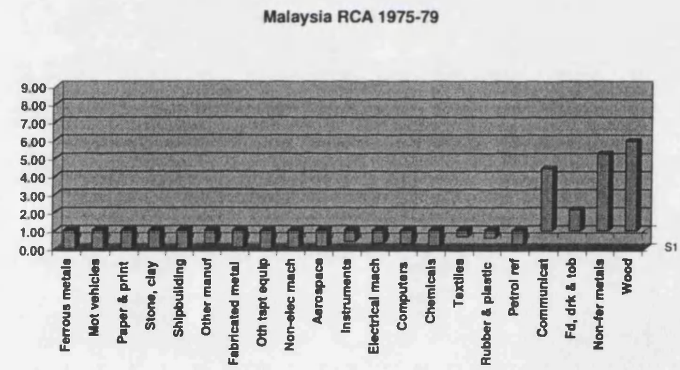


Figure 2-30: Malaysia RCA 70-74



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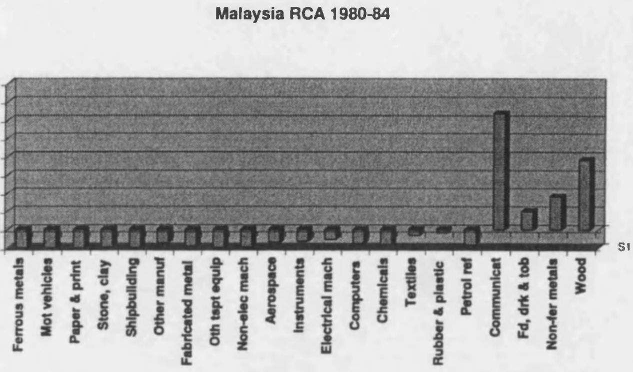


Figure 2-32: Malaysia RCA 80-84

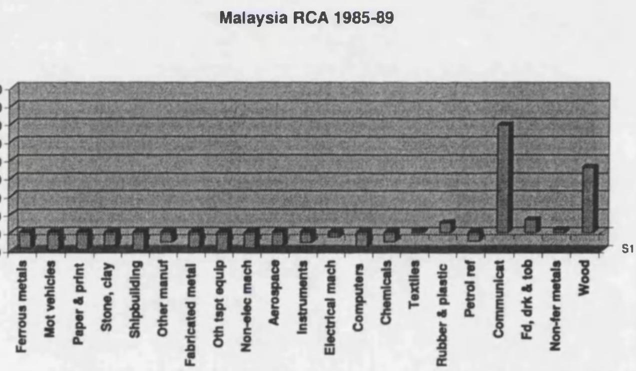


Figure 2-33: Malaysia RCA 85-89

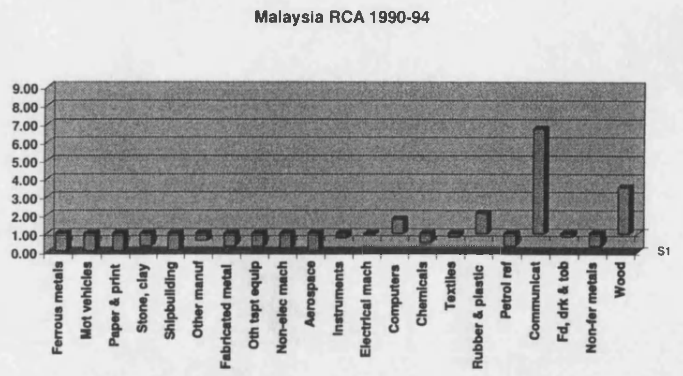


Figure 2-34: Malaysia RCA 90-94

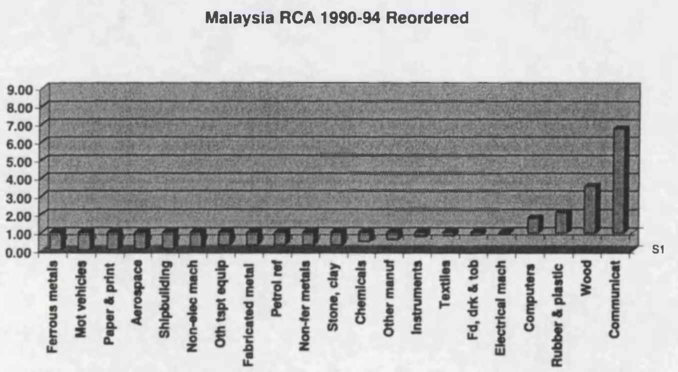


Figure 2-35: Malaysia RCA 90-94 Reordered

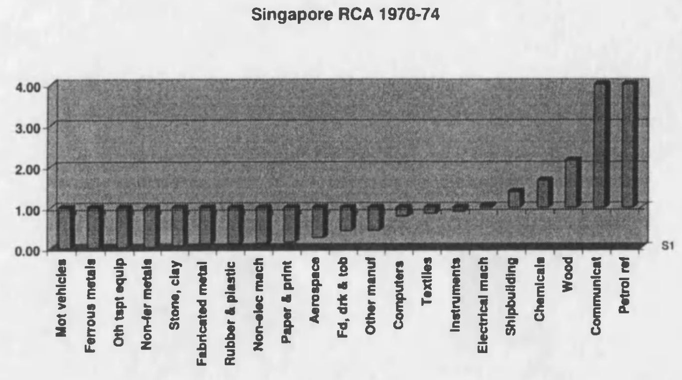
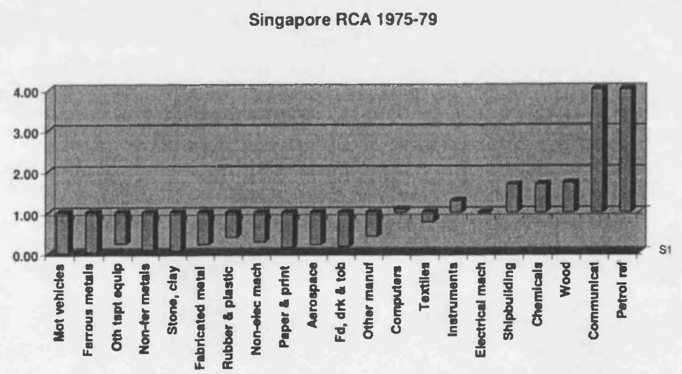


Figure 2-36: Singapore RCA 70-74



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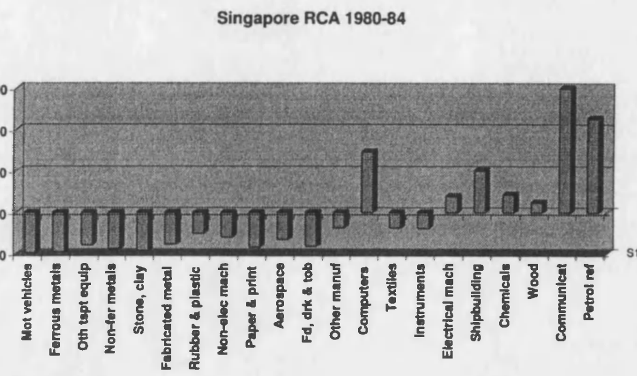


Figure 2-38: Singapore RCA 80-84

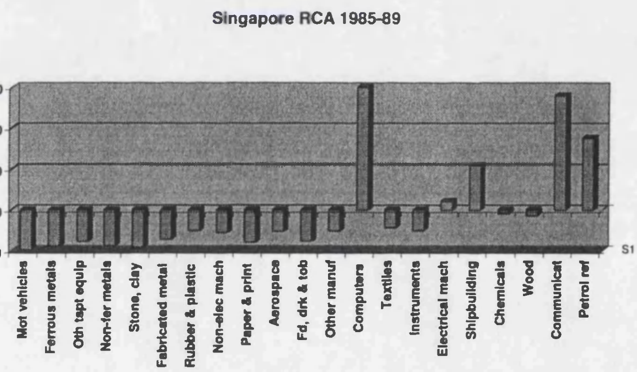


Figure 2-39: Singapore RCA 85-89

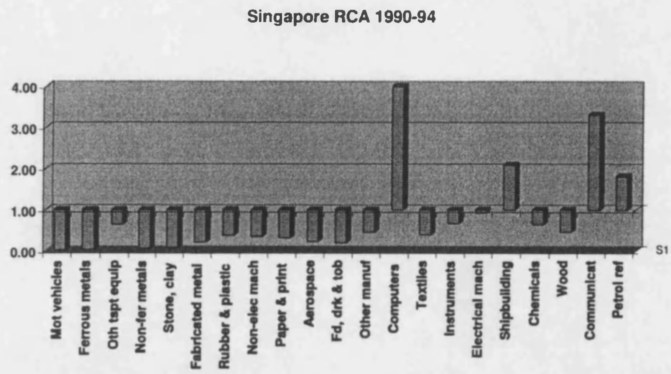


Figure 2-40: Singapore RCA 90-94

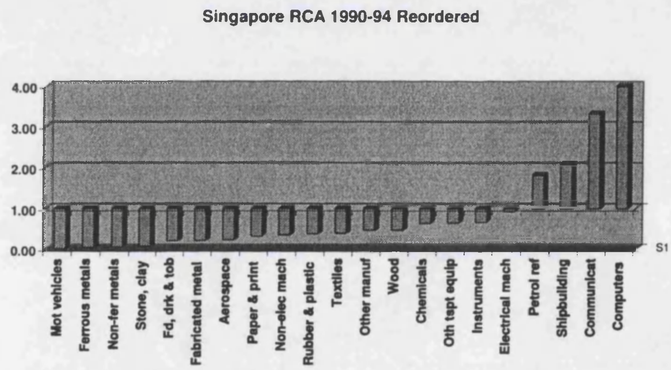


Figure 2-41: Singapore RCA 90-94 Reordered

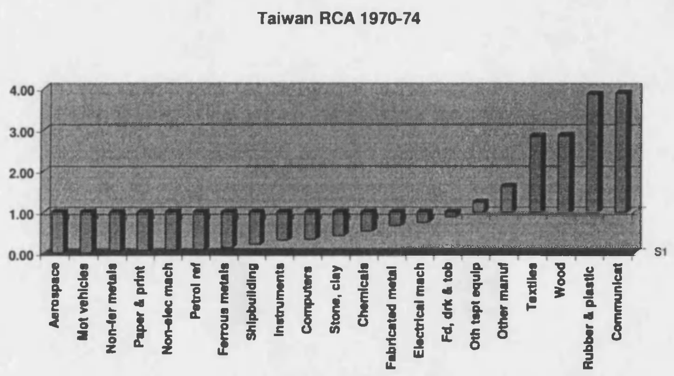


Figure 2-42: Taiwan RCA 70-74

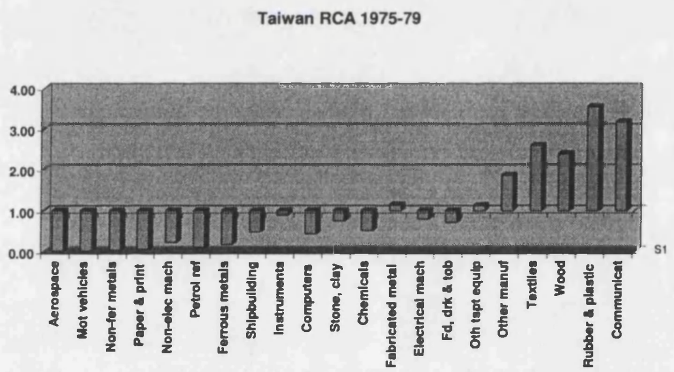


Figure 2-43: Taiwan RCA 75-79

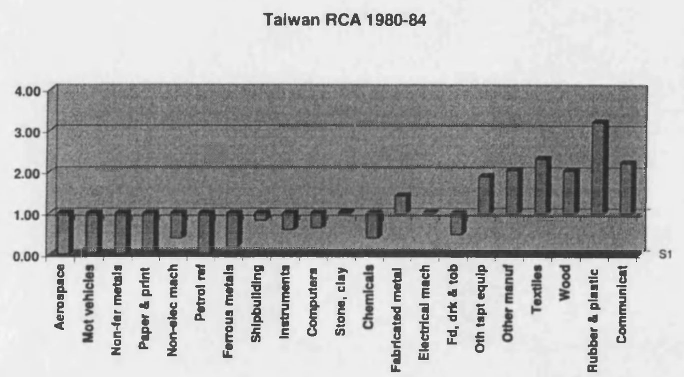


Figure 2-44: Taiwan RCA 80-84

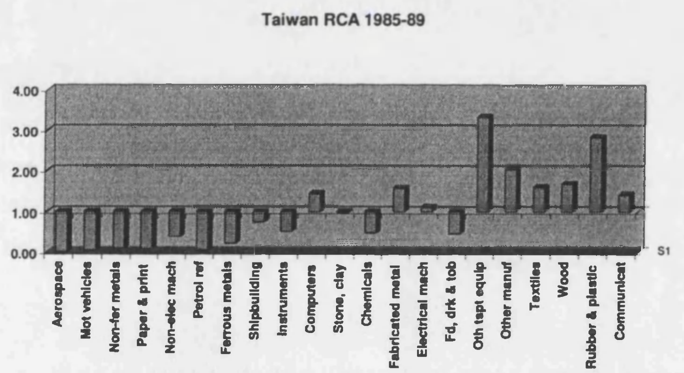


Figure 2-45: Taiwan RCA 85-89

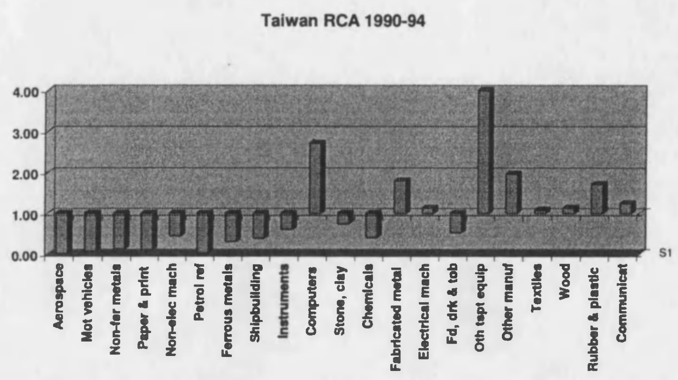


Figure 2-46: Taiwan RCA 90-94

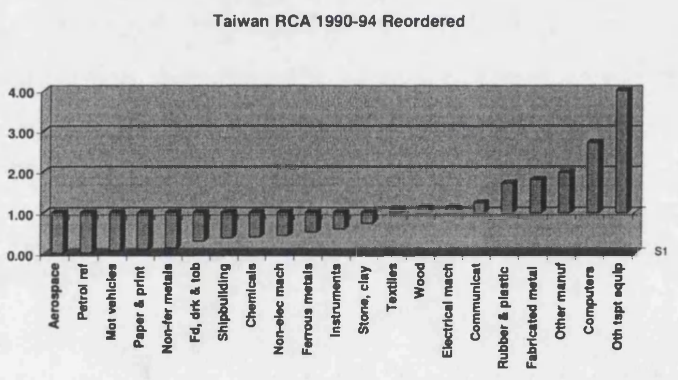


Figure 2-47: Taiwan RCA 90-94 Reordered

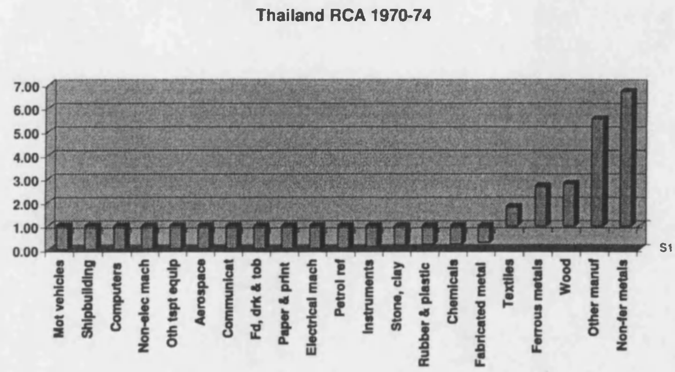


Figure 2-48: Thailand RCA 70-74

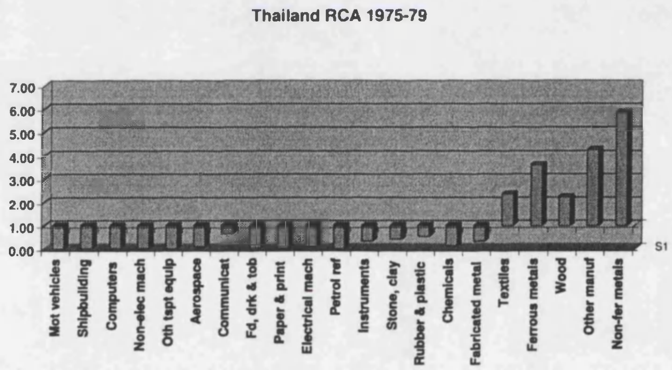


Figure 2-49: Thailand RCA 75-79

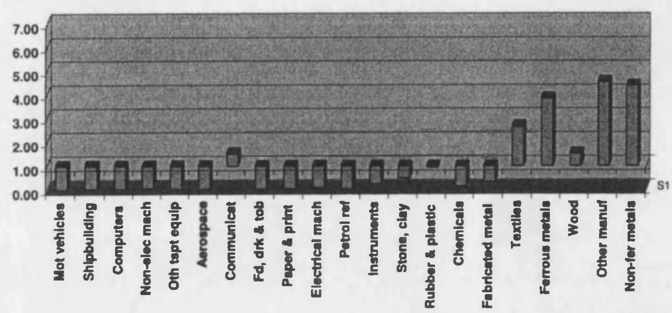


Figure 2-50: Thailand RCA 80-84

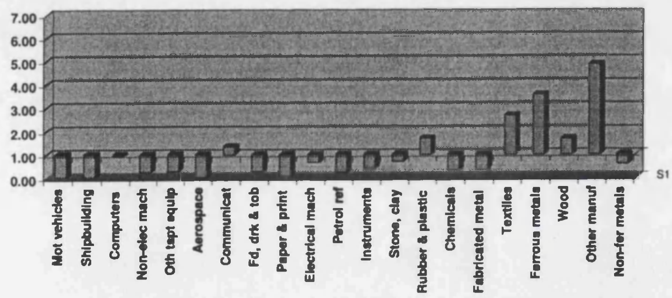


Figure 2-51: Thailand RCA 85-89

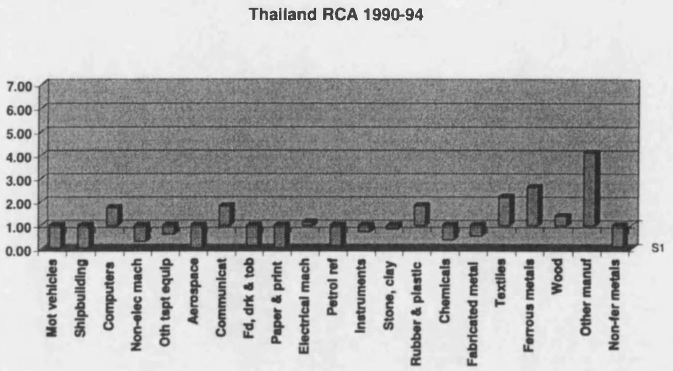


Figure 2-52: Thailand RCA 90-94

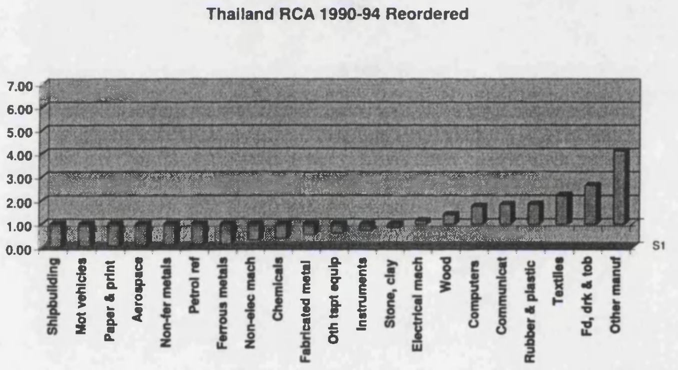


Figure 2-53: Thailand RCA 90-94 Reordered

2.8.3 Transition Matrices

China	*Upper Endpoint*			
Number	0.070	0.265	1.020	∞
(137)	0.88	0.12	0.01	0.00
(118)	0.10	0.78	0.12	0.00
(125)	0.00	0.09	0.84	0.07
(126)	0.00	0.01	0.07	0.92
Ergodic	0.190	0.232	0.303	0.275

Table 2.4: Transition matrix- China

Hong Kong	*Upper Endpoint*			
Number	0.03	0.19	0.75	∞
(141)	0.89	0.1	0.01	0.00
(113)	0.12	0.81	0.07	0.00
(126)	0.01	0.07	0.87	0.06
(126)	0.00	0.00	0.06	0.94
Ergodic	0.301	0.243	0.243	0.213

Table 2.5: Transition matrix- Hong Kong

Indonesia	*Upper Endpoint*			
Number	0.00	0.035	0.340	∞
(145)	0.80	0.19	0.01	0.00
(115)	0.17	0.65	0.17	0.00
(125)	0.02	0.07	0.82	0.10
(121)	0.00	0.00	0.05	0.95
Ergodic	0.125	0.120	0.257	0.498

Table 2.6: Transition matrix- Indonesia

Korea	*Upper Endpoint*			
Number	0.120	0.430	01.240	∞
(130)	0.90	0.10	0.00	0.00
(125)	0.05	0.86	0.10	0.00
(127)	0.00	0.06	0.86	0.08
(124)	0.00	0.02	0.05	0.94
Ergodic	0.118	0.246	0.286	0.349

Table 2.7: Transition matrix- Korea

Malaysia	*Upper Endpoint*			
Number	0.020	0.170	1.070	∞
(134)	0.88	0.11	0.01	0.00
(122)	0.06	0.84	0.11	0.00
(124)	0.00	0.07	0.86	0.06
(126)	0.00	0.00	0.06	0.94
Ergodic	0.101	0.210	0.319	0.370

Table 2.8: Transition matrix- Malaysia

Singapore	*Upper Endpoint*			
Number	0.050	0.140	0.675	∞
(151)	0.85	0.14	0.01	0.00
(106)	0.15	0.69	0.16	0.00
(124)	0.00	0.09	0.82	0.09
(125)	0.00	0.01	0.06	0.94
Ergodic	0.172	0.166	0.278	0.385

Table 2.9: Transition matrix- Singapore

Taiwan	*Upper Endpoint*			
Number	0.110	0.575	1.455	∞
(131)	0.89	0.11	0.01	0.00
(122)	0.09	0.77	0.13	0.01
(127)	0.01	0.10	0.83	0.06
(126)	0.00	0.00	0.07	0.93
Ergodic	0.196	0.223	0.295	0.286

Table 2.10: Transition matrix- Taiwan

Thailand	*Upper Endpoint*			
Number	0.050	0.260	1.485	∞
(145)	0.86	0.13	0.01	0.00
(111)	0.13	0.74	0.14	0.00
(124)	0.02	0.07	0.85	0.06
(126)	0.00	0.00	0.06	0.94
Ergodic	0.186	0.175	0.296	0.343

Table 2.11: Transition matrix- Thailand

2.8.4 Stochastic kernels

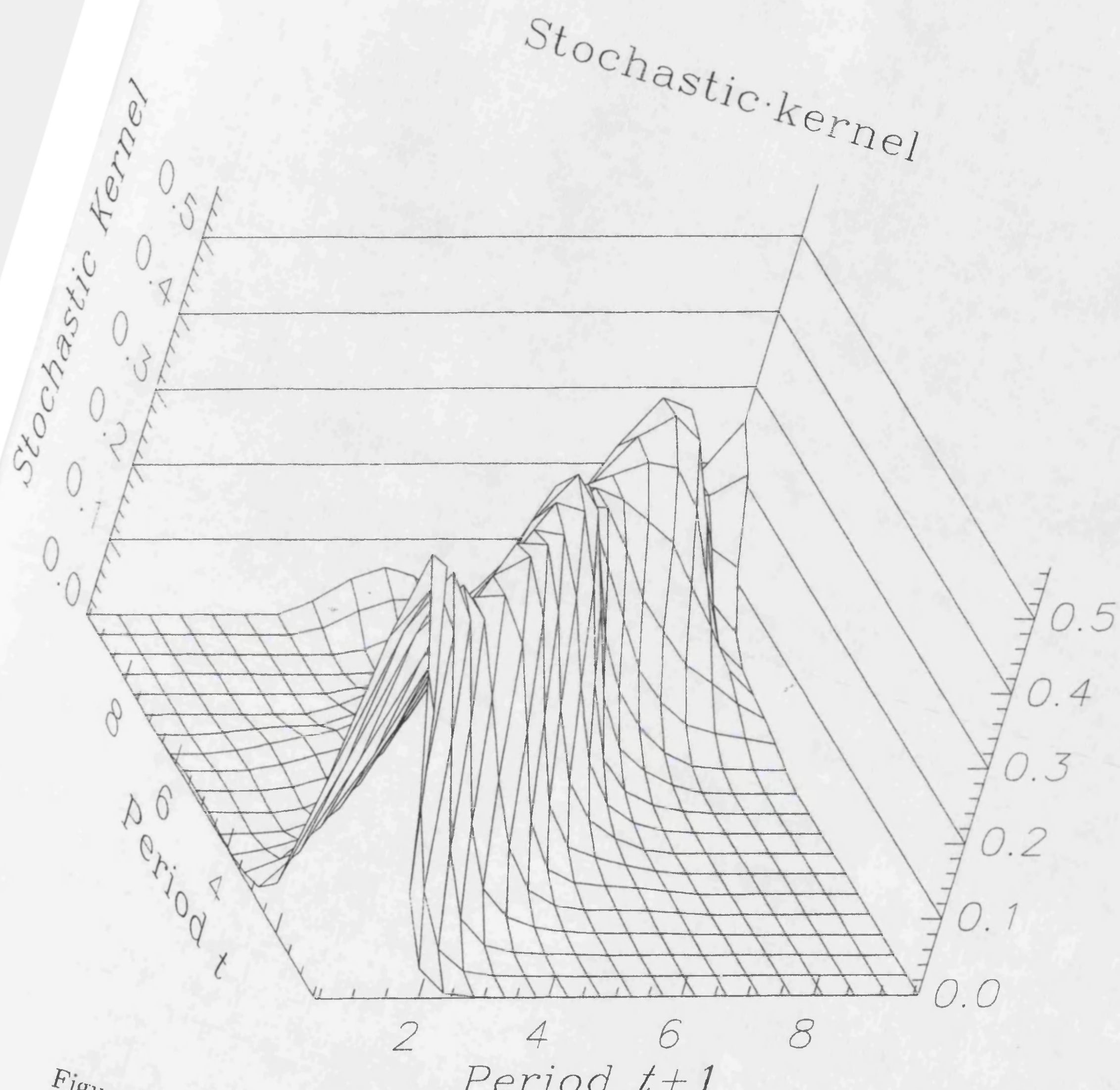


Figure 2-54: Stochastic kernel- Pooled sample kernel

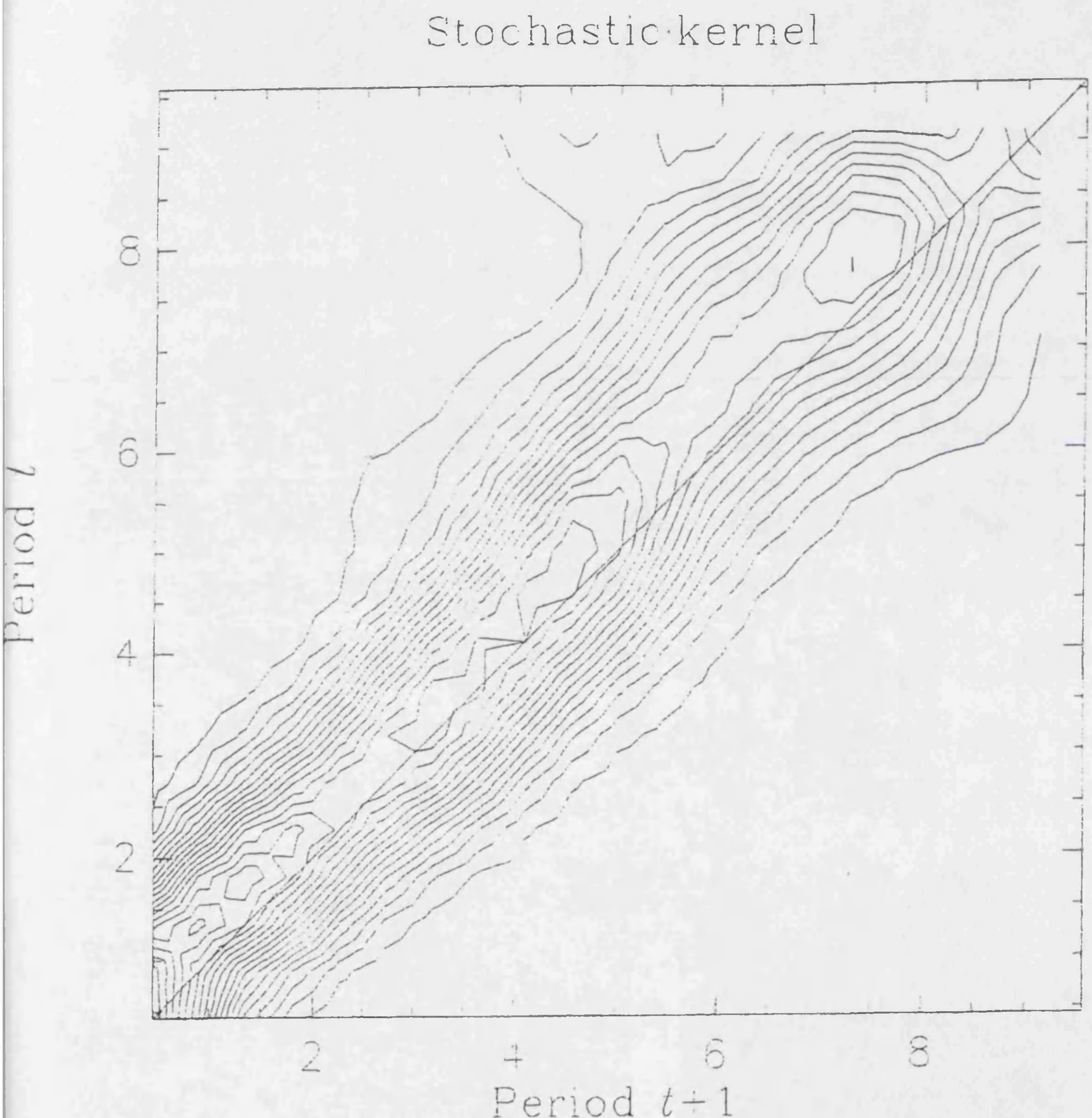


Figure 2-55: Stochastic kernel- Pooled sample kernel contour

Chapter 3

Patterns of Similarity in Industrial Structure in East Asia

3.1 Introduction

Our intention in this chapter is to study the economies of East Asia which have experienced dramatic development over the last few decades to see to what extent connections can be drawn about their patterns of industrial change. Development in the countries can be seen through income per capita over the past few decades, as shown in Figure 3-1. We see that Hong Kong and Singapore are the strongest performers, combining high GDP with small populations, leading to them reaching Japanese levels of per capita income. The subsequent most developed countries are the larger entities of Taiwan and Korea. Next best performers are the later developers of Malaysia and Thailand. The latest developer, Indonesia, shows the lowest level of income per head.

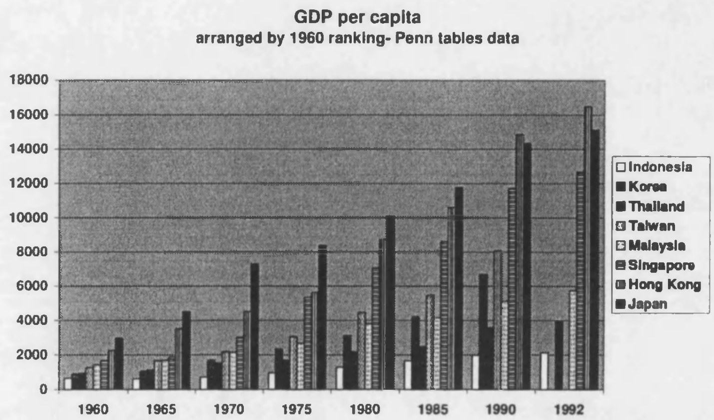


Figure 3-1: National GDP Per Capita- in order of 1960 Ranking

It has been posited that there is an intrinsic link between the countries' development as exhibited by the time precedence witnessed. The phenomenon is often loosely referred to under the heading of the 'flying geese'. The form of the idea which has been popular over the last few decades is that Japan has been at the head of a group of East Asian countries who have developed in its wake. The order in which nations follow is displayed through their developmental time precedence. Expositions of the concept include Yamazawa (1992) and Kwan (1994). The explanation suggested is that the instrument by which countries followed Japan was the operation of Japanese multinational companies. When Japan became too expensive a country for labour-intensive manufacturing both for exports and domestic consumption, such production was shifted to the first group of follower countries- Korea, Taiwan, Hong Kong and Singapore- and subsequently to the next group of countries, as wage costs eventually rose in each location. Countries specialise in the export of products in which they have a comparative advantage, and at the same time they seek to upgrade their endowments of capital and technology. Foreign direct investment, through relocating industries between countries, plays a major role in sustaining this process. Though Japanese firms are held as the largest group of exponents of such a policy, European, American and regional companies are also participants. Such movements in production have been surmised from the manner in which exports and production in these countries have been said to have moved through stages of labour-intensity beginning with agriculture, then simple manufacturing, to automobiles and chemicals, and eventually high-tech industries. The implication of such an idea is that the structure of industry in each of these countries passes through a definite and observable path of progression. Furthermore, the structure of industry in each country at any point in time should be similar to the previous industrial structure of another country who has already passed through this stage of development.

It is of course possible that countries have had other routes for engendering the conditions for similar performance. Change in factor endowments in the same manner over countries independently is one such possibility. Though the idea of a definite progression of development has been widely mentioned and may be due to a variety of factors, we wish to investigate how precise such a phenomenon has been through measurements of degree of similarity in industrial structure and the time precedence of similarity between these East Asian countries.

There is much reason to believe that there should not be any great discernible connection between the development of the countries mentioned. This is because of the disparity in natural characteristics they exhibit and policies they have followed, even when the take-off of some countries has been at roughly the same time. Amsden (1989) and Wade (1990), amongst others, describe how Korea and Taiwan pursued a route of encouraging domestic industry through subsidies and attempting to 'pick winners' ahead of the country's labour-endowment profile. Examples include the steel and shipbuilding industries of the country. Singapore is a small city-state which has been extremely encouraging towards foreign investment, doing little to encourage home-grown industry until recently. Hong Kong is another small state which has historically been the trading gateway to China. It also exhibits one of the most laissez-faire economic regimes in the world. Malaysia has become a strongly industry-based economy whereas Thailand still displays a continuing dependence on rural primary production. Indonesia also attempted to 'pick winners' such as the automobile and aircraft industries.

The countries' policies with respect to education and infrastructure also should play a role in determining their likelihood to be able to move up the value chain of production to more capital and skilled-labour intensive industries. The region displays different emphases on education (see Figure 3-2) and infrastructure spending. Thailand has been noticeably slower to develop its education system than its neighbours and Indonesia lags behind others in the region in terms of education and infrastructure with little sign of increase. This may mean that though countries follow each others' patterns in the initial stages, their ability to carry on progressing will depend on their particular emphases on upgrading their capabilities.

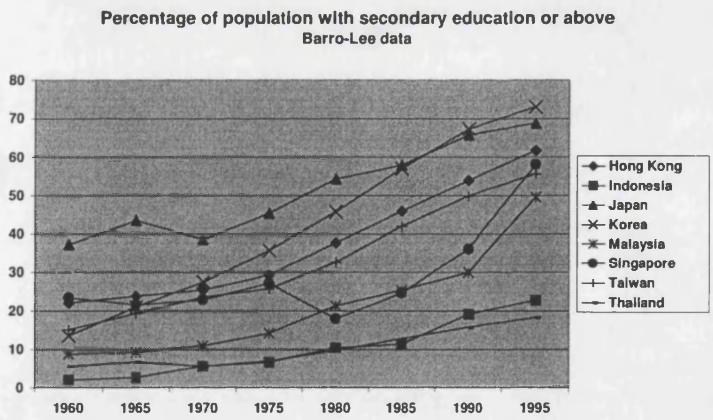


Figure 3-2: Percentage of population with secondary education or above

There is a rich tradition in the consideration of issues of development paths. Chenery and Kuznets in the 1960s and 70s popularised the idea of thinking about similarities in development process between developing countries. Answers were sought as to the characteristics of change across such countries. Using fairly aggregated data, variables such as the degree of industrialisation of countries were compared to their output levels in order to draw out the inherent resemblance between paths. Leamer (1987) used cross-sectional data to provide rankings for a 'ladder of development' that countries follow as they increasingly specialise in industries which are capital-intensive. Land scarcity in countries was seen to alter their development path.

Chenery and Taylor (1968) offer a useful way of thinking about the issues mentioned above. They discussed how development patterns can be considered in a cross-country and time-related manner. Increasing relative capital endowments is suggested as a common explanator for similar country development patterns. On the other hand, changing technology and economic organization are suggested as forces for diversity between countries. At a cross-country level there is the hope of observing a definite production structure with relation to national income level. Across time one is keen to see whether the relationship between production structure and income remains stable. Cross-country analysis of large samples led to the finding that countries' income-production structure relationship was dependent on a number of country characteristics. Three separate groups of importance were found- large countries, small primary-oriented countries and small industry-oriented countries. Across time analysis of these groups found that the income-production structure relationship remained robust. We would be keen to apply a cross-sectional and time-related analysis to our data as well as be aware of the possible presence of differing trends according to the characteristics of particular countries.

Industrial change has also been explored by Feenstra et al. (1997), in the form of patterns of export performance across countries. A general order of change in export composition in time is arrived at and then countries' stage of development is given by how their particular export composition at a point in time compares to the export composition ordering. Accordingly it is seen that the order among the East Asian countries we consider is Taiwan first, followed by Hong Kong, Korea, Singapore, Thailand, Malaysia, and Indonesia. Our analysis is similar in that we consider sectoral structure of countries at a disaggregated level. We however differ in that we consider production data instead of exports and we do not attempt to arrive at any general order of sectoral change but compare the actual structures of countries bilaterally at different points in time.

3.2 Empirical Analysis

Our manner of investigation is to compare the industrial structure of pairs of countries in the region in order to obtain indicators as to their extent of similarity across time. The sample countries are Hong Kong, Indonesia, Korea, Malaysia, Singapore, Taiwan and Thailand. These are the countries for which suitable data is available and which offer a representative cross-section of countries in the different stages of rapid development in the region. There are clearly many other countries which were not as dynamic as these but our wish is to understand the phenomenon of East Asian industrial change for its successful members as a guide as to how distinct a phenomenon it was.

The period under consideration has been clearly a period of considerable structural change in the region. The proportion of agriculture in GDP (see Table 3.1) provides a measure of the conversion of many of the economies from agriculture-based to industry-based and services-based economies. As can be seen all of the economies, except for the land-scarce island economies of Hong Kong and Singapore, have seen structural change towards a decrease in the importance of agriculture. There appears to be some pattern to this decrease. The more advanced countries in terms of GDP per capita, Korea and Taiwan, see the greatest decrease in percentage of agriculture in their economies. The next group of countries in terms of GDP per capita; Malaysia and Thailand, have the next largest decrease in proportion of agriculture. The country with least decrease in agricultural importance is Indonesia, the least advanced country in terms of GDP per capita.

	HK	Indonesia	Korea	Malaysia	Singapore	Taiwan	Thailand
1974	1.12	31.13	24.96	30.52	2.05	14.50	27.01
1978	0.89	28.10	20.51	25.91	1.72	11.28	24.50
1982	0.68	23.94	14.47	21.12	1.41	9.16	18.55
1986	0.44	23.15	11.18	19.82	0.77	6.44	15.66
1990	0.26	20.42	8.51	15.22	0.36	4.88	12.50
1994	0.17	17.29	6.52	13.66	0.21	4.24	10.56

Table 3.1: Agriculture percentage share of GDP

It is our intention to explore the connection between the structural change seen above and industrial change in the countries concerned. We have chosen to concentrate on intra-sectoral structural change in manufacturing, though we are aware that there has been inter-sectoral change at the same time from agriculture to manufacturing. There are a number of reasons for our specific interest. One is that patterns in agricultural change may be somewhat different in nature and causes, though part of the same development process that also leads to change in manufacturing. Similarity stems from being influenced by the forces of comparative advantage through change in endowments of labour, capital and land, and the phenomenon of increase in technological capability releasing workers from agriculture to industry. However there are also some differences in causes. Chenery et al. (1986) discusses in detail some features of international inter-sectoral structural transformation which are relevant to our work. This transformation is seen to depend on differences in country size and natural resources. It is possible that change within manufacturing may be less dependent on such considerations, offering a greater possibility of similarity in development path of countries. The sample countries to be examined offer a cross-section of country sizes and natural resource wealth. On the other hand country manufacturing patterns may diverge, for instance, because manufacturing related to agricultural inputs would be more persistent in countries which are plentiful in such inputs.

Chenery finds that during the transformation from less developed to mature developed economies the share of manufacturing in value-added more than doubles and the decline in primary production is greater. The difference is made up by increase in the contribution of nontradables (social overhead and services). A point of note is that the reasons behind the change in agriculture are different to those for manufacturing. The rise in manufacturing is due more to change in trade patterns whereas the decline in agriculture is due more to domestic demand changes. Furthermore, the importance of intermediate goods is greater for change in manufacturing than that in agriculture.

Share of intermediate use in gross output is seen to increase with income across countries. It is also observed that manufactured goods substitute for primary inputs during this process. Increasing use of intermediates reflects increasing specialisation and complexity in the economy and is among the characteristics of the process of industrialisation. This occurrence is related to the concerns of economic geography explanations of industrial change which study the effects of agglomeration due to linkages to suppliers and consumers of intermediate goods. We are keen to consider whether, given the distinctive nature of manufacturing, patterns can be still noted between sample countries. The intermediate usage intensity of industries, in addition to their capital and labour intensities and technological needs, will determine their patterns of change. If similarity in patterns is found to be the case it would be of interest to establish the determinants of these common manufacturing patterns.

The statistic used to highlight the industrial mix of a country at a point in time is one measuring an industry's relative employment compared to total employment in all manufacturing industry. It is adopted from the Krugman (1991b) index of industrial specialisation and is expressed as,

$$IS_{ij} = \frac{E_{ij}}{E_j} \tag{3.1}$$

where IS_{ij} represents the industrial specialisation of manufacturing industry i in country j, E_{ij} is employment in industry i in country j, and E_j is total manufacturing employment in country j.

IS (industrial specialisation) measures are obtained for the industries of each of the sample countries. The industry group is the 28 ISIC 3-digit industries as listed in the UNIDO 3-digit Industrial Statistics and the time period is 20 years from 1974-93. Five sets of four year averages of IS are calculated for industries in each country to minimise time-specific shocks. The year groupings are 1974-77, 1978-81, 1982–85, 1986-89 and 1990-93. Bilateral correlations are then calculated for the IS industry structures of each of the seven sample countries with respect to the other countries. This is done for the five time periods listed above. The output is 42 matrices (7x6) of IS correlations. The matrices are provided in Appendix Tables 3.8 to 3.21. They can be read in terms of seven sets of matrices, one for each 'base' country with respect to its six 'partner' countries. In each matrix the row headings represent the IS year in question for the base country and the column headings represent the IS year in question for the partner country. For example, the matrix in Table 3.2 is for the base country Taiwan and the partner country Malaysia. The second entry in the first row gives the correlation in IS structure for Malaysia in 1978 with respect to IS structure in Taiwan in 1974.

Partner country: Malaysia						
		74	78	82	86	90
Base: Taiwan	74	0.609	0.641	0.632	0.622	0.604
	78	0.589	0.653	0.664	0.677	0.696
	82	0.544	0.624	0.647	0.674	0.708
	86	0.522	0.623	0.658	0.700	0.758
	90	0.510	0.623	0.666	0.705	0.770

Table 3.2: Example of IS bilateral correlation matrix

Such raw data allows us to have an insight into the growing similarity or dissimilarity in industrial structure on a bilateral basis between all sample countries over time. We analyse this information in a number of different ways in order to highlight the trends present in the data. First, we attempt a graphical representation of some of the salient issues contained in the statistics. This is done by first obtaining tables of the time of maximum similarity for *partner country* IS with respect to *base country* IS measured at each of the five time points of 1974-77, 1978-81, 1982–85, 1986-89 and 1990-93. This data is provided in Tables 3.22 to 3.24 in Appendix 3.5.3. In the example in Table 3.3 the base country is Taiwan. The second entry in the second row states that Indonesian industrial structure was most similar to 1978 Taiwan industrial structure in 1990. In other words we see how each of the partner countries' industrial structure compares to the base country in terms of time precedence or lag.

Base country: Taiwan dates					
	74	78	82	86	90
HK	86	86	78	78	78
Ind	90	90	90	90	78
Kor	78	86	86	90	90
Mal	78	90	90	90	90
Sin	74	74	74	78	82
Th	90	90	90	90	90

Table 3.3: Partner maximum similarity with base country

We are then able to back out tables for each base country showing *base country* point of maximum industrial structure similarity to its *partner countries* at the five time periods. The corresponding example for Taiwan is provided in Table 3.4. The second entry in the second column highlights the year for Taiwan when its industrial structure most resembles that of Indonesia in 1978. Taiwan's structure most resembles Indonesia's 1978 structure in 1974.

Base country: Taiwan dates					
	74	78	82	86	90
HK	82	82	82	82	82
Ind	74	74	74	74	74
Kor	74	74	74	78	90
Mal	74	78	90	90	90
Sin	90	90	90	90	90
Th	74	74	74	74	74

Table 3.4: Base country maximum similarity with partner

We display each of the latter tables graphically in Figures 3-3 to 3-9 in Appendix 3.5.4 along with the corresponding data to show the relationships between the countries more clearly. The x-axis represents the IS year in question for the partner country and the y-axis represents the year for the base country IS point of maximum similarity with respect to the partner country IS year in question. We discuss each of the country results in a systematic manner. For convenience we refer to a country as being 'behind' another when its when its year of most similar IS structure is later than that of the measurement IS year of the latter country. Likewise, we refer to a country as being 'ahead' of another when its year of most similar IS structure is earlier than that of the measurement IS year of the latter country. The manner to interpret the graphs is to note that a straight horizontal line for a country at the top of the chart means that the country is always 'ahead' of the base country. A straight horizontal line for a country at the bottom of the chart means that the country is always 'behind' the base country. A diagonal upward movement for a country in the chart implies the years of maximal correlation of IS levels of the two countries are the same with a diagonal downward movement implying that the years of maximal correlation of IS levels for the two countries are becoming farther apart.

We ultimately wish to understand whether when countries' years of maximal correlations are changing there is a pattern to the direction of change of similarity in their industrial structures. Specifically we are interested to see if as years of maximum similarity become more alike, industrial structure correlation is also higher or "converging". Likewise when maximal correlation IS levels are becoming farther apart, we wish to see if their industrial structure correlations are "diverging". In this way we obtain an idea of the movements in comparative industrial structure of particular countries over time. Furthermore we wish to obtain further detail of industrial structure correlation movements in the case when a country is far behind another, which will appear in the tables in Appendix Figures 3-3 to 3-9 as numerous partner country values of 1974. Since there is no change in year of maximum similarity between countries we have to look within the maximal correlation figures to obtain details of increasing similarity or divergence between countries. Similarly we have to do the same when one country is far ahead of another, which will appear in the tables as numerous partner country values of 1990. We therefore discuss below changes in the maximal correlation values as well as changes in year of maximal correlation between countries.

We summarise the message from each of the graphs below.

Findings

Hong Kong chart- Hong Kong is behind and then ahead of Taiwan and Korea, with correlation values increasing and then decreasing. So correlation values' convergence and divergence is in line with the time pattern. Hong Kong is in line and then ahead of Malaysia, with correlation values increasing. Hong Kong is first behind and then ahead of Singapore, with correlation values decreasing. Hong Kong is far behind Thailand always, in all periods most resembling Thailand in 1990, with correlation values increasing. Indonesia is far behind Indonesia first and then far ahead, with correlation values increasing.

Indonesia chart- Indonesia is far behind all countries in all years. Partner countries in all periods, except only Thailand sometimes, most resemble Indonesia in 1990. There are decreasing correlation values for Singapore, Korea, Taiwan and Malaysia. This indicates increasing divergence of these countries from even the newest industrial structure of Indonesia. Hong Kong and Thailand exhibit stable correlation values over time.

Korea chart- Korea is always far ahead of Thailand and Indonesia, with the latters' industrial structure in all periods most resembling Korea in 1974. Thailand's correlation values are increasing, indicating it is becoming more similar in time to Korea's oldest structure. Indonesia's correlation values are stable, indicating it maintains its difference over time with Korea's oldest structure. Korea is first behind and then ahead of Malaysia, with correlation first increasing and then decreasing. This indicates their structures converging and then diverging over time in line with the time pattern. Korea is always far behind Singapore, with the latter's industrial structure in all periods most resembling Korea in 1990. Their correlations are decreasing, indicating that Singapore over time is diverging from the latest industrial structure of Korea. Korea is always slightly behind Taiwan and becoming less similar in correlation. This indicates that the countries' structures are diverging over time.

Malaysia chart- Malaysia is always far ahead of Indonesia and Thailand, with the latters' industrial structure in all periods most resembling Malaysia in 1974. Thailand's correlation values are increasing, indicating it is becoming more similar in time to Malaysia's oldest structure. Indonesia is not changing in correlation. Malaysia and Korea are generally the same in time pattern, with correlation becoming more similar over time. This indicates that the countries are converging in structure over time. Malaysia is always far behind Singapore and Taiwan, with Singapore's industrial structure always, and Taiwan's nearly always, most resembling Malaysia in 1990. Taiwan's correlation is increasing over time, indicating that the gap between Taiwan and Malaysia's newest structure is decreasing over time. Singapore's correlations are stable, indicating that the same difference in industrial structure is being maintained over time.

Singapore chart- Singapore is far ahead of all countries in all years. Partner countries in all periods most resemble Singapore in 1974. There are increasing correlation values for all countries except Hong Kong. This indicates increasing convergence of these countries to the oldest structure of Singapore. Hong Kong exhibits stable correlation values over time, indicating the same difference in industrial structure is being maintained over time.

Taiwan chart- Taiwan is always far ahead of Indonesia and Thailand, with the latters' industrial structure in all periods most resembling Taiwan in 1974. Indonesia's correlation values are increasing, indicating it is becoming more similar in time to Taiwan's oldest structure. Taiwan is always far behind Singapore, with the latter's industrial structure in all periods most resembling Taiwan in 1990. Their correlations are decreasing, indicating that Singapore over time is diverging from the latest industrial structure of Taiwan. Taiwan is first ahead and then the same as Korea, with their correlations decreasing over time. Taiwan is first the same and then ahead of Malaysia, with their correlations increasing over time. Taiwan is first behind and then ahead of Hong Kong, with their correlations remaining stable over time.

Thailand chart- Thailand is always far behind Korea, Singapore, Taiwan and

Hong Kong, with the latters' industrial structure in all periods most resembling Thailand in 1990. Korea, Singapore and Taiwan's correlations are decreasing, indicating that the countries over time are diverging from the latest industrial structure of Thailand. Thailand is first behind and then ahead of Indonesia, with correlation values increasing and then decreasing. So correlation values' convergence and divergence is in line with the time pattern. Hong Kong shows first increasing and then decreasing correlation over time. Thailand is always slightly behind Malaysia and becoming less similar in correlation. This indicates that the two countries' structures are diverging over time.

We see that exploration of the patterns of years of maximal correlation, combined with information about the details of the maximal correlation values' changes, provides us with a discernible though noisy pattern of progression in terms of industrial structure similarity between the sample countries. There are fairly clear patterns of increasing similarity in time of maximal correlation and direction of change of maximal correlation values for countries when they are most similar to the oldest structure of a partner. This may indicate that there is "catch-up" in progress for this group. Such results are obtained for all countries except Hong Kong and Singapore, with the latter being "ahead" of all countries always. We also obtain a discernible pattern in some cases of the direction of change in maximal correlation values as compared to direction of change of years of maximal correlation. Hong Kong-Taiwan, Hong Kong-Korea, Korea-Malaysia, Thailand-Indonesia and Thailand-Malaysia displays such results.

Considering the relative development levels of the countries, we can suggest a possible order of change in industrial structure for some of them. The information that Indonesia, the least developed country in the region, is far "behind" all the other countries in time pattern, as well as displaying decreasing maximal correlation values, suggests the countries' industrial structures are diverging from it. Thailand displays similar results in time and correlation value patterns to Indonesia, being "ahead" of only Indonesia in most cases. Singapore, one of the most developed countries, is far "ahead" all the other countries in time pattern, as well as displaying increasing maximal correlation values, suggesting the countries are "catching-up" to Singapore's old industrial structure. Taiwan is generally the next furthest "ahead" in terms of time as well as displaying some increasing maximal correlation values in a similar manner to Singapore. Korea and Malaysia display more noisy results. The results for Hong Kong are different, in that it is sometimes seen to have an industrial structure which is not emulated by less developed countries. In the next section we wish to study more precisely the association between country development level and industrial structure.

3.3 Econometric Analysis

We attempt a more clear representation of the trends seen through an econometric study of the IS correlation data discussed above. The correlations for each pair of countries are compared with a measure of the ratio of their respective GDP per capita levels. The latter provides an approximation as to the countries' relative developmental stages. This analysis is conducted for all permutations of the five data periods available for pairs of countries. Differences in initial conditions between countries are accounted for by application of fixed effects terms for each country in the pairing. We initially abstract from the consideration of economic variables such as factor endowments in an attempt to concentrate directly on the movement of development paths in the region. The equation to be estimated is therefore,

$$ISCORR_{ct_c,zt_z} = \alpha + \phi d_c + \psi d_z + \gamma(GDP_{ct_c,zt_z}) + u_{ct_c,zt_z} \qquad (3.2)$$

where c and z represent a pairing of distinct countries, t_c and t_z are the respective country time periods, $ISCORR$ is bilateral IS correlation, GDP_{ct_c,zt_z} is a relative GDP per capita measure defined as

$$GDP_{ct_c,zt_z} = \begin{cases} \frac{GDP_{ct_c}}{GDP_{zt_z}} \text{ if } GDP_{ct_c} \geqslant GDP_{zt_z} \\ \frac{GDP_{zt_z}}{GDP_{ct_c}} \text{ if } GDP_{ct_c} < GDP_{zt_z} \end{cases} \qquad (3.3)$$

where GDP_c and GDP_z are the respective country GDP per capitas, and d_c and d_z represent the fixed effects term for each of the countries. The relative GDP per capita variable provides a measure of deviation from the value of 1, the point at which GDPs of the respective countries are equal.

The raw data for the GDP per capita ratio calculation is summarised in Table 3.5. It is drawn from the Penn World Tables and is expressed in constant 1995 US dollars. The change in the GDP per capita measure for each pair of countries over time provides a summary of countries' relative developmental stages across the 20 year period.

	HK	Indonesia	Korea	Malaysia	Singapore	Taiwan	Thailand
74	5,675	892	2,236	2,791	4,870	3,003	1,641
78	7,737	1,124	3,083	3,239	6,247	3,920	2,025
82	9,493	1,487	3,395	4,171	7,928	4,642	2,195
86	11,520	1,687	4,622	3,869	8,696	5,901	2,510
90	14,849	1,974	6,673	5,124	11,592	8,063	3,580

Table 3.5: Real GDP per capita

The data consists of 525 observations of bilateral IS correlations and relative GDP per capita. This is after the removal of half of the raw bilateral IS correlation data to avoid double counting. GDP pairings can be considered in the order of the numerator always being the country which is ranked higher in terms of GDP per capita in 1994. This leads to some values of their GDP ratio being below one, occurring when the GDP per capita of the more developed country is lower in an earlier period than that of the less developed country in a later period. We use the GDP measure variable outlined above as a measure of ~~GDP difference~~ between countries which allows us to retain values of GDP ratio below one. The order of country pairings used is listed in Appendix 3.5.1. The ~~statistic~~ ISCORR was tested for normality for all country pairings using a joint chi-squared test for skewness and kurtosis with normality not being rejected for any country pairing at the 1% significance level. It is highly likely that the error terms from observations for the same country pair are correlated. Robust standard errors are calculated with clustering by country pairs to account for such correlation.

The results of the estimation, as seen in Table 3.6, indicate a strongly significant negative association between relative GDP per capita and bilateral IS correlation. This indicates that increasing similarity in industrial structure between countries is associated with increasing similarity in their relative levels of development. Such a finding illustrates that less developed countries' industrial structure resembles most the past structure of their more developed partners as the latter is closest to them in terms of developmental stage. The magnitude of the coefficient can be interpreted as implying that a decrease of 1 in the relative GDP per capita measure is associated with an increase in the IS correlation measure of 0.06, an increase of 6% given the IS correlation scale of -1 to +1. The distribution of the relative GDP per capita measure has an upper bound of 15.65 expressing the gap between Indonesia in 1974 and Hong Kong in 1990, and a mean value of 1.80. The degree of industrial change captured by the dependent variable over the measurement period is therefore considerable. Support is obtained for the view of a blueprint of a common industrial structure path for the region as a whole with countries belonging to different points in such a path associated with their stage of development.

		Coeff	t	R-squared	No.of Obs
Specif 1	GDP	-0.059	-3.37	0.64	525

Table 3.6: Regression results with GDP

It should be borne in mind that this analysis in no way implies causation leading from development stage, as shown by GDP per capita, to type of industrial structure. The level of income of a country can both affect its industrial structure and be affected by its industrial structure. Changes in industrial structure through trade changes due to lower transport costs, for instance, would reinforce industrial patterns according to country comparative advantage which in turn affects country GDP. An increase in country GDP, on the other hand, can cause changes in country industrial structure, for instance, through support for increasing returns to scale industries. Our intention is only to see if countries display a similar pattern of industrial structure during their development process. The significant association between variables in our regression shows that the variables are related to each other.

It is a valuable exercise to measure how much of the effect observed can be related to changes in endowment levels between countries. Factor endowments are generally regarded as the most important element in development in the region as discussed previously in Chapter 1 and so it is important to account for them. Factor endowments are measured by us in terms of a physical capital and a skilled labour endowment. Physical capital is expressed in terms of the ratio of total capital stock with respect to total labour force in each country. Skilled labour is the proportion of people in the total population who have attained at least secondary education. Details of the data sources are presented in Appendix 3.5.1. The ratio of these terms for each pair of distinct countries are added as additional independent variables in the specification (3.2) in the same manner as for the GDP ratio variable previously. We thus measure,

$$ISCORR_{ct_c,zt_z} = \alpha+\phi d_c+\psi d_z+\delta(GDP_{ct_c,zt_z})+\varepsilon(K_{ct_c,zt_z})+\zeta(L_{ct_c,zt_z})+u_{ct_c,zt_z} \tag{3.4}$$

where $K_{ct_c,zt_z}$is a relative capital endowment measure defined as

$$K_{ct_c,zt_z} = \begin{cases} \frac{K_{ct_c}}{K_{zt_z}} \text{if } K_{ct_c} \geqslant K_{zt_z} \\ \frac{K_{zt_z}}{K_{ct_c}} \text{if } K_{ct_c} < K_{zt_z} \end{cases} \tag{3.5}$$

where K_c and $K_z$are the respective country capital stocks, and $L_{ct_c,zt_z}$is a relative capital endowment measure defined similarly as

$$L_{ct_c,zt_z} = \begin{cases} \frac{L_{ct_c}}{L_{zt_z}} \text{if } L_{ct_c} \geqslant L_{zt_z} \\ \frac{L_{zt_z}}{L_{ct_c}} \text{if } L_{ct_c} < L_{zt_z} \end{cases} \tag{3.6}$$

where L_c and $L_z$are the respective country skilled labour stocks.

We see in the results in Table 3.7 that the inclusion of changes in capital stock and skilled labour over time between countries are not enough to explain the industrial structure similarity paths observed. Capital and skilled labour both display the expected negative sign, however both terms are insignificant (though capital only marginally so at the 10% level). The GDP term remains highly negatively significant with a t-statistic of -2.54.

		Coeff	t	R-squared	No.of Obs
Specif 2	GDP	-0.0549	-2.54	0.65	525
	Capital	-0.0006	-1.61		
	Skilled labour	-0.0182	-0.02		

Table 3.7: Regression results with GDP and factor endowments

What emerges from this analysis is that there are clear similarities in the developmental paths of the rapidly industrialising East Asian countries as seen from patterns in their industrial change. It is seen that the inclusion of factor endowments effects through a physical capital and skilled labour measure does not explain all of the change witnessed. This provides support for the view that the industrial change in the region though similar in its nature contains a significant element that can not be explained by these factor endowment measures alone.

3.4 Conclusion

We wished in this chapter to examine the pattern of industrial change in East Asia during the period of rapid development in the region between 1974 and 1994. We utilise the statistic of bilateral industrial structure correlations between sample countries in the region as an indicator of their similarity in manufacturing production. This allows us to capture a rich source of disaggregated industrial trade data across pairs of countries and therefore permits comparatively thorough estimates of cross-country patterns. A graphical analysis of aspects of the data highlights trends in the region. We see that there is a definite though somewhat noisy order of precedence evident in terms of the type of industrial structure found in sample countries with the order depending on countries' relative prosperity. There is thus support for the view that there is a common blueprint for industrial change in the region with each country's structure matching it at particular points in line with the country's relative stage of development.

The connection between industrial structure and developmental stage is studied more precisely through an econometric estimation. The GDP per capita ratio between countries is used as an approximation to their relative developmental positions at each point in time. A measure of bilateral GDP per capita ratio and fixed effects, as a proxy for differences in initial conditions between countries, are compared to changes in bilateral industrial structure correlation. It is found that GDP per capita differences are highly significant and negatively associated with changes in industrial structure. This corroborates our earlier findings. It should be noted that our specification does not consider causality, it only considers whether countries' income levels and industrial structures are related.

We explore the components of the relationship by estimating a regression comparing developmental stage and industrial structure with the inclusion as added variables of differences in a physical capital and skilled labour endowment measure in countries. It is seen that these factor endowments measures are not enough to explain the patterns of similarity in the East Asian countries along their development path. It is therefore important to investigate factor endowments in more detail as well as alternative theories as explanations for the common pattern of industrial change seen in the region. This is what we proceed to do in the next two chapters.

3.5 Appendix

3.5.1 Data Description

Country pairings used in econometric estimation

The first term in each pairing listed is the numerator in the relative GDP calculation and the second the denominator: Hong Kong-Indonesia, Hong Kong-Korea, Hong Kong-Malaysia, Hong Kong-Singapore, Hong Kong-Thailand, Hong Kong-Taiwan, Korea-Indonesia, Korea-Malaysia, Korea-Thailand, Malaysia-Indonesia, Malaysia-Thailand, Singapore-Indonesia, Singapore-Korea, Singapore-Malaysia, Singapore-Thailand, Singapore-Taiwan, Thailand-Indonesia, Taiwan-Indonesia, Taiwan-Korea, Taiwan-Malaysia, Taiwan-Thailand.

Data sources

GDP- Penn World Tables expressed in terms of constant 1990 US$.

Share of agriculture in GDP- From World Bank World Development Indicators, except for Taiwan from Taiwan Bureau of Statistics.

Relative capital stock- Ratio of total capital stock to total labour force in each country. Capital stock obtained from King and Levine (1994) data set, expressed in terms of constant 1990 US$. Total labour force data from World Bank World Development Indicators, except for Taiwan from Taiwan Bureau of Statistics.

Skilled labour endowment- Ratio of people in the total population who have attained at least secondary education. Secondary and tertiary educational attainment data from Barro and Lee (2000). Total population data from World Bank World Development Indicators, except for Taiwan from Taiwan Bureau of Statistics.

3.5.2 Industrial structure correlation tables for partner countries with respect to base countries

Partner country: Singapore

	74	78	82	86	90
74	0.510	0.498	0.452	0.420	0.347
78	0.559	0.557	0.514	0.487	0.409
82	0.562	0.563	0.522	0.496	0.423
86	0.557	0.550	0.507	0.482	0.424
90	0.510	0.482	0.439	0.406	0.388

Partner country: Taiwan

	74	78	82	86	90
74	0.611	0.605	0.635	0.575	0.485
78	0.606	0.618	0.655	0.611	0.531
82	0.574	0.588	0.629	0.589	0.511
86	0.620	0.622	0.654	0.605	0.525
90	0.583	0.560	0.580	0.518	0.448

Partner country: Thailand

	74	78	82	86	90
74	0.290	0.277	0.490	0.543	0.765
78	0.244	0.226	0.440	0.495	0.722
82	0.204	0.190	0.407	0.465	0.705
86	0.268	0.250	0.457	0.514	0.745
90	0.310	0.294	0.493	0.554	0.787

Table 3.8: Industrial structure correlations for partner countries with respect to Hong Kong

Partner country: Singapore

	74	78	82	86	90
74	0.510	0.498	0.452	0.420	0.347
78	0.559	0.557	0.514	0.487	0.409
82	0.562	0.563	0.522	0.496	0.423
86	0.557	0.550	0.507	0.482	0.424
90	0.510	0.482	0.439	0.406	0.388

Partner country: Taiwan

	74	78	82	86	90
74	0.611	0.605	0.635	0.575	0.485
78	0.606	0.618	0.655	0.611	0.531
82	0.574	0.588	0.629	0.589	0.511
86	0.620	0.622	0.654	0.605	0.525
90	0.583	0.560	0.580	0.518	0.448

Partner country: Thailand

	74	78	82	86	90
74	0.290	0.277	0.490	0.543	0.765
78	0.244	0.226	0.440	0.495	0.722
82	0.204	0.190	0.407	0.465	0.705
86	0.268	0.250	0.457	0.514	0.745
90	0.310	0.294	0.493	0.554	0.787

Table 3.9: Industrial structure correlations for partner countries with respect to Hong Kong cont.

Base Country: Indonesia

Partner country: Hong Kong

	74	78	82	86	90
74	0.177	0.135	0.104	0.156	0.195
78	0.216	0.173	0.140	0.191	0.225
82	0.237	0.191	0.161	0.205	0.236
86	0.268	0.220	0.194	0.233	0.266
90	0.456	0.404	0.382	0.415	0.444

Partner country: Indonesia

	74	78	82	86	90
74	1.000	0.992	0.953	0.895	0.784
78	0.992	1.000	0.974	0.923	0.821
82	0.953	0.974	1.000	0.977	0.895
86	0.895	0.923	0.977	1.000	0.949
90	0.784	0.821	0.895	0.949	1.000

Partner country: Korea

	74	78	82	86	90
74	0.617	0.565	0.502	0.377	0.331
78	0.674	0.627	0.566	0.446	0.383
82	0.656	0.608	0.548	0.429	0.366
86	0.652	0.602	0.552	0.431	0.357
90	0.717	0.668	0.630	0.498	0.415

Partner country: Malaysia

	74	78	82	86	90
74	0.467	0.405	0.338	0.246	0.105
78	0.545	0.478	0.408	0.317	0.177
82	0.663	0.588	0.511	0.402	0.246
86	0.740	0.656	0.582	0.472	0.284
90	0.737	0.662	0.599	0.509	0.325

Table 3.10: Industrial structure correlations for partner countries with respect to Indonesia

Partner country: Singapore

	74	78	82	86	90
74	0.062	-0.012	-0.050	-0.064	-0.080
78	0.117	0.039	-0.005	-0.022	-0.046
82	0.147	0.060	0.006	-0.022	-0.052
86	0.149	0.057	-0.001	-0.035	-0.070
90	0.205	0.116	0.048	0.007	-0.045

Partner country: Taiwan

	74	78	82	86	90
74	0.547	0.434	0.346	0.257	0.218
78	0.604	0.495	0.405	0.314	0.271
82	0.602	0.491	0.404	0.311	0.258
86	0.589	0.475	0.394	0.298	0.238
90	0.625	0.510	0.444	0.341	0.254

Partner country: Thailand

	74	78	82	86	90
74	0.814	0.871	0.846	0.770	0.610
78	0.842	0.893	0.872	0.797	0.641
82	0.819	0.875	0.851	0.781	0.635
86	0.800	0.866	0.851	0.806	0.667
90	0.761	0.817	0.844	0.844	0.782

Table 3.11: Industrial structure correlations for partner countries with respect to Indonesia cont.

Base Country: Korea

Partner country: Hong Kong

	74	78	82	86	90
74	0.691	0.663	0.633	0.682	0.697
78	0.689	0.670	0.641	0.686	0.692
82	0.719	0.706	0.681	0.720	0.722
86	0.674	0.683	0.665	0.693	0.673
90	0.585	0.601	0.589	0.620	0.605

Partner country: Indonesia

	74	78	82	86	90
74	0.617	0.674	0.656	0.652	0.717
78	0.565	0.627	0.608	0.602	0.668
82	0.502	0.566	0.548	0.552	0.630
86	0.377	0.446	0.429	0.431	0.498
90	0.331	0.383	0.366	0.357	0.415

Partner country: Korea

	74	78	82	86	90
74	1.000	0.989	0.964	0.879	0.766
78	0.989	1.000	0.989	0.933	0.845
82	0.964	0.989	1.000	0.965	0.886
86	0.879	0.933	0.965	1.000	0.946
90	0.766	0.845	0.886	0.946	1.000

Partner country: Malaysia

	74	78	82	86	90
74	0.567	0.557	0.545	0.535	0.463
78	0.581	0.589	0.587	0.584	0.533
82	0.575	0.594	0.606	0.616	0.570
86	0.593	0.650	0.684	0.721	0.718
90	0.539	0.622	0.660	0.676	0.694

Table 3.12: Industrial structure correlations for partner countries with respect to Korea

Partner country: Singapore

	74	78	82	86	90
74	0.509	0.437	0.377	0.350	0.292
78	0.606	0.535	0.479	0.448	0.401
82	0.672	0.601	0.551	0.513	0.473
86	0.809	0.765	0.728	0.702	0.663
90	0.861	0.810	0.790	0.758	0.785

Partner country: Taiwan

	74	78	82	86	90
74	0.896	0.823	0.757	0.661	0.591
78	0.915	0.867	0.810	0.730	0.678
82	0.889	0.862	0.821	0.755	0.715
86	0.864	0.885	0.864	0.837	0.826
90	0.824	0.866	0.855	0.851	0.874

Partner country: Thailand

	74	78	82	86	90
74	0.809	0.796	0.862	0.887	0.913
78	0.761	0.746	0.813	0.846	0.883
82	0.684	0.673	0.763	0.806	0.874
86	0.540	0.524	0.619	0.664	0.750
90	0.468	0.445	0.505	0.562	0.658

Table 3.13: Industrial structure correlations for partner countries with respect to Korea cont.

Base Country: Malaysia

Partner country: Hong Kong

	74	78	82	86	90
74	0.253	0.248	0.235	0.250	0.241
78	0.303	0.316	0.307	0.313	0.282
82	0.354	0.375	0.371	0.369	0.328
86	0.416	0.447	0.447	0.438	0.378
90	0.402	0.450	0.450	0.435	0.348

Partner country: Indonesia

	74	78	82	86	90
74	0.467	0.545	0.663	0.740	0.737
78	0.405	0.478	0.588	0.656	0.662
82	0.338	0.408	0.511	0.582	0.599
86	0.246	0.317	0.402	0.472	0.509
90	0.105	0.177	0.246	0.284	0.325

Partner country: Korea

	74	78	82	86	90
74	0.567	0.581	0.575	0.593	0.539
78	0.557	0.589	0.594	0.650	0.622
82	0.545	0.587	0.606	0.684	0.660
86	0.535	0.584	0.616	0.721	0.676
90	0.463	0.533	0.570	0.718	0.694

Partner country: Malaysia

	74	78	82	86	90
74	1.000	0.976	0.933	0.862	0.744
78	0.976	1.000	0.986	0.940	0.858
82	0.933	0.986	1.000	0.977	0.911
86	0.862	0.940	0.977	1.000	0.963
90	0.744	0.858	0.911	0.963	1.000

Table 3.14: Industrial structure correlations for partner countries with respect to Malaysia

Partner country: Singapore

	74	78	82	86	90
74	0.531	0.479	0.433	0.408	0.347
78	0.660	0.633	0.596	0.577	0.492
82	0.732	0.719	0.688	0.670	0.565
86	0.777	0.793	0.766	0.762	0.633
90	0.847	0.887	0.867	0.875	0.742

Partner country: Taiwan

	74	78	82	86	90
74	0.609	0.589	0.544	0.522	0.510
78	0.641	0.653	0.624	0.623	0.623
82	0.632	0.664	0.647	0.658	0.666
86	0.622	0.677	0.674	0.700	0.705
90	0.604	0.696	0.708	0.758	0.770

Partner country: Thailand

	74	78	82	86	90
74	0.550	0.569	0.548	0.555	0.468
78	0.483	0.497	0.489	0.505	0.449
82	0.409	0.430	0.444	0.470	0.447
86	0.313	0.332	0.382	0.414	0.428
90	0.182	0.175	0.227	0.254	0.301

Table 3.15: Industrial structure correlations for partner countries with respect to Malaysia cont.

Base Country: Singapore

Partner country: Hong Kong

	74	78	82	86	90
74	0.510	0.559	0.562	0.557	0.510
78	0.498	0.557	0.563	0.550	0.482
82	0.452	0.514	0.522	0.507	0.439
86	0.420	0.487	0.496	0.482	0.406
90	0.347	0.409	0.423	0.424	0.388

Partner country: Indonesia

	74	78	82	86	90
74	0.062	0.117	0.147	0.149	0.205
78	-0.012	0.039	0.060	0.057	0.116
82	-0.050	-0.005	0.006	-0.001	0.048
86	-0.064	-0.022	-0.022	-0.035	0.007
90	-0.080	-0.046	-0.052	-0.070	-0.045

Partner country: Korea

	74	78	82	86	90
74	0.509	0.606	0.672	0.809	0.861
78	0.437	0.535	0.601	0.765	0.810
82	0.377	0.479	0.551	0.728	0.790
86	0.350	0.448	0.513	0.702	0.758
90	0.292	0.401	0.473	0.663	0.785

Partner country: Malaysia

	74	78	82	86	90
74	0.531	0.660	0.732	0.777	0.847
78	0.479	0.633	0.719	0.793	0.887
82	0.433	0.596	0.688	0.766	0.867
86	0.408	0.577	0.670	0.762	0.875
90	0.347	0.492	0.565	0.633	0.742

Table 3.16: Industrial structure correlations for partner countries with respect to Singapore

Partner country: Singapore

	74	78	82	86	90
74	1.000	0.979	0.959	0.921	0.880
78	0.979	1.000	0.993	0.978	0.907
82	0.959	0.993	1.000	0.990	0.927
86	0.921	0.978	0.990	1.000	0.932
90	0.880	0.907	0.927	0.932	1.000

Partner country: Taiwan

	74	78	82	86	90
74	0.592	0.693	0.710	0.761	0.808
78	0.550	0.671	0.703	0.771	0.819
82	0.502	0.635	0.675	0.755	0.819
86	0.492	0.627	0.667	0.752	0.815
90	0.450	0.575	0.613	0.696	0.783

Partner country: Thailand

	74	78	82	86	90
74	0.151	0.121	0.202	0.256	0.381
78	0.060	0.027	0.119	0.169	0.301
82	0.010	-0.024	0.065	0.114	0.244
86	-0.009	-0.046	0.037	0.078	0.204
90	-0.034	-0.079	-0.015	0.026	0.174

Table 3.17: Industrial structure correlations for partner countries with respect to Singapore cont.

Base Country: Taiwan

Partner country: Hong Kong

	74	78	82	86	90
74	0.611	0.606	0.574	0.620	0.583
78	0.605	0.618	0.588	0.622	0.560
82	0.635	0.655	0.629	0.654	0.580
86	0.575	0.611	0.589	0.605	0.518
90	0.485	0.531	0.511	0.525	0.448

Partner country: Indonesia

	74	78	82	86	90
74	0.547	0.604	0.602	0.589	0.625
78	0.434	0.495	0.491	0.475	0.510
82	0.346	0.405	0.404	0.394	0.444
86	0.257	0.314	0.311	0.298	0.341
90	0.218	0.271	0.258	0.238	0.254

Partner country: Korea

	74	78	82	86	90
74	0.896	0.915	0.889	0.864	0.824
78	0.823	0.867	0.862	0.885	0.866
82	0.757	0.810	0.821	0.864	0.855
86	0.661	0.730	0.755	0.837	0.851
90	0.591	0.678	0.715	0.826	0.874

Partner country: Malaysia

	74	78	82	86	90
74	0.609	0.641	0.632	0.622	0.604
78	0.589	0.653	0.664	0.677	0.696
82	0.544	0.624	0.647	0.674	0.708
86	0.522	0.623	0.658	0.700	0.758
90	0.510	0.623	0.666	0.705	0.770

Table 3.18: Industrial structure correlations for partner countries with respect to Taiwan

Partner country: Singapore

	74	78	82	86	90
74	0.592	0.550	0.502	0.492	0.450
78	0.693	0.671	0.635	0.627	0.575
82	0.710	0.703	0.675	0.667	0.613
86	0.761	0.771	0.755	0.752	0.696
90	0.808	0.819	0.819	0.815	0.783

Partner country: Taiwan

	74	78	82	86	90
74	1.000	0.977	0.938	0.873	0.803
78	0.977	1.000	0.986	0.953	0.903
82	0.938	0.986	1.000	0.984	0.937
86	0.873	0.953	0.984	1.000	0.977
90	0.803	0.903	0.937	0.977	1.000

Partner country: Thailand

	74	78	82	86	90
74	0.729	0.702	0.729	0.746	0.748
78	0.602	0.569	0.611	0.632	0.651
82	0.496	0.462	0.528	0.553	0.604
86	0.386	0.345	0.412	0.439	0.494
90	0.334	0.288	0.344	0.372	0.414

Table 3.19: Industrial structure correlations for partner countries with respect to Taiwan cont.

Base Country: Thailand

Partner country: Hong Kong

	74	78	82	86	90
74	0.290	0.244	0.204	0.268	0.310
78	0.277	0.226	0.190	0.250	0.294
82	0.490	0.440	0.407	0.457	0.493
86	0.543	0.495	0.465	0.514	0.554
90	0.765	0.722	0.705	0.745	0.787

Partner country: Indonesia

	74	78	82	86	90
74	0.814	0.842	0.819	0.800	0.761
78	0.871	0.893	0.875	0.866	0.817
82	0.846	0.872	0.851	0.851	0.844
86	0.770	0.797	0.781	0.806	0.844
90	0.610	0.641	0.635	0.667	0.782

Partner country: Korea

	74	78	82	86	90
74	0.809	0.761	0.684	0.540	0.468
78	0.796	0.746	0.673	0.524	0.445
82	0.862	0.813	0.763	0.619	0.505
86	0.887	0.846	0.806	0.664	0.562
90	0.913	0.883	0.874	0.750	0.658

Partner country: Malaysia

	74	78	82	86	90
74	0.550	0.483	0.409	0.313	0.182
78	0.569	0.497	0.430	0.332	0.175
82	0.548	0.489	0.444	0.382	0.227
86	0.555	0.505	0.470	0.414	0.254
90	0.468	0.449	0.447	0.428	0.301

Table 3.20: Industrial structure correlations for partner countries with respect to Thailand

Partner country: Singapore

	74	78	82	86	90
74	0.151	0.060	0.010	-0.009	-0.034
78	0.121	0.027	-0.024	-0.046	-0.079
82	0.202	0.119	0.065	0.037	-0.015
86	0.256	0.169	0.114	0.078	0.026
90	0.381	0.301	0.244	0.204	0.174

Partner country: Taiwan

	74	78	82	86	90
74	0.729	0.602	0.496	0.386	0.334
78	0.702	0.569	0.462	0.345	0.288
82	0.729	0.611	0.528	0.412	0.344
86	0.746	0.632	0.553	0.439	0.372
90	0.748	0.651	0.604	0.494	0.414

Partner country: Thailand

	74	78	82	86	90
74	1.000	0.979	0.934	0.915	0.744
78	0.979	1.000	0.958	0.930	0.765
82	0.934	0.958	1.000	0.975	0.873
86	0.915	0.930	0.975	1.000	0.916
90	0.744	0.765	0.873	0.916	1.000

Table 3.21: Industrial structure correlations for partner countries with respect to Thailand cont.

3.5.3 Countries' years of maximum structure correlation with respect to base country tables

Base country: Hong Kong dates

	74	78	82	86	90
Ind	90	90	90	90	90
Kor	82	82	82	82	82
Mal	86	86	86	86	86
Sin	74	74	74	74	74
Twn	82	82	82	82	82
Th	90	90	90	90	90

Base country: Indonesia dates

	74	78	82	86	90
HK	90	90	74	74	74
Kor	74	74	74	74	74
Mal	74	74	74	74	74
Sin	74	74	74	74	74
Twn	74	74	74	74	74
Th	78	78	78	78	82

Table 3.22: Year of maximum similarity of partner country structure to base country structure in 1974-90

Base country: Korea dates

	74	78	82	86	90
HK	90	90	90	86	86
Ind	90	90	90	90	90
Mal	74	78	86	86	90
Sin	74	74	74	74	74
Twn	74	74	74	78	90
Th	90	90	90	90	90

Base country: Malaysia dates

	74	78	82	86	90
HK	74	78	78	78	82
Ind	86	90	90	90	90
Kor	86	86	86	86	86
Sin	74	74	74	78	78
Twn	74	78	90	90	90
Th	78	86	86	90	90

Table 3.23: Year of maximum similarity of partner country structure to base country structure in 1974-90 cont.

Base country: Singapore dates

	74	78	82	86	90
HK	82	82	82	82	86
Ind	90	90	90	90	90
Kor	90	90	90	90	90
Mal	90	90	90	90	90
Twn	90	90	90	90	90
Th	90	90	90	90	90

Base country: Taiwan dates

	74	78	82	86	90
HK	86	86	78	78	78
Ind	90	90	90	90	78
Kor	78	86	86	90	90
Mal	78	90	90	90	90
Sin	74	74	74	78	82
Th	90	90	90	90	90

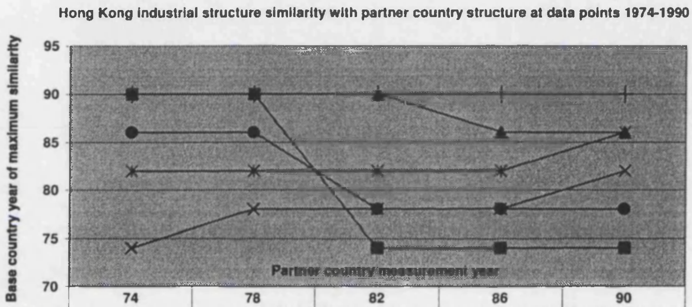
Base country: Thailand dates

	74	78	82	86	90
HK	90	90	90	90	90
Ind	78	78	78	90	90
Kor	74	74	74	74	74
Mal	74	74	74	74	74
Sin	74	74	74	74	74
Twn	74	74	74	74	74

Table 3.24: Year of maximum similarity of partner country structure to base country structure in 1974-90 cont.

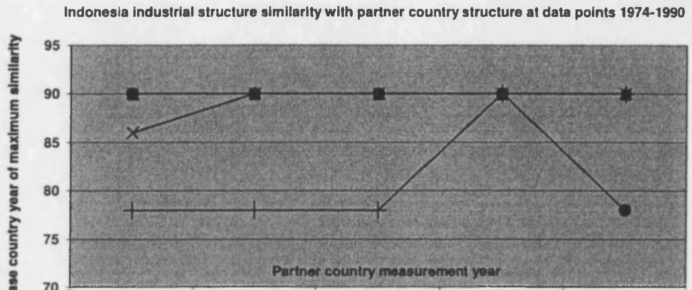
3.5.4 Base country similarity to partner country structure graphs and tables

Base country similarity to partner country measured at the five partner country periods- 1974, 1978, 1982, 1986 and 1990



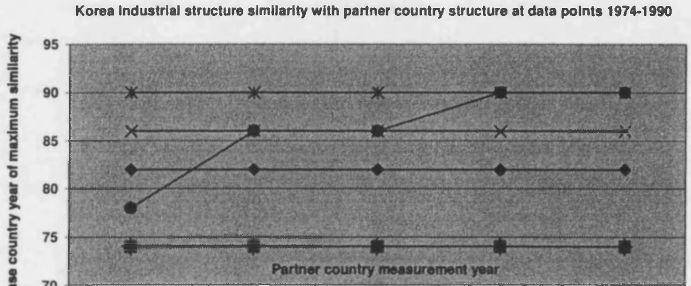
	74	78	82	86	90
Hong Kong					
Indonesia	90	90	74	74	74
Korea	90	90	90	86	86
Malaysia	74	78	78	78	82
Singapore	82	82	82	82	86
Taiwan	86	86	78	78	78
Thailand	90	90	90	90	90

Figure 3-3: Hong Kong similarity to partner country structure at data points 1974-90



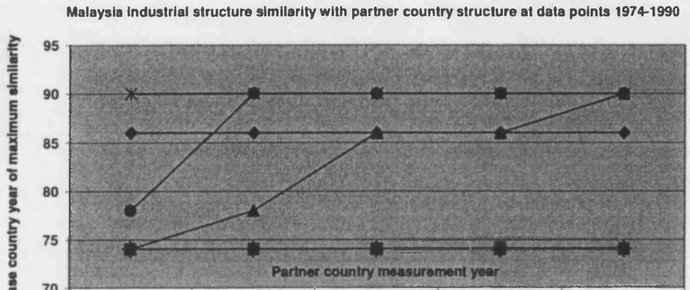
	74	78	82	86	90
Hong Kong	90	90	90	90	90
Indonesia					
Korea	90	90	90	90	90
Malaysia	86	90	90	90	90
Singapore	90	90	90	90	90
Taiwan	90	90	90	90	78
Thailand	78	78	78	90	90

Figure 3-4: Indonesia similarity to partner country structure at data points 1974-90



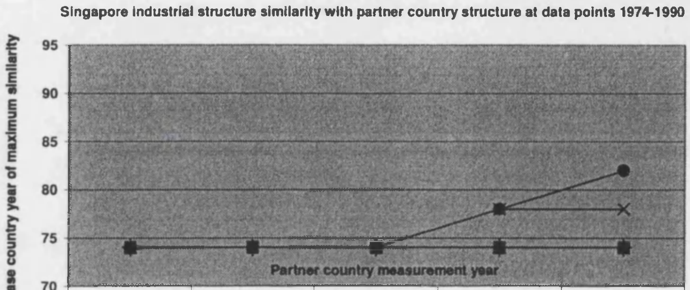
	74	78	82	86	90
Hong Kong	82	82	82	82	82
Indonesia	74	74	74	74	74
Korea					
Malaysia	86	86	86	86	86
Singapore	90	90	90	90	90
Taiwan	78	86	86	90	90
Thailand	74	74	74	74	74

Figure 3-5: Korea similarity to partner country structure at data points 1974-90



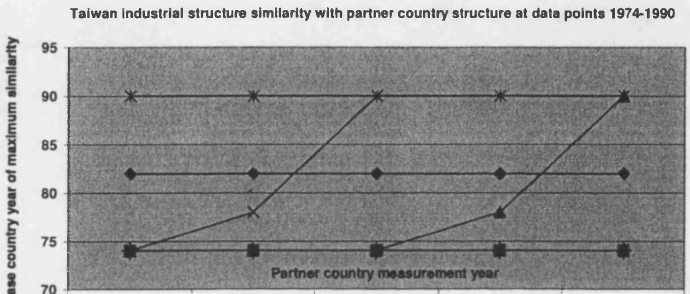
	74	78	82	86	90
Hong Kong	86	86	86	86	86
Indonesia	74	74	74	74	74
Korea	74	78	86	86	90
Malaysia					
Singapore	90	90	90	90	90
Taiwan	78	90	90	90	90
Thailand	74	74	74	74	74

Figure 3-6: Malaysia similarity to partner country structure at data points 1974-90



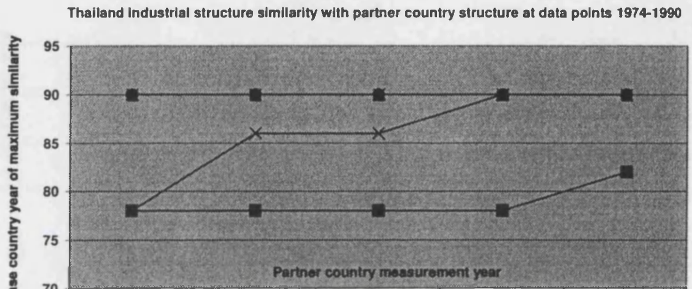
	74	78	82	86	90
Hong Kong	74	74	74	74	74
Indonesia	74	74	74	74	74
Korea	74	74	74	74	74
Malaysia	74	74	74	78	78
Singapore					
Taiwan	74	74	74	78	82
Thailand	74	74	74	74	74

Figure 3-7: Singapore similarity to partner country structure at data points 1974-90



	74	78	82	86	90
Hong Kong	82	82	82	82	82
Indonesia	74	74	74	74	74
Korea	74	74	74	78	90
Malaysia	74	78	90	90	90
Singapore	90	90	90	90	90
Taiwan					
Thailand	74	74	74	74	74

Figure 3-8: Taiwan similarity to partner country structure at data points 1974-90



	74	78	82	86	90
Hong Kong	90	90	90	90	90
Indonesia	78	78	78	78	82
Korea	90	90	90	90	90
Malaysia	78	86	86	90	90
Singapore	90	90	90	90	90
Taiwan	90	90	90	90	90
Thailand					

Figure 3-9: Thailand similarity to partner country structure at data points 1974-90

Chapter 4

Factor Endowments, Technological Progress, and Structural Transformation in East Asia

4.1 Introduction

We have seen in earlier chapters that industrialisation in the region has been accompanied by structural transformation in manufacturing. Based on our findings, we then wish to look at possible drivers for the industrial changes witnessed. We wish to test between factor endowments and industry-specific technological differences as explanators, using a specification which allows us to jointly consider both groups of variables using disaggregated manufacturing data.

The rapidity and degree of change one finds both in the level of total manufacturing and the individual industrial components of manufacturing, offers a rich dataset. Timmer (1999) has studied capital intensity and technology at a disaggregated national level for the region. He finds that capital intensity and technology are both considerably below that of the industrialised world. Within this framework however he finds considerable difference in results in particular industrial sectors. This highlights the importance of a disaggregated view of the issue. We see from Figure 4-1 below that over the period 1974-1994, each of the high growth East Asian countries studied has either already possessed or gained a substantial degree of manufacturing industry.

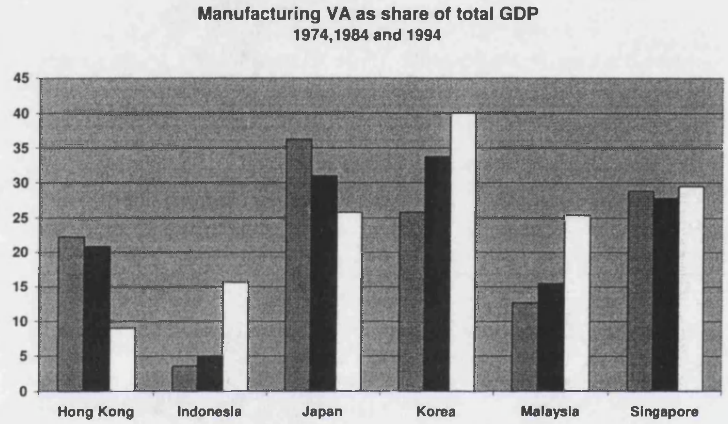


Figure 4-1: Manufacturing value added as share of total GDP- 74,84 & 94

Indeed all countries in the sample are industrialising rapidly or already at the point of deindustrialising as the economy moves to the next stage of development, a service economy. One sees clear signs of this move in Japan with manufacturing showing a steady fall from 36% to 26% of total GDP. Hong Kong shows a fall too with the most dramatic part of it coming between 1984 and 1994 from 21% to 9%. This is what would be expected as its development started later than Japan. Singapore has seen its share remain stable over the periods at 29%. Of the first wave of development, Korea is an exception in moving from its already high level of industrialisation of 26% to a further steady gain to 40%. The two countries in the later stage of development both see strong increases in their manufacturing content. Malaysia's output increases from 13% to 25% steadily. Indonesia sees manufacturing increase from 4% to 16%, with nearly all of the change occurring in the period 1984-94. This also ties in with our expectations as Indonesia was the last country in the group to embark on its industrialisation spurt.

To obtain a better idea of the reasons behind such industrialisation, we need to look to a more disaggregated level. We therefore study the components of change within the 9 ISIC 2-digit manufacturing sectors. A study of production shares is a useful addition to the analysis we undertook in Chapter 2 utilising trade data to see whether similar trends are still witnessed. We look first at changes in the share of these sectors as a percentage of total manufacturing value added for our sample countries for the cutoff years 1974, 1984 and 1994. We present in Table 4.1 the industries which have experienced increase or decline in each of our sample countries for the periods 1974-84 and 1984-94.

We observe a number of trends in the data. First, we see that machinery sees increase in practically all countries and in all periods. Only Indonesia does not see machinery increase in a particular period, 1974-84. Apparel declines in all countries in all periods bar Malaysia and Indonesia. In Malaysia it increases in 1974-84 and in Indonesia it increases during 1984-94. This would seem to be appropriate as the industry is seen as a low technology one and thus appropriate for countries in the initial stages of development. We can only surmise on this until we obtain an idea of the factor intensities of the various industries, as we do below. Other than machinery and apparel, we see that there is considerable change in increasing industries in all countries during the periods in question. In the extreme case, Malaysia sees no industries repeat their positive performance. We confirm our earlier findings from disaggregated trade data that the sample countries seem to be passing through different periods in their development within the two decade time frame under consideration. We will be attempting to obtain an idea of what leads a country to move between these different development stages.

JAPAN				**KOREA**			
1974-84		1984-94		1974-84		1974-84	
Gain	*Loss*	*Gain*	*Loss*	*Gain*	*Loss*	*Gain*	*Loss*
Mach	Wood	Chem	Metal	Mach	Wood	Mach	Food
Food	Metals	Paper	Text	Paper	Food	Wood	Text
	Text	Food	Glass	Others	Text	Paper	Metal
	Glass				Metal		Chem
	Paper				Glass		Others
	Chem				Chem		
SIN				**HK**			
1974-84		1984-94		1974-84		1974-84	
Gain	*Loss*	*Gain*	*Loss*	*Gain*	*Loss*	*Gain*	*Loss*
Paper	Metal	Mach	Text	Glass	Metal	Food	Wood
Chem	Wood	Chem	Wood	Mach	Wood	Paper	Chem
Mach	Food		Metal	Paper	Food	Glass	Text
Glass	Text		Glass	Others	Text	Metal	
Others			Food		Chem	Mach	
			Paper				
			Others				
MAL				**IND**			
1974-84		1984-94		1974-84		1974-84	
Gain	*Loss*	*Gain*	*Loss*	*Gain*	*Loss*	*Gain*	*Loss*
Mach	Wood	Mach	Food	Metal	Food	Paper	Metal
Chem	Food	Wood	Paper	Wood	Text	Mach	Food
Metal	Glass	Others	Metal	Chem	Paper	Text	Glass
Text	Others		Chem	Glass	Mach	Wood	Chem
Paper			Glass		Others	Others	
			Text				

Table 4.1: Industry value added gains and losses per country, 1974-84 and 1984-94

The factor endowments approach provides suggestions as to the pattern of development which should be expected at an industrial level. Leamer (1987) discusses how a country's mix of starting endowments and subsequent changes in factor mix decides which industries are specialised in over time. Harrigan (1995) tests for comparative advantage due to endowments for industries in 20 OECD countries. He finds capital to have a positive effect with possibly skilled labour abundance having some effect as well. The analysis of residuals suggests that the model does poorly, significantly under or over predicting output in many industries and countries. This suggests that industrial patterns are not fully explained by the factor proportions model. One issue to be aware of when testing for a Heckscher-Ohlin specification in a region is that of a common cone of diversification. Membership of the same cone is necessary for factor price equality for all endowments in all sample countries (see Schott (1999)). The idea is of considerable importance when one considers regions of significant change in relative factor endowments such as East Asia. We receive some justification for the belief that all East Asian countries are in a common cone by the fact that we find positive production of goods in all sectors at every point in time across our sample. We cannot however reach a firmer conclusion as we only have evidence of positive sectoral production at a low level of disaggregation (nine industrial sectors). It would be interesting to test further for multi-cones if more disaggregated data were available for our sample countries.

Another reason suggested for paths of development across industries has been industry-specific technological differences. The Ricardian model of technological differences predicts that countries will specialise in industries in which they have a technological advantage relative to other countries. Harrigan (1997) models this source of specialisation formally and applies the analysis to OECD countries. He finds it to be important, but less so than factor endowment differences, in explaining change in his sample. Our work is useful as it similarly incorporates both factor endowment and technological change explanations but applies them specifically to explaining industrial change in East Asia.

4.2 Theoretical framework

We use the standard neoclassical theory of trade following Redding (1999) as developed by authors such as Dixit and Norman (1980), Harrigan (1997) and Woodland (1982). Time is indexed by t, countries by $c \in \{1, ..., C\}$, final goods by $j \in \{1, ..., n\}$, and factors of production by $i \in \{1, ..., m\}$. Each country has an exogenous vector of factors of production v_{ct}. We assume constant returns to scale in production and perfect competition. There may be differences in factor endowments across countries c and technology differences across countries c and time t.

We assume a small open economy and so can assume a given vector of world prices for final goods p^t. Equilibrium for producers may be represented by the revenue function $r_c(p_t, v_{ct})$. If we assume this function is twice differentiable, the profit maximising output function $y_c(p_t v_{ct})$ is given by the differential of the revenue function with respect to p_t. Given that technology differences over countries, time and industries are Hicks-neutral, we have $y_{cjt} = \theta_{cjt} F_j(v_{cjt})$, where θ_{cjt} expresses technology in country c in industry j at time t. The revenue function can then be expressed as $r_c(\theta_{ct}, p_t, v_{ct})$ where θ_{ct} is a $n \times n$ matrix of the parameters θ_{cjt}. We therefore model changes in technology in the same way as changes in endowments or prices, in terms of their effect on revenue. Output is still given by the differential of the revenue function with respect to prices.

In the manner of Kohli (1991), Harrigan (1997) and Woodland (1982) we approximate the true revenue function with a translog function,

$$\begin{aligned}\ln r(\theta.p, v) &= \alpha_{00} + \sum_j \alpha_{0j} \ln \theta_j p_j \\ &+ \frac{1}{2} \sum_j \sum_k \alpha_{jk} \ln(\theta_j p_j) \ln(\theta_k p_k) + \sum_i \beta_{0i} \ln v_i \\ &+ \frac{1}{2} \sum_i \sum_h \beta_{ih} \ln v_i \ln v_h + \sum_j \sum_i \gamma_{ji} \ln(\theta_j p_j).(\ln v_i) \quad (4.1)\end{aligned}$$

where $j, k \in \{1, ..., n\}$ are goods and $i, h \in \{1, ..., m\}$ are factors of production. Since there are symmetries of cross effects, we get

$$\alpha_{jk} = \alpha_{kj} \text{ and } \beta_{ih} = \beta_{hi} \tag{4.2}$$

Linear homogeneity of degree 1 in v and p requires,

$$\sum_j \alpha_{0j} = 1, \sum_i \beta_{0i} = 1, \sum_j \alpha_{kj} = 0, \tag{4.3}$$

$$\sum_i \beta_{ih} = 0, \sum_i \gamma_{ji} = 0 \tag{4.4}$$

Assume that (4.1) holds for all countries c and time periods t. Differentiating each term of (4.1) with respect to p_j we obtain an expression for the share of industry j output in country c's output at time t,

$$s_{cjt} = \alpha_{0j} + \sum_k \alpha_{jk} \ln p_{ckt} + \sum_k \alpha_{jk} \ln \theta_{ckt} + \sum_i \gamma_{ji} \ln v_{cit} \tag{4.5}$$

If we assume that all goods are tradeable and that goods prices are the same in all countries ($p_{ckt} = p_{kt}$ for all c) then the second term in the above equation can be replaced with time dummies (d_{jt}) of a $\{0, 1\}$ type for each industry j. This allows us to consider the following specification,

$$s_{cjt} = \alpha_{0j} + \phi_j d_{jt} + \sum_i \gamma_{ji} \ln v_{cit} + u_{cjt} \tag{4.6}$$

The equation can be thought of as a pure Heckscher-Ohlin specification. We are omitting the technology term as according to Heckscher-Ohlin theory technology is identical between countries. The coefficient estimates will be consistent given a number of possible assumptions about the behaviour in practice of technology. One would be if technology differences are neutral across sectors ($\theta_{cjt} = \mu_{ct}\theta_{zjt}$ for all c, j and some reference country z). Another manner of obtaining consistency would be if technology (θ_{cjt}) is not correlated with factor endowments (v_{cit}). Neutral technology differences would not be important as they affect levels of value added but not shares of industry (Harrigan and Zakrajsek (1999)). This is the assumption made by Trefler (1995). If technology differences are non-neutral across sectors, shares of industry will be affected but there is no generally accepted view on how these technology differences would be connected with factor endowments. One view is that a country with high levels of a factor displays high productivity in sectors which use this factor intensively (David (1975)). However one also finds evidence of countries displaying high productivity in sectors which use a scarce resource intensively. Amsden (1989) and Porter (1990) discuss cases where this is evident such as many manufacturing industries in Japan. It is argued by some, for example Sachs and Warner (1995) that land abundance actually decreases technology levels.

We subsequently allow for country technological differences by considering the specification with both technology and factor endowment terms as below,

$$s_{cjt} = \alpha_{0j} + \phi_j d_{jt} + \sum_k \alpha_{jk} \ln \theta_{ckt} + \sum_i \gamma_{ji} \ln v_{cit} \tag{4.7}$$

An important assumption of the neoclassical model is that the production function is constant returns to scale. This is a point of some discussion with there being a number of alternative explanations for industrial change assuming increasing returns to scale. These include the ideas of new economic geography (see Fujita, Krugman and Venables (1999)). For constant returns to scale to hold, there should be homogeneity in factors of production as seen in the equations above. We test for this in the econometrics that follows.

4.3 Data Description

The sample period used is 1974-1994. This encompasses the different periods of rapid industrialisation for the countries in our sample. The sample countries we use are six representative East Asian ones. These are Japan, Korea, Hong Kong, Singapore, Malaysia and Indonesia. Other rapidly industrialising countries in the region which would have been relevant for our analysis- Taiwan and Thailand- could not be included due to lack of data. We believe that the countries used provide a fair understanding of the forces at work in the region as they encompass countries in different stages of development within our sample period. The industrial disaggregation studied is the 2-digit ISIC level of classification within the manufacturing sector. Further disaggregation is not possible due to limitations in the availability of data.

Information has been drawn from a number of national and international sources. Industrial data is from the United Nations Industrial Development Organization (UNIDO). This is the raw value added, employment, gross fixed capital formation, and industrial price deflator data. This source contains some missing data points for the countries in question. These are interpolated using available data points, or extrapolated when necessary using a five year linear trend from available data points. The dataset is useful as the only source of such production-related data at a disaggregated level in an internationally comparable form for the region. It has been utilised recently by Harrigan and Zakrajsek (2000) to analyse factor endowment effects on industrial production for a sample of 28 countries.

National physical capital data comes from King and Levine (1994). Data on educated labour endowments is from Barro and Lee (2000). Land data is from the UN Food and Agricultural Organisation (FAO). All data with a money value is converted to 1990 Purchasing Power Parity (PPP) dollars. PPP data for this purpose was obtained from the World Bank and derives from the International Comparison Programme (ICP) of the United Nations.

Technology is estimated by means of a total factor productivity (TFP) index as used by Harrigan (1997). The relevant statistic for calculation is

$$TFP_{bc} = \frac{y_b}{y_c}(\frac{\bar{l}}{l_b})^{\sigma_b}(\frac{\bar{k}}{k_b})^{1-\sigma_b}(\frac{l_c}{\bar{l}})^{\sigma_c}(\frac{k_c}{\bar{k}})^{1-\sigma_c} \tag{4.8}$$

where y is value added, l is labour input, k is capital input, and b and c are any two countries. $\bar{l}$ and $\bar{k}$ are geometric averages over all the observations in the sample and $\sigma_c = \frac{(s_c+\bar{s})}{2}$ where s_c is labour's share in total cost in country c. To interpret the equation we can see that if the value added function is Cobb-Douglas, the labour shares are constant and so the equation reduces to the Cobb-Douglas index:

$$TFP_{bc} = \frac{y_b}{y_c}(\frac{l_c}{l_b})^{s}(\frac{k_c}{k_b})^{1-s} \tag{4.9}$$

l is measured by means of industrial employment data, corrected for average weekly hours worked. k is measured as industrial capital stock calculated from gross fixed capital formation (GFCF) data. The choice of index country and year is not important as the TFP function is transitive. Our base year and country is 1990 Japanese TFP for each industry.

4.4 Preliminary Data Analysis

It is useful to consider some of the comparative characteristics of our sample countries. Working with a subset of all possible countries, our East Asian sample, is theoretically sensible in terms of the assumptions we have made in order to derive our estimation equations. It may be more likely that common prices and diversified production will be found in a limited group of countries which share the characteristic of being in the same region and linked by trade ties, than in a broad international sample.

First, we consider the magnitude and change in factor endowments for our sample countries. The data is presented in Appendix Tables 4.2 and 4.3. In terms of physical capital, the city states of Singapore and Hong Kong have large absolute amounts per capita, with Singapore having even more than Japan by

1994. Indonesia has by far the lowest amount, indicating its early stage of development. There are significant differences in rates of increase in physical capital endowment between the sample countries. Japan, the most developed country in the group, increases physical capital slowest and steadily with a percentage increase between 1974-94 of 107%. Indonesia sees the fastest increase in physical capital with an increase of 400% between 1974-94. Singapore also sees high increase of 340% between 1974-94. In each case except Japan the first decade 1974-84 sees a far higher increase than the subsequent decade. Within this, Indonesia (229% 74-84 vs 52% 84-94) and Malaysia (120% 74-84 vs 17% 84-94) see the greatest fall in the rate of increase between the first period and the second. This would seem to follow from the fact that they are earlier in their industrialisation spurt than the other countries.

We now consider endowments of labour of different educational attainments in our sample countries. Attainment is divided into up to primary school attained, secondary school and high school attainment as classified by Barro and Lee (2000). First, we see that educational attainment is closely tied to stage of development. Japan has 100% of students attaining at least primary education by 1994. Japan is followed in order for the same measure by Korea, Hong Kong, Singapore, Malaysia and Indonesia. Japan achieves complete coverage by the second decade. Korea and Hong Kong have their greatest increase in the first decade too. Singapore and Malaysia see more increase in the second decade. In terms of the distribution of attainment, the majority of the educated populace in Japan and Korea by the first decade is concentrated in those who attain a secondary education. By the second decade, Hong Kong, Singapore and Malaysia display the same characteristic. In terms of higher education, the advanced countries are steadily increasing attainment numbers. Japan (22% of population in 1994) is closely followed by Korea (20%) in achievement. Hong Kong (14%) is significantly ahead of the others in the chasing pack, Singapore (7%) and Malaysia (6%). Indonesia is still in the phase of having the majority of its educated at only a primary level (32%), with only a small minority (3%) having a tertiary education.

The possibility that factor endowments would play a role in industrial change depends on there being differences in factor intensities in the industries, thus allowing the factors to influence them in different ways. For a precise factor intensity calculation we would need education breakdowns for each industry as well as capital numbers. Since we do not possess worker skills at this level of disaggregation, we attempt to give an idea of industry factor intensities by looking at the average number of workers employed and average physical capital employed per million dollars of value added in each industry. We do this for Japan as a representative country for the years of 1974, 1984 and 1994 as shown in Appendix Table 4.4. We see that factor intensity has decreased across time for both capital and labour in Japan. More importantly for our purpose as a guide for all sample countries, we note that intensities are substantially different across most industries. For example, Apparel displays a labour intensity of 28.9 in 1994 as opposed to Chemical's figure of 9.1. In terms of capital intensity we see Metals in 1994 with a ratio of 3.3 as opposed to Paper with a ratio of 1.6. When extrapolated to other countries, an assumption of factor price equalisation would point to the same figures in other countries in the same industries. However we know that more realistically this assumption will not hold, so we can expect a range of intensities in the sample varying across countries and industries.

4.5 Econometric analysis

4.5.1 Factor Endowments

We now conduct a more formal analysis of the effects of factor endowments on industrial development in the region. We utilise equation (4.6) as outlined above. The error term assumed is of the form,

$$\varepsilon_{cjt} = \eta_{cj} + d_{jt} + \psi_{cjt} \tag{4.10}$$

where η_{cj} are country fixed effects and d_{jt} are time fixed effects and ψ_{cjt}

is a serially uncorrelated stochastic error term. The country fixed effect term accounts for changes in non-tradeable goods prices (Harrigan (1997)) and any other time-invariant changes dependent on country characteristics. The time dummy accounts for changes in tradeable goods prices as outlined above and common macroeconomic shocks across countries.

The dependent variable used is the share of manufacturing sector j's value added in country c's total value added and the explanatory variables are the log of the five different types of factor endowments. The use of such a form allows us to interpret the coefficients obtained as semi-elasticities. For example a coefficient value of 0.1 implies that a 1% increase in the independent variable is associated with an increase in the share of value added of the particular sector of 0.1 percentage points.

We consider some of the properties of the relationship between factor endowments and national production through the results obtained from specifications with time and time and country dummies. Heteroskedasticity is accounted for in all the following estimations through the calculation of robust standard errors. We first present the regression results with time dummies. The results for each of the 9 2-digit ISIC code industrial sectors are presented in Appendix Table 4.5. Appendix Table 4.6 presents the regression with time and country dummies. The pattern of estimated coefficients changes as we move from the first to the second specification and the goodness of fit improves. For example, for the Food sector regression, the first specification provides a R^2 of 0.68 as opposed to a R^2 of 0.92 with both time and country dummies. We conduct a formal test of importance of including the time and country dummies through F-tests of their joint significance. The results are presented in Appendix Table 4.7. We see that including time dummies only are significant for four of the nine industrial sectors. Country dummies are significant for all sectors and including both time and country dummies are significant for all sectors.

The inclusion of country dummies may have been important due to the presence of a common error component across time within individual countries that is correlated with factor endowments. This can be caused by differences in internal relative prices, such as countries' internal or external taxes and subsidies. Import tariff rates have been kept at different levels in the region to protect local industries. In the mid-1990s Thailand, Indonesia and Malaysia had the highest tariff rates in the region, 25%, 17% and 12% respectively (DFAT (2002)). Korean and Taiwanese average tariff rates were somewhat lower at 9% and 7%. Hong Kong and Singapore on the other hand are free-traders, with tariff rates close to 0%.

Another reason for the change caused by introducing country dummies may be due to the presence of non-neutral technology differences. If there are technology differences across sectors or factors, but these are constant over time, their effect will be picked up by the country dummy. Examples of country-specific technology differences would be educational qualifications embodying different levels of human capital across countries or agricultural land having different productivities in one country as compared to another. It can be seen that the quality of education, as measured by international test scores differs widely among countries in the region. Singapore, Korea, and Hong Kong, as measured in the Third International Mathematics and Science Study 1994, rank among the top countries internationally in secondary school students' mathematics test performance. Thailand on the other hand scores around the average. The relative ranking of countries is the same with respect to science test scores. In the same test conducted in the late 1990s including more of our sample countries it is seen that Indonesia ranks far below the international average. Malaysia ranks between the top international performers- Singapore, Korea, Taiwan and Hong Kong- and Thailand- which is just below the average (ADB (2002)).

Using the specification with both time and country dummies, we find capital endowments to have a significant effect at the 5% level in the Wood, Paper, Chemicals, Glass, Metals and Machinery sectors. The capital coefficients are positive in all cases. We find education to only primary level to be significant for the Food, Wood, Glass, Metals and Machinery sectors. It is positive for the Food sector and negative for all the others. Secondary education is not significant for any sector. Tertiary education is significant for Food, Wood, Glass and

Metals. It is positive for all of them. It is interesting to note that, except for Food, the common sectors for primary education and tertiary education display opposite signs. Land is seen to be significant for every sector. It has a positive effect for all sectors except Food.

The land coefficient may appear somewhat counterintuitive for the Food sector where it is negative and significant. It should be borne in mind that this result is not so stark as Food in this case is not a primary sector but is the manufacture of processed food and beverages. Furthermore two countries in our sample, Singapore and Hong Kong, are very small geographically leading to large proportional effects of their small absolute changes in arable land endowment. The land result is also affected by little variability in land endowments for the other sample countries, except Malaysia where there is a substantial increase.

We also investigate our regression equation in the presence of a lag in response of industry share to changes in factors. The equation is modelled as

$$s_{cjt} = \delta s_{cjt-1} + \alpha_{0j} + \phi_j d_{jt} + \sum_i \gamma_{ji} \ln v_{cit} + u_{cjt} \tag{4.11}$$

where $1 - \delta$ can be considered as the speed of adjustment to long-run equilibrium. The long run effect of a change in a factor of production is obtained as $\gamma_j/(1 - \delta_j)$. We find the lag to be significant for the Food, Textiles, Wood, Chemicals, and Machinery sectors. The regression results are presented in Appendix Table 4.9. There are 18 significant coefficients out of the 45 possible. The inclusion of time and country fixed effects in the lagged specification is seen to be important (Appendix Table 4.8) with similar patterns but lower significance as compared to the unlagged specification. With this specification, we find that capital is significant for the Paper, Glass and Metals sectors, a subset of the group without a lag. Generally subsets of the previous results are obtained for the other endowments also. Food, Paper, Glass and Metals are significant for the low education endowment. Paper is significant for secondary education. Paper, Glass and Metals are significant for tertiary education. Textiles, Wood, Chemicals, Glass, Metals, Machinery and Others are significant for the land endowment. Coefficient values in the lagged equation are seen to be generally lower than the non-lagged. This points to the conclusion that considering adjustment not to be immediate produces weaker association between factor supplies on output shares.

4.5.2 Technology

We now consider the effects on industrial development of actively including technology factors in our analysis. We wish to see if the inclusion of these effects adds to the explanatory power of the specification. The specification used is that of equation (4.7). The results are presented as Appendix Table 4.10. An expectation from theory is that the own-TFP effects should be positive, superior technology in a sector should be positively related to greater share of that industry in the country.. We find that we obtain no significant negative values out of our nine sectors. To test for the strength of these results, we also estimate the equation using a one period lag in the format,

$$s_{cjt} = \delta s_{cjt-1} + \alpha_{0j} + \phi_j d_{jt} + \sum_k \alpha_{jk} \ln \theta_{ckt} + \sum_i \gamma_{ji} \ln v_{cit} + u_{cjt} \qquad (4.12)$$

The lagged equation results are presented in Appendix Table 4.11. We find that the own-TFP results are generally unchanged. Significant positive own-TFP effects are obtained for Food, Glass and Metals as well as the addition of Wood.

It is interesting that a positive technology effect is noted in the Food and Beverages processing sector, a sector which is generally more labour-intensive than many other sectors. This may be due to some countries in the sample being at a relatively low level of development internationally during the sample period. There may be therefore scope for output gains from the introduction of technology to less sophisticated production methods in the sector. The Glass (ie. Non-Metallic Minerals) and Metals sectors are considered more modern sectors where there is a greater role for physical capital and considerable scope for technological change.

The cross-TFP effects are a mix of positive and negative. For the nonlagged specification significant results are obtained for Wood-Machinery, Chemicals-Metals and Metals-Others, all positive. For the lagged specification, Chemicals-Metals and Metals-Others continue to remain significant. It is difficult to draw firm conclusions from the cross-TFP results. They may be merely general equilibrium effects with no obvious policy implications.

In terms of factor endowments, we look first at the unlagged specification. We find considerable significance in the results. Capital is significant and positive for Paper, Chemicals, Glass, Metals and Machinery. Little or no education is positive and significant for Food, Textiles, Chemicals and Other Manufactures. It is significant and negative for Glass and Metals. Secondary education is positive and significant for Textiles, Glass and Metals. It is negative and significant for Paper. Tertiary education is positive for every sector and significant for Wood, Paper, Metals, Machinery and Others. Land is positive and significant for every sector except Food. It is negative and significant for Food. The possible causes for the Land result are discussed in the previous section.

The education results are seen to be quite clear. We see that education above a primary level is good or neutral for most industries. For the Food sector we see that low-skilled labour abundance is associated with increased output, as may be expected from the labour-intensive nature of the sector. Textiles is notable as the sector where human capital is only important until the medium-skilled level, as measured by secondary school attainment. This is consistent with the popularity of the sector for countries at the initial stage of industrial development. Tertiary education has proved particularly valuable in the encouragement of particular sectors. It is important for the more technologically complex sectors of Metals and Machinery as well as Wood and Paper. It is seen that in all but the "traditional" sectors of Food, Textiles and Wood, we find a positive effect of higher-educated workers mirrored by a negative effect of low-educated workers. By "traditional" industries we mean natural resource-based or relatively low complexity manufacturing industries. Capital growth has been positively important in the "modern", relatively higher-technology, industries. It is indeed negative (but not significant) for the "traditional" relatively low technology industries of Food, Textiles and Wood. A trend is suggested of increasing capital endowment leading to countries altering their industrial structure by moving from the "traditional" towards the "modern" industries.

It is interesting if one compares our high education effects with those of Harrigan (1997). He obtains widespread negative results, leading him to observe that this is due to workers leaving manufacturing to enter services. We do not find such clear cut results here, with many industries showing positive significant responses. This may be due to many economies in the region not having reached the absolute levels of high educated workers found in the developed world. This may have prevented the takeoff of as fast growing a service sector as in the developed world. It is clearly important to look at East Asia as an area apart as general results or developed country results can mask regional and less developed country variation.

Inferences of trends in industrial change related to factor mix, for physical capital, education and technology, should be made with caution given the sample used. References to "traditional" or "modern" industrial sectors can not be too accurately made. This is due to the high level of aggregation involved. Within the broad 2-digit ISIC categories used there are a range of industrial sub-sectors with different technological complexities. As mentioned in United Nations (2002), "manufacturing units are classified according to the principal kind of economic activity in which they engage, whether the work is performed by power-driven machinery or by hand, or whether it is done in a factory or in a household".

Another point to note is that we should be wary of any lack of significance in what can be loosely considered the natural resource based industries. These would be the Wood, Paper, Chemicals, Glass and Metals sectors. We have had to omit a measure of national resource supplies due to lack of data. Given the obvious relationship between output in these sectors and the availability of the relevant natural resources this means we are underestimating the total effect of factor endowments for them.

For the lagged equation we see generally the same pattern of results with lower significance. Accounting for adjustment time of manufacturing share to endowment changes seems to produce weaker associations as compared to when automatic adjustment was assumed. For capital, significant positive results are Paper, Chemicals, Glass, Metals and Machinery. Negative results are for Food. Little or no education is positive and significant for Food, Textiles, Chemicals and Other Manufactures. It is significant and negative for Glass and Metals. Secondary education is positive and significant for Textiles, Glass and Metals. It is negative and significant for Paper. Tertiary education is positive for every sector except Textiles and significant for Food, Wood, Paper, Glass, and Metals.

It is interesting to investigate the predictions of Heckscher-Ohlin theory with respect to the relation between factor endowments and intensities using our results. The two factors considered in Appendix Tables 4.12 and 4.13 are capital and workers educated to primary level. The coefficients of each significant value of the factors for each industry are ranked by value, offering a view of the model's prediction for their relative magnitudes. This measurement of endowments is compared to the 1994 ranking of factor intensities observed in Japan as a proxy for intensity in all sample countries. For capital we find that the ranking in the four significant sectors is identical to that expected from our belief about their intensities, other than the marginal switching of positions between Metals and Chemicals. For example, Glass is seen to be the least capital intensive sector in the group as expected from its endowment responsiveness coefficient. For up till primary educated workers, endowment coefficient data is compared with total labour intensity which is taken as a suitable proxy for low educated workers as they are the largest component of the labour force. We see again that the ranking of responsiveness to endowments among industries is exactly in line with the ranking of their intensities other than the stronger than expected positive endowment effect in the Chemicals sector. These results provide us with support for the belief that industrial change is responding to endowment changes in countries in line with the predictions of Heckscher-Ohlin theory.

We wish to establish the statistical significance of the technology and factor endowments groups of terms in explaining manufacturing patterns. This is done through tests for the significance of the technology and factor endowments groups separately and jointly for each of the industry equations. We run F tests for the unlagged and lagged specifications. We present the probabilities of having values greater than the F statistic observed in Appendix Tables 4.14 and 4.15. We find both TFP and factor endowments to be significant separately and jointly in every case for the unlagged and lagged specifications. It is seen that though TFP terms may not often show significance individually they are significant as a group.

We would like to quantify the extent to which technology and factor endowments explain manufacturing change in the region. We do this by calculating average prediction errors for the factor endowment only and endowments and technology specifications. The statistic provides us with the mean across time and countries of the absolute value of actual versus predicted manufacturing share. This is expressed as $\frac{|s_{cjt}-\hat{s}_{cjt}|}{s_{cjt}}$. The results are presented in Appendix Table 4.16.

We find the results to be stable across most industries. Other Manufacturing shows little explanation from factors, and a considerable improvement when TFP is introduced. We omit the Metals industry results as the small size of some observations leads to skewed results. In the sample as a whole (excluding the outliers of Metals and Other Manufacturing), including factors leaves a prediction error of 35% whereas TFP and factors together produce a prediction error of 21%.

We see a mixed picture with respect to the pattern of prediction errors across industries. Endowments explain a considerable degree of change, with prediction errors ranging from 40% to 13% (not including the outliers discussed above). The inclusion of TFP is important in explaining change in some industries, for example Food, Wood, and Machinery. In these cases prediction errors are improved by close to 100% through the inclusion of TFP. In other industries however TFP has much less effect on improving prediction error. Though for the sample as a whole factor endowments have more importance, the extent of diversity across industries means that technology can be seen to often play a significant role.

It is useful to investigate the applicability of the two specifications to the particular countries in our sample. We obtain the differences between predicted and actual results for each country for the factor endowments and factor endowments and TFP regressions. These are presented in Appendix Table 4.17 with respect to each industry. The Metals results for Indonesia are not included for the same reasons as outlined above for Metals in the industry prediction errors. The final rows provide average results for each country across all industries. We see that there is a considerable divergence in the applicability of a regional specification to particular countries. Indonesia and Hong Kong are the least well explained countries with average prediction errors of 68% and 38% respectively. Otherwise, explanation ranges between 26% and 8% for other countries, with Korea and Japan being the best explained. The same pattern is repeated with respect to the TFP and factor endowments specification, with Indonesia and Hong Kong being the least precisely explained with 45% and 25% average prediction error respectively. The other countries are in a range of 18% to 7%, with both Korea and Japan displaying the latter figure. The reasons for poor explanation of particular countries may be due to lower quality of data or country-specific forces which cause trends to differ from the rest of the region.

We also compare the industry ranking of prediction errors for each country for the two specifications. We see that the industry rankings are different across countries in both cases. This contrasts for example with Redding et al. (2000) who find similar industry rankings in a specification that considers factor endowments for the aggregate sectors of Agriculture, Manufacturing and Services. The difference may come from the fact that our sample is more disaggregated, with factor endowments being more successful at explaining production at the aggregate level.

We find some instructive common trends across our sample. All countries show an improvement in explanation with the consideration of TFP forces at an aggregate level. The percentage change in average predicted error as one moves from the factor endowments to the factor endowments and TFP regression is displayed for each country for each industry. The mean value of these changes is displayed in the last row of the table. It is seen that in general all countries explain their industrial changes better with a model which considers factor endowments and TFP together at a regional level, as compared to a model that considers factor endowments alone.

In addition to understanding statistical significance of the regression coefficients, we wish to see the economic importance of the different variables. This is done by calculating standardized coefficients for the regressions with TFP and factor endowments. The method is to multiply the regression coefficient by the ratio of the sample standard deviations of the dependent and relevant explanatory variables. The standardized coefficient reflects the number of standard deviations by which manufacturing share changes with a one standard deviation increase in an explanatory variable. The results are presented in Appendix Table 4.18.

We see that land, followed by low-educated labour and capital, are the most important variables for the greatest number of industries. The effects are quite large in these industries with a one standard deviation change in the explanatory variable associated generally with a greater than one standard deviation change in manufacturing share. Interpretation of the Land results are difficult for the reasons outlined above. Low-educated labour is positively most important (of all the significant factor and technology standardized coefficients) for Food, Textiles, Chemicals and Other Manufactures. It is negatively most important for Glass and Metals. Capital is positively most important for Paper and Metals. Capital is positively second most important, after Land, for Glass and Machinery. It is positively third most important for Chemicals. Medium educated labour is positively second most important for Textiles. High educated labour is positively second most important for Wood and third most important for Paper, Machinery and Other Manufactures. In terms of significant own-

TFP effects, the strongest effect is for Food, followed by Metals and Glass. The own-TFP effects are however much smaller than the corresponding factor endowment effects.

This suggests that capital is the most positively important factor for most manufacturing industries, other than the natural-resource based ones of Food, Wood and Paper, and the low complexity manufacturing of Textiles. Low educated labour is most positively important in some of these latter sectors, Food and Textiles, as well as Chemicals. Higher educated labour is an important factor in a range of natural-resource based and technologically more complex industries, but much less so than capital. We see that the economic importance of own-TFP effects is substantially lower than the relevant most important endowments for all sectors.

We conduct a number of tests of appropriate specification of our model for the specification with endowments and TFP. One possible issue is omitted variables, though this may not be of such concern in our estimations. First, omitted variable bias is more likely if R^2 is low. However we obtain high R^2 values of greater than 0.9 for both lagged and unlagged specifications with TFP and factor endowments. Furthermore the use of fixed effects implicitly controls for unobserved variables that are different across countries or time. A particular possibility we consider is whether the specification is nonlinear which would otherwise lead to non-linear explanatory variables having been omitted. A model specification link test is conducted for all industries (Appendix Table 4.19), which tests for the presence of higher-order variables based on the existing independent variables. For linearity, it is required that the variable of prediction is significant whereas the variable of higher-order prediction should not be so. In six out of nine sectors the test fails to reject the assumption that the model is specified correctly. This indicates that in these cases no additional significant non-linear variables have been found. It is however still possible that there are significant independent variables we have not included and which would affect our results, such as other variables which vary across both countries and time. The expected effects would be bias in coefficient estimates as well as an effect on the standard errors of the included variables. Whereas there will not be any coefficient bias for a particular included variable if the omitted variable is not correlated with it, all included variable standard errors will be affected by the omission of a relevant variable. Including an omitted variable will use up one degree of freedom, potentially increasing standard errors. On the other hand, including the variable would reduce the residual variance thus tending to reduce the standard errors of the coefficients of the included variables.

We also test whether it would be possible to use a specification with random effects estimation instead of the fixed effects estimation we have used. Random effects estimation would be more efficient as it uses fewer degrees of freedom. However it would be necessary that errors are uncorrelated with the other variables. A Hausman specification test is used to compare the two approaches for all industries (Appendix Table 4.19). The null hypothesis is that the coefficients estimated by the efficient random effects estimator are the same as the ones estimated by the consistent fixed effects estimator. Since the null hypothesis is rejected in all cases we conclude that the use of a fixed effects model, which we believe appropriate for theoretical reasons, is also justified econometrically.

We also conduct a test of homogeneity of factor supply effects as mentioned in Section 4.2. The results are presented in Appendix Table 4.20. We find interesting results, with homogeneity being rejected for all industries. Even when rejected many of the values are close to 0 but statistically significant. There is support for an increasing returns to scale (IRS) type situation in all industries as their sum of coefficients is seen to be positive. In view of this it will be worthwhile in further work to consider alternative IRS models for the region.

4.6 Conclusion

This chapter contributes to the literature by exploring technology and factor endowments explanations for industrial change in East Asia. We utilise a specification derived from a translog revenue function to provide us with two distinct models. We first consider only factor endowments as an explanation of industrial change, using time and country dummies to account for other forces. This is followed by an explicit consideration of technology and endowments as possible explanatory variables. Some clear patterns are observed in the data. Capital endowment is seen to be a driver of change across a number of important industries. Education above the primary level is seen to have had a positive or neutral impact on most sectors. In terms of technology, we find own-TFP effects to be significant in a number of cases. Cross-TFP effects are not significant in general, however some firm results are seen. We attempt to establish the relative statistical relevance of the groups of endowment and technology terms in explaining industrial change. We find that TFP and endowments as groups both display significance as explanatory variables across industries. Prediction error tests are conducted to see the degree of explanation provided by including the two groups of variables. It is seen that factor endowments alone are enough to explain a substantial proportion of industrial change. We find nevertheless that TFP plays a considerable additional role for each industry. Furthermore, technology is important in explaining the results for each of the countries across industries. Standardized coefficients are obtained for the specification with technology and factor endowments to compare the relative economic importance of the explanatory variables. It is seen that capital and low-educated labour are the most important variables for a number of industries, with factor endowments being more important than own-TFP effects for all industries in our sample.

4.7 Appendix

4.7.1 Data Description

Years 1974-1994

Countries Hong Kong, Indonesia, Japan, Korea, Malaysia and Singapore

Product Classification System The industrial data is divided into the 9 ISIC 2-digit industrial manufacturing sectors. These are the manufacture of:

ISIC Code- Sector

31 Food, Beverages and Tobacco

32 Textiles, Wearing Apparel and Leather

33Wood and Wood Products

34 Paper, Paper Products and Pulp

35 Chemicals and Chemical Products

36 Non Metal and Mineral Products

37 Basic Metal Products

38 Fabricated metal Products, Machinery and Equipment

39 Other Products

Manufacturing Shares Value added data from UNIDO Industrial Statistics Database 3-digit level 1999. GDP data from IMF International Financial Statistics. All raw data converted to 1990 PPP$. Missing data points are interpolated using available data points, or extrapolated when necessary using a five year linear trend from available data points.

Total Factor Productivity Data for real value added, capital stocks and labour input from the UNIDO database. Missing data points are interpolated using available data points, or extrapolated when necessary using a five year linear trend from available data points. Capital stocks calculated using gross fixed capital formation data from the database utilising the standard Coe and Helpman (1995) specification. Labour input calculated using employment data from UNIDO and average weekly hours worked data from international sources, national sources and estimates. These are International Labour Organization (ILO) data for Japan and Hong Kong; the Monthly Labour Survey, Ministry of Labour, Korea; Singapore Yearbook of Labour Statistics and Singapore Yearbook of Manpower Statistics; Malaysia and Indonesia calculated using an average of Japanese, Hong Kong, Singapore and Taiwanese data as no independent data available due to non-reporting. All raw data converted to 1990 PPP$.

Purchasing Power Parity PPP data obtained from the World Bank. Derived from the International Comparison Programme (ICP) of the UN.

Factor Endowments

Capital Physical capital data is from King and Levine (1994). Converted to 1990 PPP US$ from original units in 1985 PPP US$.

Labour Data is from Barro and Lee (2000). It is divided into three educational groups using Barro and Lee's classifications of those who attain a primary education, those who attain a secondary education, and those who attain a high school education. The data are for five-year subperiods ie. 1970, 1975 etc. The data is interpolated for the years in between as in Harrigan (1997).

Land Data is for arable land from the UN Food and Agriculture Organisation (FAO). Units: thousands of hectares.

4.7.2 Data analysis

Factor Endowments

Capital per capita (total pop)				Arable land per capita (total pop)		
	1974	1984	1994	1974	1984	1994
HK	7,570	14,731	22,227	0.0014	0.0013	0.0010
Indonesia	899	2,957	4,496	0.1459	0.1126	0.0900
Japan	18,357	27,927	38,004	0.0369	0.0352	0.0320
Korea	3,468	7,691	12,920	0.0549	0.0499	0.0415
Malysia	5,479	12,071	14,123	0.1545	0.786	0.0938
Singapore	10,760	26,396	47,362	0.0005	0.0008	0.0003

Table 4.2: Factor Accumulation- Capital (1990 PPP US Dollar) and Land (ha) divided by total pop

	Low educated, %			Med educated, %			High educated, %		
	1974	1984	1994	1974	1984	1994	1974	1984	1994
HK	0.72	0.56	0.40	0.25	0.37	0.46	0.04	0.08	0.14
Indonesia	0.94	0.89	0.78	0.06	0.11	0.19	0.01	0.01	0.03
Japan	0.56	0.43	0.32	0.37	0.42	0.46	0.07	0.16	0.22
Korea	0.66	0.45	0.28	0.27	0.44	0.52	0.07	0.11	0.20
Malaysia	0.86	0.76	0.54	0.12	0.23	0.40	0.02	0.02	0.06
Singapore	0.74	0.77	0.46	0.23	0.19	0.47	0.03	0.04	0.07

Table 4.3: Factor Accumulation- Education (as percentage of total pop)

Factor Intensity

		Workers/VA			Capital/VA		
Industry	ISIC	1974	1984	1994	1974	1984	1994
Food	31	34.4	20.7	17.6	1.7	1.2	1.2
Apparel	32	76.7	45.0	28.9	1.8	1.1	0.9
Wood	33	82.7	33.9	20.6	1.2	0.7	0.5
Paper	34	22.8	15.9	15.6	1.7	1.3	1.6
Chemicals	35	14.5	9.8	9.1	1.5	1.4	1.7
Glass	36	30.4	17.0	13.2	2.0	1.4	1.4
Metals	37	18.9	11.8	9.6	2.9	2.7	3.3
Machinery	38	14.8	14.5	13.8	1.7	1.7	1.9
Others	39	26.7	15.4	14.0	0.7	0.5	0.7

Table 4.4: Japanese Relative Factor Intensity- Value Added and Capital in 1990 US Dollars

4.7.3 Regression results and tests

Regressions with Factor Endowments and Fixed Effects

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
Capital	-0.003	-0.040	0.005	0.006	0.004	0.002	0.002	0.047	-0.002
t-stat	-1.82	-14.03	8.81	15.35	1.91	3.17	2.32	7.09	-8.65
Pri Edu	-0.015	-0.009	-0.005	-0.005	-0.030	-0.008	-0.012	-0.027	-0.002
t-stat	-7.81	-3.18	-4.16	-14.93	-18.19	-13.43	-14.78	-4.42	-7.67
Sec Edu	0.001	0.049	-0.003	-0.001	0.004	-0.001	0.004	-0.042	0.002
t-stat	0.23	5.81	-1.35	-1.00	0.80	-0.26	1.38	-2.42	3.16
Ter Edu	0.005	0.007	-0.002	0.002	0.005	0.002	0.004	0.021	0.002
t-stat	2.11	1.40	-1.97	3.63	1.57	1.69	2.21	2.17	4.58
Land	0.007	-0.009	0.003	-0.001	0.009	0.003	0.003	-0.001	-0.001
t-stat	9.60	-5.18	8.93	-3.08	7.73	8.35	5.50	-0.29	-3.91
$\bar{R}^2$	0.68	0.72	0.60	0.94	0.70	0.73	0.83	0.66	0.83
Obs	126	126	126	126	126	126	126	126	126

Table 4.5: Regression with Factor Endowments and only Time Dummies

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
Capital	0.007	0.018	0.015	0.014	0.014	0.009	0.020	0.089	0.001
t-stat	1.24	1.88	5.79	5.79	2.21	4.70	5.88	3.64	1.06
Pri Edu	0.015	0.013	-0.006	0.009	0.009	-0.009	-0.019	-0.085	0.000
t-stat	2.79	1.37	-2.74	1.16	1.16	4.86	-6.39	-3.33	-0.16
Sec Edu	-0.003	0.004	-0.002	0.002	0.002	0.001	0.002	-0.011	0.000
t-stat	-0.88	0.68	-1.12	0.34	0.34	0.71	0.91	-0.58	0.17
Ter Edu	0.008	0.005	0.007	-0.001	-0.001	0.002	0.004	0.015	0.001
t-stat	2.59	0.81	4.05	-0.55	-0.55	2.65	2.57	1.62	1.92
Land	-0.005	0.022	0.007	0.010	0.010	0.008	0.008	0.034	0.003
t-stat	-2.00	3.50	5.04	2.48	2.48	9.10	5.90	2.54	4.92
$\bar{R}^2$	0.92	0.89	0.98	0.92	0.92	0.96	0.91	0.91	0.90
Obs	126	126	126	126	126	126	126	126	126

Table 4.6: Regression with Factor Endowments and Time and Country Dummies

Joint Significance Tests of Importance of Fixed Effects

Hypothesis: The indicated coefficients are all zero.

The test statistics are: (1) F (5, 95)

(2) F (19, 95)

(3) F (24, 95)

The probability statistics presented are: Prob > F

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
1.Time fixed effects-F stat	0.54	0.84	5.44	4.39	0.74	4.91	4.28	0.84	1.02
Prob	0.93	0.66	0.00	0.00	0.77	0.00	0.00	0.66	0.44
2.Country fixed effects-F stat	64.7	20.5	17.0	22.2	35.2	127.8	180.3	34.7	11.7
Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.Country & time fixed effects-Fstat	17.4	11.6	9.4	12.1	9.1.	47.1	43.7	8.6	8.3
Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.7: Joint significance test of fixed effects-unlagged specification

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
1.Time fixed effects-F stat	0.58	0.68	1.30	2.94	0.57	4.13	1.98	0.62	0.96
Prob	0.91	0.83	0.20	0.00	0.92	0.00	0.02	0.88	0.51
2.Country fixed effects-F stat	1.8	3.4	1.4	12.6	4.0	45.7	12.8	3.9	11.4
Prob	0.11	0.01	0.24	0.00	0.00	0.00	0.00	0.00	0.00
3.Country & time fixed effects-Fstat	1.04	1.51	1.54	4.67	1.31	14.66	4.17	1.17	8.03
Prob	0.42	0.08	0.07	0.00	0.18	0.00	0.00	0.29	0.00

Table 4.8: Joint significance test of fixed effects-lagged specification

Regression with Factor Endowments and One-Period Lag

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
1 Yr Lag	0.653	0.574	0.708	0.046	0.438	-0.040	-0.046	0.508	-0.005
t-stat	5.38	3.40	6.19	0.45	2.94	-0.58	-0.34	3.31	-1.08
Capital	0.000	0.003	0.007	0.014	0.011	0.010	0.021	0.050	0.001
t-stat	-0.06	0.25	1.88	6.05	1.25	4.09	4.30	1.58	1.19
Pri Edu	0.013	0.018	-0.002	-0.006	0.011	-0.009	-0.021	-0.049	0.000
t-stat	2.04	1.94	-0.73	-3.83	1.76	-4.45	-4.64	-1.95	-0.21
Sec Edu	-0.002	0.006	-0.003	-0.003	0.000	0.001	0.001	0.012	0.000
t-stat	-0.63	0.88	-1.18	-2.38	0.04	0.61	0.88	0.68	0.10
Ter Edu	0.002	-0.008	0.002	0.004	-0.004	0.002	0.004	-0.006	0.001
t-stat	0.86	-1.56	1.39	4.23	-1.40	2.80	2.76	-0.64	1.76
Land	-0.003	0.020	0.003	0.001	0.010	0.008	0.008	0.039	0.003
t-stat	1.47	2.31	2.42	1.87	3.29	7.14	4.81	4.04	5.03
$\bar{R}^2$	0.96	0.94	0.93	0.98	0.95	0.96	0.97	0.944	0.90
Obs	125	126	126	126	126	126	126	126	126

Table 4.9: Regression with Factor Endowments, 1 Period Lag, and Time and Country Dummies

Regressions with TFP and Factor Endowments

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
TFP Fd	0.011	0.018	0.002	0.001	0.002	0.000	0.000	0.005	0.000
t-stat	4.36	2.07	1.72	1.30	0.46	0.16	0.19	0.34	0.10
TFP Txt	0.002	-0.002	0.003	0.000	-0.005	0.004	0.002	-0.016	-0.001
t-stat	1.14	-0.36	2.13	-0.13	-1.41	5.06	1.13	-1.33	-1.37
TFP Wd	-0.002	0.027	0.001	0.002	0.017	-0.001	0.000	0.048	0.002
t-stat	-1.11	5.26	1.33	2.85	5.70	-1.53	-0.15	5.71	3.30
TFP Ppr	-0.002	0.019	-0.001	0.000	0.004	-0.001	-0.003	0.002	0.001
t-stat	-1.09	4.25	-1.16	-.74	1.73	-2.20	-3.82	0.29	2.13
TFP Chm	0.004	-0.021	-0.002	0.000	0.003	-0.001	0.003	-0.015	-0.001
t-stat	1.79	-2.64	-1.20	0.26	0.83	-1.24	2.00	-1.24	-1.77
TFP Gls	-0.002	-0.009	-0.003	-0.002	-0.008	0.003	-0.003	-0.028	-0.002
t-stat	-1.52	-1.77	-3.22	3.56	-2.75	3.60	-2.82	-3.59	-2.78
TFP Mtl	0.000	0.003	-0.001	0.002	0.005	0.000	0.002	0.020	0.001
t-stat	0.32	1.06	-2.67	6.66	3.75	-0.27	4.40	4.75	1.99
TFP Mch	0.004	-0.009	0.004	0.000	-0.012	-0.001	-0.003	-0.015	0.000
t-stat	1.42	-0.98	2.25	0.31	-2.37	-1.20	-1.42	-0.98	0.25
TFP Oth	0.001	0.001	0.000	-0.001	-0.003	0.001	0.002	-0.014	0.000
t-stat	0.64	0.20	0.38	-2.26	-1.54	2.19	1.97	-1.96	-0.22
Capital	-0.024	-0.024	0.000	0.014	0.022	0.008	0.021	0.114	-0.001
t-stat	-1.69	-1.69	0.17	7.39	3.05	3.66	5.92	4.37	-0.49
Pri Edu	0.026	0.073	0.002	-0.001	0.025	-0.011	-0.016	-0.021	0.005
t-stat	5.04	4.06	0.76	-0.28	2.98	-4.08	-4.58	-0.80	2.94
Sec Edu	0.002	0.025	0.000	-0.002	0.007	0.003	0.003	-0.001	0.000
t-stat	0.79	3.43	-0.27	-2.49	1.84	3.55	2.47	-0.06	0.54
Ter Edu	0.004	0.006	0.005	0.004	0.004	0.001	0.004	0.031	0.001
t-stat	1.71	1.43	4.53	6.89	1.71	1.74	3.15	3.24	1.96
Land	-0.011	0.006	0.004	0.002	0.019	0.006	0.008	0.058	0.003
t-stat	-6.06	5.32	3.08	3.25	5.48	5.32	5.76	5.43	4.80
$\bar{R}^2$	0.98	0.98	0.94	0.99	0.97	0.98	0.98	0.96	0.93
Obs	126	126	126	126	126	126	126	126	126

Table 4.10: Regression with TFP and Factor Endowments, and Time and Country Dummies

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
1 Yr Lag	0.309	0.342	0.435	-0.029	0.220	-0.065	-0.139	0.308	-0.014
t-stat	3.33	3.72	4.05	-0.38	2.02	-1.05	-2.12	2.45	-2.85
TFP Fd	0.008	0.009	0.000	0.001	0.002	0.000	0.000	0.012	0.000
t-stat	2.81	1.23	-0.25	1.23	0.53	0.14	-0.13	1.10	0.15
TFP Txt	0.002	-0.007	0.002	0.000	-0.005	0.004	0.002	-0.019	-0.002
t-stat	0.92	-1.26	1.40	-0.07	-1.38	5.28	1.34	-1.85	-1.80
TFP Wd	-0.001	0.022	0.003	0.002	0.013	-0.001	0.000	0.031	0.002
t-stat	-0.59	4.87	4.26	2.97	4.21	-1.46	0.30	4.42	3.67
TFP Ppr	-0.002	0.012	-0.001	-0.001	0.003	-0.001	-0.004	0.000	0.001
t-stat	-1.28	3.02	-1.44	-0.80	1.33	-2.11	-4.22	0.004	2.27
TFP Chm	0.002	-0.015	0.000	0.000	0.003	-0.001	0.003	-0.010	-0.001
t-stat	0.89	-2.05	-0.07	0.18	0.77	-1.20	2.55	-0.86	-1.82
TFP Gls	-0.001	-0.005	-0.002	-0.002	-0.006	0.003	-0.003	-0.027	-0.002
t-stat	-0.44	-1.10	-2.49	-3.62	-2.11	3.57	-3.06	-3.76	-2.99
TFP Mtl	0.000	0.002	-0.001	0.002	0.004	0.000	0.002	0.021	0.001
t-stat	-0.19	0.80	-3.23	6.52	3.53	-0.24	5.53	4.92	2.11
TFP Mch	0.005	-0.002	0.001	0.000	-0.008	-0.002	-0.003	-0.005	0.000
t-stat	1.73	-0.25	0.90	0.45	-1.46	-1.32	-2.00	-0.33	0.10
TFP Oth	0.000	0.002	0.000	-0.001	-0.004	0.001	0.002	-0.012	0.000
t-stat	-0.23	0.87	0.64	-2.21	-1.91	2.62	2.69	-1.94	0.12
Capital	-0.011	-0.021	0.001	0.014	0.019	0.009	0.024	0.084	0.000
t-stat	-2.39	-1.74	0.65	6.92	2.48	3.49	6.87	2.68	-0.20
Pri Edu	0.020	0.053	0.000	-0.001	0.024	-0.013	-0.020	-0.001	0.004
t-stat	3.63	3.38	0.10	-0.29	2.87	-4.04	-5.43	-0.05	2.79
Sec Edu	0.000	0.019	-0.002	-0.002	0.005	0.003	0.003	0.009	0.000
t-stat	0.15	3.19	-1.07	-2.46	1.28	3.40	2.83	0.70	0.41
Ter Edu	0.004	-0.001	0.003	0.005	0.002	0.001	0.005	0.015	0.001
t-stat	2.14	-0.44	2.91	6.22	0.69	2.07	4.92	1.73	1.88
Land	-0.008	0.018	0.003	0.002	0.018	0.006	0.009	0.056	0.004
t-stat	-4.37	3.34	3.18	3.16	5.56	4.84	6.34	6.64	5.74
$\bar{R}^2$	0.98	0.97	0.96	0.99	0.97	0.98	0.99	0.97	0.93
Obs	126	126	126	126	126	126	126	126	126

Table 4.11: Regression with TFP and Factor Endowments, 1 Period Lag, and Time and Country Dummies

Comparison of Factor Endowment and Intensity Rankings

Ranking of predicted responsiveness of industry shares to increases in capital and low education variables, compared to ranking of capital intensities for Japanese (as a proxy for the region) industries

Only statistically significant sectors from the empirical results considered

Regression Results		Factor Intensity Data	
Ranking	Coeff	Ranking	Capital /VA
Glass	0.01	Glass	1.39
Paper	0.01	Paper	1.57
Metals	0.02	Chemicals	1.71
Chemicals	0.02	Metals	3.32

Table 4.12: Capital Rankings

Regression Results		Factor Intensity Data	
Ranking	Coeff	Ranking	Capital/VA
Metals	-0.02	Chemicals	9.09
Glass	-0.01	Metals	9.62
Other manuf	0.01	Glass	13.24
Food	0.02	Other manuf	14.01
Chemicals	0.03	Food	17.59
Apparel	0.10	Apparel	28.94

Table 4.13: Low Education Rankings

Joint Significance Tests of Technology and Factor Endowments

Hypothesis: The indicated coefficients are all zero.

The test statistics are: (1) F (9, 86)

(2) F (5, 86)

(3) F (14, 86)

The probability statistics presented are: Prob > F

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
1.TFP -F stat	29.7	8.0	25.3	12.1	10.3	8.3	10.1	16.7	5.9
Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.Factors-F stat	23.6	15.3	8.0	27.0	25.3	20.3	23.8	14.6	18.1
Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.TFP&Factors -F stat	24.3	9.2	40.6	22.3	14.6	27.9	15.1	15.7	8.6
Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.14: Joint significance test of technology and factor endowments- unlagged specification

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
1. TFP -F stat	9.9	10.1	5.4	4.4	5.5	8.5	8.6	5.4	6.2
Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Factors- F stat	2.9	12.0	2.5	11.2	10.7	12.2	16.8	8.6	17.8
Prob	0.02	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
3.TFP & Factors - F stat	7.5	8.3	4.4	7.5	5.6	16.1	10.2	6.0	8.7
Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.15: Joint significance test of technology and factor endowments- lagged specification

Prediction Errors Analysis

Calculated for unlagged equation with factor endowment terms and unlagged equation with TFP and factor endowment terms.

Value stated is mean of the following statistic calculated for each country-year observation: $\frac{|s_{cjt} - \hat{s}_{cjt}|}{s_{cjt}}$.

	31	32	33	34	35	36	38	39	
	Fd	Txt	Wd	Ppr	Chm	Gls	Mch	Oth	All
Factors	0.13	0.34	0.40	0.16	0.25	0.16	0.39	0.95	0.35
TFP & Factors	0.07	0.29	0.20	0.10	0.16	0.12	0.25	0.49	0.21

Table 4.16: Prediction Errors Analysis at Industrial Level

		HK	Indonesia	Japan	Korea	Malaysia	Singapore
Food	Fac End	0.13	0.22	0.06	0.05	0.13	0.16
	TFP	0.12	0.08	0.05	0.04	0.06	0.06
	Change	0.05	0.65	0.20	0.21	0.53	0.64
Textile	Fac End	0.30	0.61	0.40	0.07	0.17	0.46
	TFP	0.13	0.73	0.19	0.08	0.33	0.27
	Change	0.58	-0.19	0.53	-0.12	-0.93	0.42
Wood	Fac End	0.65	0.98	0.11	0.13	0.18	0.33
	TFP	0.36	0.37	0.08	0.12	0.08	0.17
	Change	0.45	0.63	0.33	0.10	0.55	0.48
Paper	Fac End	0.08	0.64	0.03	0.06	0.10	0.06
	TFP	0.05	0.39	0.03	0.04	0.08	0.02
	Change	0.35	0.39	-0.07	0.40	0.20	0.63
Chemicals	Fac End	0.57	0.59	0.04	0.05	0.07	0.19
	TFP	0.24	0.44	0.04	0.06	0.06	0.10
	Change	0.58	0.25	0.06	-0.12	0.17	0.45
Glass	Fac End	0.30	0.29	0.05	0.06	0.10	0.16
	TFP	0.26	0.23	0.04	0.04	0.05	0.12
	Change	0.14	0.22	0.22	0.24	0.50	0.22
Metals	Fac End	0.62	-	0.07	0.07	0.21	0.26
	TFP	0.67	-	0.06	0.05	0.12	0.20
	Change	-0.08	-	0.20	0.33	0.40	0.23
Machinery	Fac End	0.40	1.41	0.06	0.14	0.21	0.50
	TFP	0.17	0.91	0.08	0.09	0.16	0.48
	Change	0.59	0.35	-0.24	0.33	0.25	0.05
All Industries	Fac End	0.38	0.68	0.10	0.08	0.15	0.26
	TFP	0.25	0.45	0.07	0.07	0.12	0.18
	Change	0.33	0.33	0.15	0.17	0.21	0.39

Table 4.17: Prediction Errors Analysis at Country Level

Standardized coefficients for Unlagged Specification with Factor Endowments and Technology

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
TFP Fd	0.383	0.241	0.215	0.072	0.046	0.012	0.011	0.035	0.012
TFP Txt	0.101	-0.042	0.323	-0.008	-0.157	0.406	0.077	-0.149	-0.231
TFP Wd	-0.088	0.562	0.159	0.174	0.600	-0.148	-0.010	0.535	0.444
TFP Ppr	-0.055	0.240	-0.087	-0.028	0.078	-0.087	-0.117	0.017	0.139
TFP Chm	0.111	-0.274	-0.140	0.013	0.071	-0.088	0.109	-0.104	-0.195
TFP Gls	-0.088	-0.130	-0.257	-0.138	-0.180	0.210	-0.127	-0.220	-0.250
TFP Mtl	0.023	0.101	-0.271	0.245	0.236	-0.015	0.225	0.329	0.208
TFP Mch	0.125	-0-103	0.287	0.018	-0.224	-0.095	-0.089	-0.094	0.031
TFP Oth	0.046	0.018	0.040	-0.119	-0.129	0.157	0.108	-0.181	-0.025
Capital	-1.540	-1.095	0.141	2.859	1.653	2.110	2.796	2.834	-0.374
Pri Edu	3.151	3.583	0.697	-0.115	2.043	-3.065	-2.278	-0.564	2.604
Sec Edu	0.213	1.267	-0.143	-0.443	0.629	0.956	0.500	-0.025	0.267
Ter Edu	0.910	0.335	1.751	1.174	0.414	0.396	0.663	0.979	0.716
Land	-3.107	1.815	2.812	1.194	3.521	3.365	2.704	3.492	3.919

Table 4.18: Standardized Coefficients for Regression with TFP and Factor Endowments, and Time and Country Dummies

Specification tests

For unlagged specification with TFP and Factor Endowments

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
Link test									
hat Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
hat sqProb	0.05	0.00	0.25	0.67	0.91	0.14	0.00	0.30	0.001
Hausman test									
Chi-sq(14)	277.7	135.1	99.8	105.1	391.2	78.8	197.2	735.7	92.2
Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.19: Specification tests

Homogeneity Tests

Calculated for unlagged equation with factor endowment terms and unlagged equation with TFP and factor endowment terms.

Hypothesis: sum of the factor endowment terms is zero. For each industry separately, the test statistic is F (1, 86).

	31	32	33	34	35	36	37	38	39
	Fd	Txt	Wd	Ppr	Chm	Gls	Mtl	Mch	Oth
Value	0.01	0.10	0.01	0.02	0.08	0.01	0.02	0.18	0.01
Significance	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.20: Homogeneity tests

Chapter 5

Factor Endowments and Economic Geography in East Asia

5.1 Introduction

There has been considerable debate about the causes of the dramatic industrial changes seen in East Asia in the last few decades. Older theoretical explanations for the changes witnessed include the Ricardian view of technological factors and the Heckscher-Ohlin view of factor endowments. A newer contribution to the debate is the theory of economic geography expounded by Krugman and Venables (1995) among others. This explanation has been suggested to be possibly particularly applicable to East Asia because of the developmental time precedence observed there which fits with the propositions of the theory. The theory suggests that industry moves in a series of waves from a country (or countries) to a neighbouring country (or countries). The driver of the change is the tension between backward (demand) and forward (supplier) linkages, which help to keep an industry in its location, and cost pressures, which drive an industry to a new location. The economic component targeted in the analysis of linkages is the behaviour of firms' demand and supply amongst themselves through the demand and supply of intermediate goods. Firms seek to be close to suppliers of the intermediate goods they need for their production as well as close to the firms which demand the intermediate goods that they produce. This leads to agglomerations of industries forming in particular locations above and beyond the levels dictated by a purely factor endowments consideration.

The concentration on understanding the behaviour of intermediate goods is particularly important in the East Asian context because of the importance of this sector in the region as compared to final goods. The differentiated vertical production structure in the region has been widely commented on (eg Kim (1994)) with the belief being that there are strong inter-firm links between higher-end production in more developed countries and lower-end production to supply the intermediates for the former group in less developed countries.

We apply a testable theoretical model comparing economic geography and factor endowments to East Asian data. It is possible that change in the region will be some combination of the two ideas. This approach allows us to compare the relative importance of the two theories in a concrete manner.

There have been a number of empirical explorations of economic geography, testing its implications with respect to international data (for example Redding and Venables (2000)), OECD data (Davis and Weinstein (1998, 1999)) and European data (Midelfart-Knarvik et al. (2001)). Economic geography and factor endowments are considered together by Midelfart-Knarvik et al. (2001) and Davis and Weinstein (1998, 1999). The latter explore a factor endowments framework at the 3-digit ISIC level and an economic geography framework at the 4-digit ISIC level. There is however very little empirical work on economic geography in East Asia and particularly testing for factor endowments in the region at the same time. The lack of comprehensive comparable data for the construction of economic geography variables is one reason for this. Our use of recently compiled data on input-output structure across East Asian countries allows us to explore the issue.

5.2 Theoretical Framework

We utilise an empirical framework adapted from Midelfart-Knarvik et al (2001). All industries in the specification operate under constant returns to scale and perfect competition. This is an abstraction from a full consideration of economic geography theory, which would assume that industries possess increasing returns to scale. Evidence for such effects is highlighted for example by Henderson et al. (2001) who indicate the importance of an external economies of scale measure for industries in Korea. Introducing imperfect competition would complicate the model we use as it could produce multiple equilibria, leading to no unique mapping between country and industry characteristics and industrial location. For econometric tractability this issue has been set aside, and so results obtained should be taken as an approximation to the level of economic geography forces in evidence as discussed later.

The model considers industries as producing intermediates and final goods and their production as depending on the supply of primary factors and intermediate goods. Distance is important to industries in terms of accessing markets to sell their products and for accessing their necessary supply of intermediates. The ease of availability of intermediates for production is summarised by a composite intermediate price facing an industry in a particular location. The issues of importance to an industry in terms of its location decision are therefore primary factor supply, input prices and the spatial distribution of demand.

Each industry k produces a number of differentiated goods in country i, n_i^k, which is set in proportion to the size of industry and country. Demand in the model is based on a price index for each industry which takes into account differing conditions in distinct geographical markets and expressed as,

$$G_j^k = \left[\sum_i n_i^k \left(p_i^k t_{ij}^k \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{5.1}$$

where p_i^k is the fob price of industry k goods in country i, t_{ij}^k represents the 'iceberg' transport costs that have to be paid to transport goods from country i to j, and σ is the elasticity of substitution between product varieties which is assumed to be the same in all industries.

By using Shepard's lemma on the price index one obtains an expression for the sales of industry k produced in country i and sold in country j,

$$a_{ij}^k = (p_i^k t_{ij}^k)^{1-\sigma} E_j^k (G_j^k)^{\sigma-1} \tag{5.2}$$

where E_j^k represents total sales of industry k in country j. E_j^k is a function of demand in country j for good k as an intermediate and as a final good.

Summing this expression across all demand countries and all varieties of the good k results in the equation for demand for good k produced in country i,

$$z_i^k = n_i^k (p_i^k)^{1-\sigma} \sum_j \left(t_{ij}^k\right)^{1-\sigma} E_j^k (G_j^k)^{\sigma-1} \tag{5.3}$$

The right hand summation term is a measure of demand effects affecting a country i and is referred to as the country's market potential and expressed as,

$$m\left(u^k : i\right) = \sum_j \left(t_{ij}^k\right)^{1-\sigma} E_j^k (G_j^k)^{\sigma-1} \tag{5.4}$$

where the vector u^k refers to the characteristics of the industry which depend on the geographical distribution of demand.

The production side assumes that prices are equivalent to marginal costs,

$$p_i^k = c(v_i, h_i : k) \tag{5.5}$$

where costs depend on v_i the vector of primary factor prices in country i, and h_i the price of a single composite intermediate good in country i. The composite intermediate is a Cobb-Douglas aggregate of output from different industries in the country, each with the price index G_i^k. The composite intermediate price is thus,

$$h_i = \Pi_k (G_i^k)^{\lambda^k} \quad , \quad \sum_k \lambda^k = 1 \tag{5.6}$$

with λ^k representing the share of each industry k in the composite intermediate good.

The production and demand sides can be combined to provide a measure of the determinants of output in an industry,

$$z_i^k = n_i^k (c(v_i, h_i : k))^{1-\sigma} m \left(u^k : i\right) \tag{5.7}$$

To account for country and industry size effects, output in industry i in industry k is considered relative to total size of the industry across all countries s^k and the size of the country's total production s_i. Given that $n_i^k = s_i s^k$ by assumption, we obtain,

$$r_i^k = z_i^k / s_i s^k = (c(v_i, h_i : k))^{1-\sigma} m \left(u^k : i\right) \tag{5.8}$$

Log-linearisation of the expression gives a sum of interactions between country characteristics and industry characteristics, which is expressed as,

$$\ln\left(r_i^k\right) = \delta + \sum_j \beta\,[j]\,(x_i\,[j] - \bar{x}_i\,[j])\left(y^k\,[j] - \bar{y}^k\,[j]\right) + \varepsilon_i^k \tag{5.9}$$

The country characteristics are expressed as $x_i\,[j]$ and the industry characteristics as $y^k\,[j]$ referring to a number of interactions $1, ..., j$. Log-linearisation is around a reference point for both the groups taken as the mean value of each characteristic. The interaction terms represent the idea that a country with a country characteristic above the reference level will have high production in an industry with an industry characteric above the reference level. It is not possible to derive the reference point value from the equation itself due to the lack of sufficient country observations compared to the number of variables. Mean reference values are taken as a reasonable approximation to the cut-off points which separate countries and industries into high and low abundance and intensity groups. The equation was re-estimated using median value reference points and the relative importance of comparative advantage and economic geography effects were not seen to change markedly. It would be ideal to obtain reference values directly from the equation as there is otherwise the risk that the reference characteristics may be changing over time. This problem is managed by splitting the data in four-year periods, as explained later, and calculating the different reference values for these groups.

The expression describes the manner in which industry characteristics interact with country characteristics to affect the location decisions of industrial sectors. Seven interactions between country and industry characteristics are considered (see Table 5.1). The costs side considers both primary and intermediate inputs prices. Primary factor prices are represented by factor endowments as the former are endogenous. The corresponding industry characteristics are industries' input shares, which represent the elasticities of costs with respect to input prices. The demand side considers two industry characteristics, the effect of transport costs on expenditure on each good k, E_i^k and the nature of variation in E_i^k, due to the spatial distribution of demand. These industry characteristics interact with the elasticities of countries' market potential with respect to the characteristics. The costs and demand sides together represent four primary factor interactions and three economic geography interactions.

j	Industry characteristic, $y^k[j]$	Country characteristic, $x_i[j]$
1	Agricultural intensity	Agricultural endowment (log)
2	Capital intensity	Capital endowment (log)
3	Researchers intensity	Researchers endowment (log)
4	Skilled labour intensity	Skilled labour endowment (log)
5	Intermediate intensity	Intermediate price (Eq. 5.11) (log)
6	Transport intensity (log)	Elasticity of market potential w.r.t. transport intensity (Eq.5.15)
7	Share of production to intermediates (log)	Elasticity of market potential w.r.t. production share to intermediates (Eq.5.14)

Table 5.1: Country and industry interactions

The factor endowment interactions are for capital, skilled workers, researchers, and agriculture. For agriculture, output of agriculture, forestry and fishery products is used instead of land endowments. Since our analysis is of the structure of manufacturing we take agricultural production as an exogenous measure of agricultural abundance rather than using the underlying endowment of land. The factor endowment interactions illustrate how industries which are relatively intensive in the use of these factors seek to locate in places where the price of such factors is low (as expressed by the location's relative abundance in the factors). Non-skilled workers are not considered as they are a residual term given the skilled workers variable. Capital is included as it is not considered internationally mobile in the East Asian case and so possesses a differentiated price across countries in the region (as shown by their widely differing capital endowments levels).

The economic geography interactions are threefold. First is the variation in the composite intermediate goods price h_i across countries given cross-industry variation in intermediate input shares, λ^k. The intermediate price country characteristic measures the attractiveness of a particular country with respect to ease of availability of intermediates for production in industries. The interaction term is a measure of forward linkages as industries who require relatively high amounts of intermediates seek to locate in a location where the intermediates price is relatively low. The second interaction term is the effect of transport costs on demand through the market potential variable $m\left(u^k : i\right)$. The country transport elasticity of market potential term measures the attractiveness to an industry of locating in a country with respect to the transport costs it would face in producing its goods from that location. It is expressed in terms of the responsiveness of market potential of country i to changes in the transport intensity δ^k of an industry k. The third economic geography interaction is the difference in the spatial pattern of demand E_i^k across industries. Demand in this case is the relative importance of intermediates demand. The country production share elasticity of market potential term measures the attractiveness of a country for intermediates producers due to the country's closeness to sources of regional demand for intermediate goods. It is seen from the effect on a country's market potential when the proportion of sales of industry k going to intermediates increases. The interaction term is a backward linkages measure as it expresses how industries who sell a relatively high amount of intermediates seek to be in a location where intermediates demand is high. The derivation of the econometric representations of these effects is provided in Appendix 5.7.2.

5.3 Data

Our sample is based on six East Asian countries and 22 ISIC 3-digit industrial sectors. The time period considered is 1973-1994. Our country sample provides a cross-section of the countries that we consider important in the region as outlined above for their rapid development over the last few decades. We have been obliged to leave a number of the candidates out because of data limitations but the remaining countries provide representatives from each of the time-preceding waves of the development discussed. The countries considered are Japan (the first in the region to develop); Korea and Singapore (in the second group of developers); and Malaysia, Indonesia and Thailand (in the third group of developers). Out of the 28 possible ISIC 3-digit industrial sectors six are left out- petroleum refineries (ISIC Code 353), petroleum and coal products (ISIC Code 354), pottery, china and earthenware (ISIC Code 361), glass and products (ISIC Code 362), non-ferrous metals (ISIC Code 372), and other manufactured products (ISIC Code 390). The first two sectors are not included as they are primarily endowment-driven, the next three are omitted due to lack of full data and the last because it is equivalent to a residual term.

This work has been made possible due to the compilation recently of comprehensive comparable input-output data for countries in the region for 1990. The organisation responsible is the Institute of Developing Economies (IDE) in Japan, aided by the statistical authorities in each of the countries analysed. The IDE has kindly made available all the data comprising these input-output tables allowing accurate estimation of all the industry linkage variables. Details of other data sources used are provided in Appendix 5.7.1.

The time period was chosen to provide as long a frame of reference as possible within the period of rapid change in the region. The sample is divided into five groups of periods- 1973-76, 1978-81, 1983-86, 1987-90 and 1991-94. The pooled sample is the combined data for each of these 5 periods. The country variables are measured at the start-points of each period. The five separate periods provide an approximation as to the time variance characteristics of the cross-sectional data. We do not utilise fully pooled data across the whole sample period and within sample periods as this may lead to problems of variation in the underlying data, as seen below, in the results. The main point of interest in the analysis is the behaviour of the cross-section of production in the region in response to endowments and intensities.

The dependent variable is the log of the output in a particular country in a particular industry with respect to total production of the particular industry in all the sample countries, and the total manufacturing output of the particular country. The average value of production for each of the four-year periods is used to account for business cycles. The industry intensity variables are measured as the weighted average of all national amounts for the year 1990. Lack of data has meant the need to utilise two proxies. Proportions of non-manual workers in each industry, which are necessary to construct the skilled labour intensity variable, have been proxied by their European average level from Eurostat. The possible effect on our results of the use of this data is discussed later. The level of R&D spending in industries is proxied by their counterpart in Japan.

5.4 Preliminary Data Analysis

It is useful to obtain an idea of the national trends we will be discussing. There are seven country characteristics we examine: agricultural abundance; capital, skilled labour and R&D endowments; and forward linkage, transport cost and backward linkage attractiveness. We find that the relative developmental stages of the sample countries are borne out in the statistics. Japan and Korea generally lead the way with Indonesia bringing up the rear. We look first at the role of agriculture in Figure 5-1.

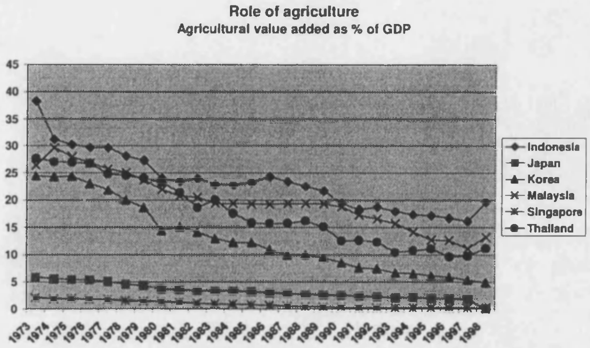


Figure 5-1: Role of agriculture

We see that the role of this item has declined across our sample. The relative rankings of the countries are related to their developmental stage. Indonesia is the most agriculture-abundant country.

For capital, we see in Figure 5-2 that Japan is eventually overtaken by Singapore as the most relatively capital-abundant country. Indonesia and Thailand are both roughly equal in their capital endowments. Malaysia is seen interestingly, considering its developmental stage, to be relatively more capital abundant than Korea.

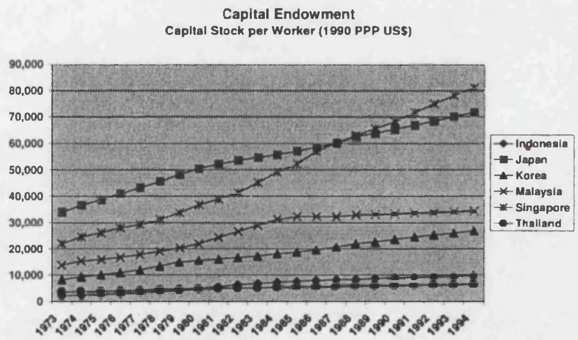


Figure 5-2: Capital endowment

In terms of skilled labour endowment, we see generally rising levels throughout our sample in Figure 5-3. Japan and Korea lead the way with Indonesia consistently behind the rest. It is instructive to see Thailand's good performance as compared to Singapore and Malaysia, pointing to the good educational attainment of its population while the country is behind the others in terms of wealth.

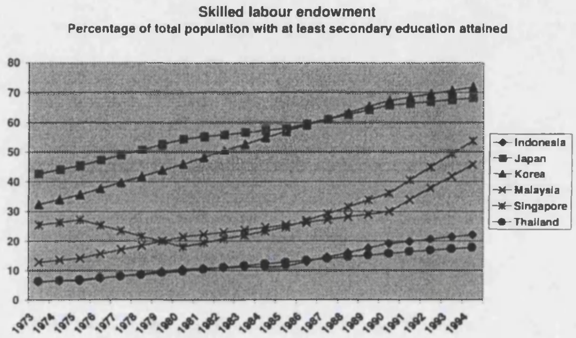


Figure 5-3: Skilled labour endowment

R&D emphasis has generally increased throughout our sample as seen in Figure 5-4. Korea eventually overtakes Japan according to our formulation, showing the former's growing concentration on the high-technology sector. Malaysia stands out for its noticeably poor R&D showing given its relative level of development in our sample.

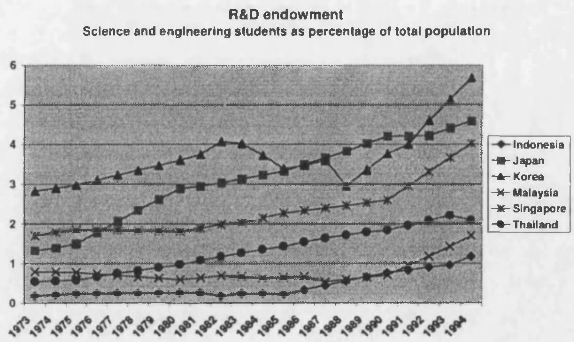


Figure 5-4: R&D endowment

We see that the strength of forward linkages is increasing throughout our sample (Figure 5-5) but with considerably different speeds. Japan has remained fairly stable, Malaysia and Singapore have increased slowly while increase has been strongest in Korea, Indonesia and Thailand. It is interesting that the two least developed countries have done so well in terms of developing their forward linkage attractiveness. This is due to their growing domestic production of intermediates.

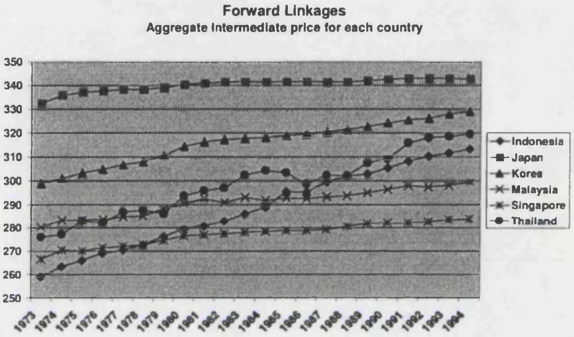


Figure 5-5: Forward linkages

Our consideration of transport costs (Figure 5-6) by means of the variable measuring the elasticity of market potential with respect to transport costs highlights some specific forces to East Asia. The importance of the Japanese home market in terms of size in the region means that Japan is the most attractive country to locate in terms of transport costs. Indonesia is also attractive due to the size of its home market. Korea and Singapore are good performers because of their geographical closeness to large markets.

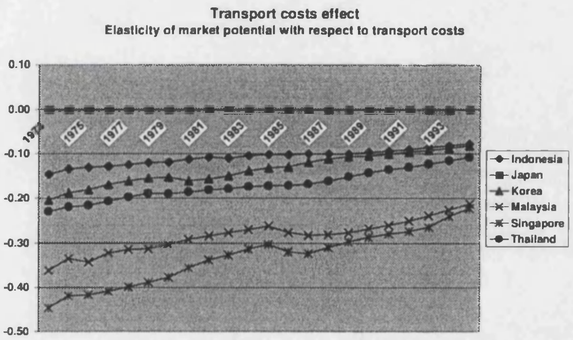


Figure 5-6: Transport costs effect

The backward linkages analysis (Figure 5-7) is also illuminating. The negative performance of Japan is linked to the manner in which we consider the strength of backward linkages in a country. This is by means of the difference between the importance of final good sales and intermediate goods sales in the country. The relative importance of final goods in Japan as opposed to intermediate goods in the rest of the sample gives rise to the movements exhibited. The country is therefore relatively unattractive as a source of demand for intermediate goods producers and such producers are not keen to locate there. We also see that Korea is important as a source of intermediates demand and such demand has increased rapidly in Thailand.

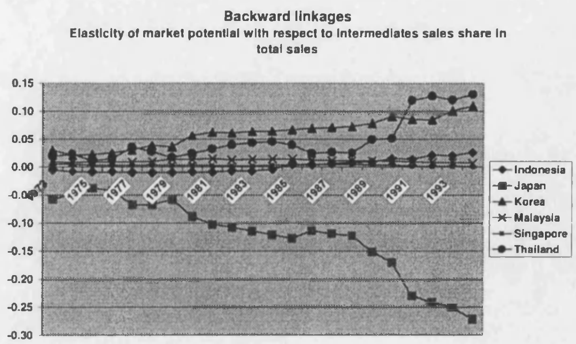


Figure 5-7: Backward linkages

5.5 Estimation

We look first at the pooled data sample of the 5 sub-periods together. Results for the coefficients of the interaction terms are presented in the first column of Table 5.2. These are displayed in terms of standardised coefficients through normalising by their respective standard deviations. The coefficients may be interpreted as elasticities with respect to industry and country characteristics and allow comparisons to be made of the contribution of each of the variables.

Dependent variable: $\ln\left(r_{ij}^{k}\right)$									
	Interactions: $\beta\,[j]$								
	$\beta\,[1]$	$\beta\,[2]$	$\beta\,[3]$	$\beta\,[4]$	$\beta\,[5]$	$\beta\,[6]$	$\beta\,[7]$		
	Agric	Cap	Sk lab	R&D	Fw link	Tr cost	Bw link	R^2	Obs
Pooled	0.13	0.08	0.14	0.07	0.10	0.04	0.02	0.22	660
t-stat	3.44	2.21	3.61	1.73	2.69	1.06	0.48		
1973-76	0.17	-0.01	0.08	0.08	0.10	-0.01	-0.05	0.32	132
t-stat	1.88	-0.10	0.89	0.95	1.14	-0.07	-0.58		
1978-81	0.18	-0.05	0.18	0.07	0.13	0.05	-0.02	0.31	132
t-stat	2.10	-0.54	2.10	0.83	1.54	0.55	-0.19		
1983-86	0.18	0.07	0.20	0.07	0.12	0.04	0.01	0.30	132
t-stat	2.04	0.76	2.32	0.87	1.43	0.44	0.06		
1987-90	0.14	0.13	0.12	0.12	0.08	0.09	0.06	0.21	132
t-stat	1.49	1.43	1.36	1.33	0.91	0.98	0.68		
1991-94	0.07	0.24	0.04	0.13	0.04	0.10	0.08	0.27	132
t-stat	0.81	2.72	0.48	1.47	0.51	1.21	0.85		

Table 5.2: OLS Regression results

We find significance at the 10% level for all the endowment interactions. Agriculture, capital and skilled labour are significant at the 1% level, and R&D at the 10% level. The coefficients are all positive signed as predicted by theory. For the geography interactions, we find positive coefficients as predicted and significance for forward linkages at the 1% level. Transport costs and backward linkages are not significant. In terms of the comparative advantage coefficients we see that skilled labour considerations have the most influence on output, followed by land and capital. This is not surprising given our knowledge of the importance of increases in human capital in the region. R&D does not have as great an effect, a result suggesting that the generally developing country nature of the sample means that production is not innovative in nature.

It is important to ensure that pooling across years is valid for the sample. The assumption has been made that the coefficients remain constant across time. However the responsiveness of output to country and industry characteristics may change over time due to changes across the region such as closer economic relations due to reduced trade barriers. Time effects are tested for by entering time dummies and time dummies interacted with each of the regression variables. A Wald test of significance with 32 restrictions is conducted for the dummy terms producing a test statistic of 8.82 which is significant at the 1% level. It is therefore necessary to split the sample to consider smaller periods of time which are less likely to display unstable coefficients.

Strange way of proceeding
1 split into time periods is arbitrary
2 dummy for years might be sgn even if coeffts are the same

The five sub-periods are considered separately with their results being presented in Table 5.2. It is seen that, other than capital in two periods, the factor endowment terms are positive in all sub-periods as would be expected from theory. Agriculture is significant in all periods at at least the 10% level, except in 1987-90 and 1991-94. Capital initially displays negative values, however after 1978-81 the coefficient is increasing rapidly in value and significance. It is highly significant by the final period. Skilled labour is significant throughout the mid 1970s to the mid 1980s, as seen in 1978-81 and 1983-86. After that, the variable declines in significance and value. The significance of R&D is increasing in the last few sub-periods though it is not significant at the 10% level. For the geography variables, we find positive results in most periods for all the variables as is predicted theoretically. We find as in the pooled results that forward linkages are generally the most significant term. They are slightly less than 10% significant in 1978-81 and 1983-86. Since 1978-81, however, the significance of forward linkages declines consistently over time. Transport costs have a negative sign in the first period but are positive and generally growing in significance and value thereafter. Backward linkages exhibit a negative sign in the first two periods and are otherwise positive. The variable is growing in significance and value throughout the sample. However none of the transport cost or backward linkage effects are significant by the end of the measurement period.

We attempt to discover if economic geography variables are sensitive to the choice of trading partners for countries in the region. It is clear that countries are heavily influenced by Japan in terms of its attractiveness as a source of final and intermediate goods demand. However we would like to see if the inclusion of the other large trading partner for the region, the United States, changes market potential relationships. The US is added as a partner country to the calculation of the transport costs elasticity and backward linkages variables. It is not added to the forward linkages variable as it is assumed that the country is more important as a source of demand for the region than supply. Though East Asia as a region is far from the United States, there are still sizeable differences between distances to the US from various sample countries in the region For example distance from Indonesia is 16,165km whereas it is 11,055km from Korea. This raises the possibility of some sensitivity of our variables to the country's inclusion.

The results of the modified regressions are presented in Table 5.3. We see that there is not much change in explanation for the new sample. The two variables altered see a slight fall in coefficient values and significance. In general though the US is an important trading partner it appears that relative distance to the country within the region does not have a significant impact on establishing location decisions of industries. We continue with this specification of the data as it is a more comprehensive measure.

Dependent variable: $\ln\left(r_{ij}^{k}\right)$									
	Interactions: $\beta[j]$								
	$\beta[1]$	$\beta[2]$	$\beta[3]$	$\beta[4]$	$\beta[5]$	$\beta[6]$	$\beta[7]$		
	Agric	Cap	Sk lab	R&D	Fw link	Tr cost	Bw link	R^2	Obs
Pooled	0.13	0.08	0.14	0.07	0.10	0.03	0.02	0.23	660
t-stat	3.44	2.21	3.62	1.76	2.67	0.94	0.45		
1973-76	0.17	-0.01	0.08	0.08	0.10	0.00	-0.05	0.32	132
t-stat	1.89	-0.10	0.89	0.94	1.15	-0.01	-0.57		
1978-81	0.18	-0.05	0.18	0.07	0.13	0.04	-0.02	0.31	132
t-stat	2.09	-0.54	2.10	0.83	1.53	0.52	-0.21		
1983-86	0.18	0.07	0.20	0.07	0.12	0.03	0.00	0.29	132
t-stat	2.03	0.75	2.32	0.87	1.42	0.39	0.05		
1987-90	0.14	0.13	0.12	0.12	0.08	0.08	0.06	0.21	132
t-stat	1.48	1.42	1.36	1.33	0.89	0.92	0.66		
1991-94	0.07	0.24	0.04	0.13	0.04	0.10	0.08	0.27	132
t-stat	0.80	2.71	0.48	1.48	0.50	1.16	0.83		

Table 5.3: OLS Regression results with United States included

It is important to ensure that the regression estimated is robust in the presence of possible problems. An issue we are concerned with is whether there is multicollinearity in the explanation terms. We re-estimate the results for all time periods dropping each of the right-hand interaction variables in turn from the specification. The coefficient results in Appendix Tables 5.4 to 5.8 are seen to remain consistent across estimations.

We are interested in seeing how good the specification is at explaining production specialization in the region. In terms of R^2 we explain between 21% and 32% of changes in the data. In comparison, other studies which utilise endowment and intensity interactions such as Ellison and Glaeser (1999) for US states and Midelfart-Knarvik et al. (2001) for EU data explain between 14% and 20% of production specialization. It is instructive to study the goodness of fit of the estimated equation over time, industries and countries. As seen in Appendix Table 5.9, the specification generally explains similar levels of specialization over time. Country and industry goodness of fit are analysed for the 1991-94 period. The country data in Appendix Table 5.10 illustrates that there is a considerable divergence in explanatory power for the model across countries. Indonesia and Japan are the best explained and Korea and Malaysia the least with slightly negative figures. This is perhaps an indication that there are other less obvious economic forces at work in the latter regions. With respect to industries Appendix Table 5.11 illustrates the specification's wide variability in explanation of their behaviour. There are a number of industries which are very well explained such as food, tobacco and the economically dynamic sectors of machinery and electrical machinery. Nine out of 22 industries display negative correlation results. Some of this is due to industries' links to a country's natural endowments such as rubber and paper.

It is important to verify whether the divergent goodness-of-fit results obtained across countries and industries may be due to heteroscedasticity. It is possible that there have been consistent errors in measurement for particular countries or industries. Heteroscedasticity of this type can be controlled through the use of country and industry fixed effects. We compare our specification to one with such fixed effects. This is done through estimating our equation with only the interaction variables and replacing the country and industry variables by corresponding fixed effects. The results are given in Appendix Table 5.12. We see that our original estimation displays similar coefficients and standard errors as compared to the fixed effects estimation.

WEIRD

The information from our regression results points to the lack of significance of economic geography variables considered individually in our sample. Information about their significance as a group is obtained from a joint test of significance of the economic geography interactions. As Appendix Table 5.13 illustrates, economic geography terms are not significant jointly in any of the periods. There is an increase in significance up till 1987-90, after which it is declining.

We also conduct a comparison of the relative explanatory roles of economic geography and factor endowment variables in our specification. In equation (5.9) this can be done by setting the comparative advantage and economic geography variables to their reference values in turn and then using the estimated coefficients of the other group of variables along with the actual data points. This provides a measure of the correlation between predicted and actual results using each group of variables in turn. As calculated from the raw data in Appendix Table 5.14 the extent of explanation contributed by the economic geography variables is between 6% and 9%. In contrast, comparative advantage variables explain between 55% and 92% of the correlation between predicted and actual results, with the degree of explanation rising over time.

5.6 Conclusion

This chapter contributes to the debate on the importance of economic geography forces in explaining industrial change in East Asia. Using a formulation which allows us to consider both comparative advantage and economic geography forces together, we see that both explanations have some relevance for our sample. We find our formulation follows theory in predicting the positive effect of comparative advantage forces, with the most relevance given to agriculture and skilled labour and with capital and R&D increasing in importance over time. Economic geography variables exhibit mixed significance with significance of forward linkages being the greatest at first but declining over time whereas those of transport costs and backward linkages are generally increasing in over time. However when considered as a group, we find that economic geography factors do not explain a significant degree of the industrial change seen in any period. A consideration of the relative explanatory roles of the two forces indicates that comparative advantage effects offer more and increasing explanation. It is important to bear in mind that the specification considered abstracts from a full consideration of economic geography theory.

? What?

There are a number of important shortcomings in the method of estimation used which may have led to substantial measurement errors. The first is not considering increasing returns to scale in industries. The assumption of constant returns to scale leads to an aspect of the relationship between industry and country characteristics being ignored. According to new economic geography theory, industries with increasing returns to scale would locate disproportionately in countries with good market access, to take advantage of agglomeration cost savings. In our specification increasing returns to scale industries will react to country market access characteristics more than they would be expected to. This would affect all the economic geography variables leading them to be biased upwards to the extent that there are increasing returns to scale industries present. As mentioned earlier there is evidence of the widespread presence of such industries in East Asia. A further effect for the results is that the significance of the economic geography variables will be lower due to the lack of accurate measurement of the industry variables.

A second reason for lack of accuracy of the results is the need to use the EU data proxy for skilled workers intensity due to lack of such data for the East Asian countries. It is likely that European data would display higher proportions across industries than would be the case in East Asia. It has been seen in developed countries that the share of skilled workers is increasing across manufacturing industries over time (Berman et al. (1998)). In our specification the use of skilled labour intensity variables larger than actual East Asian levels would lead to coefficient values being likely biased downwards. This is because output changes with respect to skilled labour occur relative to larger intensity variables than real East Asian skilled intensity values. Therefore the skilled labour coefficients are likely smaller than they should be. Furthermore there is greater measurement error for the skilled labour variable due to use of the proxy. EU skilled workers intensity though likely to be larger than that of East Asia, will not be equally larger across all industries. Greater measurement error will lead to lower significance for the skilled labour coefficients.

It is nevertheless of interest why less support has been found for economic geography in East Asia than, for example, in Europe (as in Midelfart-Knarvik et al.(2001)) using a similar specification. One possible reason is that East Asia is still less integrated than Europe in terms of regional production linkages. The share of intra-regional trade in East Asia is lower than that of Europe. Barrell and Choy (2003) find that intra-regional export share in the EU was 62.1% in 2000 while the East Asian countries in our sample display values between 35% and 55% for intra-regional exports to 14 East Asian countries. Therefore backward and forward linkages in industries between countries in the region may not be as important a consideration in East Asia as in Europe.

5.7 Appendix

5.7.1 Data description

Years 22 years: 1973-1994

Countries Six countries: Indonesia, Japan, Korea, Malaysia and Singapore and Thailand.

Product Classification System 22 ISIC 3-digit code industrial sectors. Six sectors are removed: petroleum refineries (ISIC Code 353), petroleum and coal products (ISIC Code 354), pottery, china and earthenware (ISIC Code 361), glass and products (ISIC Code 362), non-ferrous metals (ISIC Code 372), and other manufactured products (ISIC Code 390). The first two sectors are not included as they are primarily endowment-driven, the next three are omitted due to lack of full data and the last because it is equivalent to a residual term.

The 22 sectors are:

ISIC Code- Sector

311 Food products

313 Beverages

314 Tobacco

321 Textiles

322 Wearing apparel, except footwear

323 Leather products

324 Footwear, except rubber or plastic

331 Wood products, except furniture

332 Furniture, except metal

341 Paper and products

342 Printing and publishing

351 Industrial chemicals

352 Other chemicals

355 Rubber products

356 Plastic products

369 Other non-metallic mineral products

371 Iron and steel

381 Fabricated metal products

382 Machinery, except electrical

383 Machinery electric

384 Transport equipment

385 Professional & scientific equipment

Dependent variable $\ln r_i^k$. Log of output in industry k in country i with respect to total production of industry k in all the sample countries and the total manufacturing output of country i. Manufacturing data from UNIDO Industrial Statistics Database 3-digit level 2000. Missing data points are interpolated using available data points, or extrapolated when necessary using a five year linear trend from available data points.

Industrial Data

Agricultural intensity

Use of agricultural inputs (incl. fishery and forestry) in each industry as share of gross value of output in each industry. Agricultural inputs from Asian International Input-Output Table 1990. Published 1998. Produced as part of the Asian International Input-Output Project of the Institute of Developing Economies, Tokyo, Japan.

Capital Intensity

Gross fixed capital formation in each industry divided by value of output in each industry. From UNIDO 3-Digit Industrial Statistics.

R&D Intensity

R&D expenditures as share of gross value of output. Proxied by Japanese data from ANBERD and STAN, OECD.

Skill Intensity

Proportion of non-manual workers in each industry (proxied by European average data from Eurostat) multiplied by each East Asian sample country's labour compensation as a percentage of total output (from UNIDO). Missing data points for UNIDO data are interpolated using available data points, or extrapolated when necessary using a five year linear trend from available data points.

Forward linkages importance for an industry

Total use of intermediates as a share of gross value of output. From IDE Asian Input-Output Tables.

Backward linkages importance for an industry

Sales to manufacturing as share of total sales: Percentage of domestic sales to domestic manufacturing as intermediates. From IDE Asian Input-Output Tables.

Transport Costs   Transport costs as share of fob price sales within the East Asian sample and the US. From the GTAP 4 Data Base (McDougall et al. (1998)).

National Data

Agricultural Endowment

Gross value added of agriculture, forestry and fishery products as percentage of all value added. From World Bank World Development Indicators.

Capital Endowment

Country capital stock divided by its labour force. Capital data from King and Levine (1994) reported in 1990PPP US$, labour force data from World Bank World Development Indicators.

Skilled Labour Endowment

Percentage of total population with secondary or tertiary education attained. From Barro and Lee (2000).

R&D Endowment

Science and engineering students as percentage of the total population. From World Bank World Development Indicators.

Economic Geography Variables- Forward linkages measure for countries, backward linkages measure for countries, transport costs effect on countries

Indicators following formulation of Midelfart-Knarvik et al (2001). Distance data is between the economic centre of gravity of cities.

5.7.2 Derivation of economic geography variables

Forward linkages measure for countries

Considers variance in the price of the intermediate good in the presence of transport costs.

Using the price index as defined in (5.1) with the term for total value of industry k output in country i, z_i^k (5.3), gives

$$(G_i^k)^{1-\sigma} = \sum_j \left[\frac{z_j^k (t_{ji}^k)^{1-\sigma}}{\sum_l E_l^k (t_{jl}^k / G_l^k)^{1-\sigma}} \right] \tag{5.10}$$

Most variation in countries is assumed to come from the numerator. The denominator is therefore held constant at $\frac{1}{\beta}$ and (5.10) put in the h_i term (5.6). After taking logs one obtains,

$$\log(h_i) = \beta \sum_k \frac{\lambda^k}{1-\sigma} \log \left[\sum_j z_j^k (d_{ji}^{\delta^k})^{1-\sigma} \right] \tag{5.11}$$

where transport costs effects on an industry k, t_{ji}^k, are approximated by $d_{ji}^{\delta^k}$, a distance measure taking account of industry-specific transport intensity δ^k. The term in brackets represents the closeness of country i to production of each industry in every partner country j. Data needed for the calculation of (5.11) are:

- the share of each industry in the composite intermediate, λ^k: Sales to manufacturing as a share of total output for each sector. From IDE Asian Input-Output Tables.

- elasticity of substitution between varieties of each good, σ assumed to be in line with estimates from gravity models of trade as $\delta^k(1-\sigma) = -1$ and the same in all countries.

- distance between countries, d_{ji}. Distance to own country taken as 1.

- output for each industry in each country, z_j^k. From UNIDO 3-Digit Industrial Statistics. Missing data points are interpolated using available data points, or extrapolated when necessary using a five year linear trend from available data points.

Backward linkages measure for countries

Measures elasticity of market potential with respect to the proportion of sales of industries to intermediates.

Demand for good k in country j, E_j^k, is comprised of demand for good k as a final good and an intermediate good in the following manner,

$$E_j^k = \rho^k I_j + \lambda^k h_j w_j \tag{5.12}$$

where I_j represents income in country j, ρ^k represents a fixed share of income in each country spent on final goods, w_j the amount of total intermediates used in country j and λ^k the share of total demand for intermediates that is spent on good k. (5.12) used in the market potential term (5.4) results in,

$$m\left(u^k : i\right) = \sum_j (\rho^k I_j + \lambda^k h_j w_j) \left(\frac{d_{ij}^{\delta^k}}{G_j^k}\right)^{1-\sigma} \tag{5.13}$$

The proportion of sales of industry k going to intermediates, ϕ^k, is expressed as,

$$\phi^k \equiv \frac{\lambda^k \sum_j h_j w_j}{\sum_j E_j^k} \text{ and } 1 - \phi^k = \rho^k \frac{\sum_j I_j}{\sum_j E_j^k} \tag{5.14}$$

Combining (5.13) and (5.14) gives,

$$m\left(u^k:i\right)=\sum_j\left(\frac{(1-\phi^k)I_j}{\sum_j I_j}+\frac{\phi^k h_j w_j}{\sum_j h_j w_j}\right)\left(\frac{d_{ij}^{\delta^k}}{G_j^k}\right)^{1-\sigma}\sum_j E_j^k \tag{5.15}$$

The elasticity of (5.15) with respect to ϕ^k is,

$$\mu_\phi\left(\overline{u}:i\right)=\sum_j\left(\frac{d_{ij}^{\overline{\delta}}}{\overline{G}_j}\right)^{1-\sigma}\left(\frac{h_j w_j}{\sum_j h_j w_j}-\frac{I_j}{\sum_j I_j}\right)\frac{m\left(\overline{u}:i\right)}{\overline{\phi}} \tag{5.16}$$

where the barred terms refer to reference values. Data needed for the calculation of (5.16) are:

- the value of total intermediates wanted in each partner country j, $h_j w_j$. From IDE Asian Input-Output Tables.
- distance between countries, d_{ji}. Transport intensity at reference value used as previously, $\widetilde{\delta}(1-\sigma)=-1$
- country incomes I_j, taken as proportional to GDP. From World Bank World Development Indicators reported in 1990PPP US$ values.

Transport costs effect on countries

Measures elasticity of market potential with respect to transport costs.

The market potential term $m(u^k:i)$ in (5.4) is measured with respect to two different levels of transport intensity, $\tilde{\delta}$ and $\tilde{\delta}+\Delta\delta$, to obtain a measure of the elasticity,

$$\mu_\delta\left(\overline{u}:i\right)=\left[\frac{\sum_j\overline{E}_j(\overline{G}_j)^{\sigma-1}(d_{ij}^{-(1-\sigma)(\tilde{\delta}+\Delta\delta)}-d_{ij}^{-(1-\sigma)\tilde{\delta}})}{\sum_j\overline{E}_j(\overline{G}_j)^{\sigma-1}d_{ij}^{-(1-\sigma)\tilde{\delta}}}\right]\frac{\tilde{\delta}}{\Delta\delta} \tag{5.17}$$

where the demand term for each partner country $E_j^k(G_j^k)^{\sigma-1}$ is held at its reference industry value. Data needed for the calculation of (5.17) are:

- distance between countries, d_{ji}. Transport intensity at reference value used as previously, $\tilde{\delta}(1-\sigma)=-1$
- the two levels of transport intensity, $\tilde{\delta}$ and $\tilde{\delta}+\Delta\delta$, measured at $\tilde{\delta}=0.7$, $\Delta\delta=0.6$.

- partner country demand at the reference industry values $\overline{E}_j(\overline{G}_j)^{\sigma-1}$, approximated by GDP levels of each country. From World Bank World Development Indicators reported in 1990PPP US$ values.

5.7.3 Regression tests and analysis

Test for Multicollinearity- all time periods

Regression estimates dropping each of the seven independent variables in turn.

Second row of each table provides the full regression results with all terms included.

Dependent variable: $\ln\left(r_{ij}^{k}\right)$								
	Interactions: $\beta\,[j]$							
	$\beta\,[1]$	$\beta\,[1]$	$\beta\,[4]$	$\beta\,[4]$	$\beta\,[5]$	$\beta\,[6]$	$\beta\,[7]$	
	Agric	Cap	Sk lab	R&D	Fw link	Tr cost	Bw link	R^2
with all vars	0.17	-0.01	0.08	0.08	0.10	0.00	-0.05	0.32
t-stat	1.89	-0.10	0.89	0.94	1.15	-0.01	-0.57	
no Agric		0.01	0.12	0.11	0.12	-0.02	-0.10	0.30
t-stat		0.14	1.24	1.11	1.18	-0.21	-1.18	
no Cap	0.18		0.09	0.09	0.12	0.00	-0.05	0.32
t-stat	1.90		0.90	0.96	1.18	0.00	-0.57	
no Sk lab	0.20	-0.01		0.11	0.09	-0.01	-0.05	
t-stat	2.09	-0.09		1.26	0.96	-0.08	-0.62	
no R&D	0.19	0.01	0.11		0.14	0.01	-0.04	0.31
t-stat	1.99	0.15	1.22		1.40	0.08	-0.44	
no Fw link	0.19	-0.03	0.06	0.12		-0.02	-0.04	0.31
t-stat	1.91	-0.28	0.63	1.23		-0.28	-0.49	
no Tr cost	0.18	-0.01	0.09	0.09	0.11		-0.05	0.32
t-stat	1.91	-0.10	0.90	0.95	1.19		-0.59	
no Bw link	0.20	0.00	0.09	0.08	0.11	0.01		0.32
t-stat	2.17	0.04	0.92	0.87	1.11	0.11		

Table 5.4: Test for Multicollinearity for 1973-76 data

Dependent variable: $\ln\left(r_{ij}^{k}\right)$								
	Interactions: $\beta\,[j]$							
	$\beta\,[1]$	$\beta\,[2]$	$\beta\,[3]$	$\beta\,[4]$	$\beta\,[5]$	$\beta\,[6]$	$\beta\,[7]$	
	Agric	Cap	Sk lab	R&D	Fw link	Tr cost	Bw link	R^2
with all vars	0.18	-0.05	0.18	0.07	0.13	0.04	-0.02	0.31
t-stat	2.09	-0.54	2.10	0.83	1.53	0.52	-0.21	
no Agric		-0.03	0.21	0.09	0.14	0.03	-0.08	0.28
t-stat		-0.30	2.27	1.05	1.55	0.31	-0.94	
no Cap	0.18		0.19	0.06	0.14	0.05	-0.01	0.31
t-stat	2.05		2.10	0.73	1.63	0.57	-0.09	
no Sk lab	0.21	-0.04		0.13	0.09	0.03	-0.03	0.28
t-stat	2.26	-0.48		1.51	0.99	0.33	-0.32	
no R&D	0.20	-0.03	0.21		0.16	0.05	-0.01	0.30
t-stat	2.20	-0.36	2.47		1.80	0.60	-0.12	
no Fw link	0.19	-0.07	0.15	0.11		0.01	-0.01	0.29
t-stat	2.10	-0.75	1.74	1.24		0.13	-0.12	
no Tr cost	0.18	-0.05	0.18	0.08	0.13		-0.03	0.31
t-stat	2.06	-0.59	2.07	0.89	1.45		-0.32	
no Bw link	0.20	-0.04	0.19	0.07	0.14	0.05		0.31
t-stat	2.30	-0.51	2.13	0.82	1.53	0.57		

Table 5.5: Test for Multicollinearity for 1978-81 data

Dependent variable: $\ln\left(r^k_{ij}\right)$								
	Interactions: $\beta\,[j]$							
	$\beta\,[1]$	$\beta\,[2]$	$\beta\,[3]$	$\beta\,[4]$	$\beta\,[5]$	$\beta\,[6]$	$\beta\,[7]$	
	Agric	Cap	Sk lab	R&D	Fw link	Tr cost	Bw link	R^2
with all vars	0.18	0.07	0.20	0.07	0.12	0.03	0.00	0.29
t-stat	2.03	0.75	2.32	0.87	1.42	0.39	0.05	
no Agric		0.09	0.21	0.10	0.13	0.19	-0.05	0.27
t-stat		0.99	2.43	1.10	1.48	0.22	-0.63	
no Cap	0.19		0.20	0.08	0.12	0.03	-0.01	0.29
t-stat	2.14		2.36	1.00	1.38	0.34	-0.16	
no Sk lab	0.19	0.08		0.13	0.07	0.01	-0.01	0.26
t-stat	2.15	0.85		1.55	0.83	0.17	-0.07	
no R&D	0.19	0.09	0.22		0.14	0.04	0.01	0.29
t-stat	2.15	0.90	2.67		1.65	0.46	0.11	
no Fw link	0.18	0.06	0.17	0.10		0.00	0.01	0.28
t-stat	2.08	0.67	2.00	1.20		0.01	0.15	
no Tr cost	0.17	0.06	0.20	0.08	0.12		-0.00	
t-stat	2.01	0.73	2.30	0.91	1.37		-0.03	
no Bw link	0.18	0.06	0.20	0.08	0.13	0.03		0.30
t-stat	2.14	0.77	2.33	0.88	1.44	0.39		

Table 5.6: Test for Multicollinearity for 1983-86 data

Dependent variable: $\ln\left(r_{ij}^k\right)$								
	Interactions: $\beta\,[j]$							
	$\beta\,[1]$	$\beta\,[2]$	$\beta\,[3]$	$\beta\,[4]$	$\beta\,[5]$	$\beta\,[6]$	$\beta\,[7]$	
	Agric	Cap	Sk lab	R&D	Fw link	Tr cost	Bw link	R^2
with all vars	0.14	0.13	0.12	0.12	0.08	0.08	0.06	0.21
t-stat	1.48	1.42	1.36	1.33	0.89	0.92	0.66	
no Agric		0.16	0.14	0.18	0.10	0.08	0.03	0.19
t-stat		1.65	1.50	1.52	0.99	0.84	0.31	
no Cap	0.16		0.14	0.13	0.08	0.08	0.03	0.20
t-stat	1.71		1.47	1.46	0.88	0.84	0.34	
no Sk lab	0.15	0.14		0.15	0.06	0.07	0.06	0.20
t-stat	1.62	1.52		1.69	0.60	0.81	0.64	
no R&D	0.15	0.15	0.16		0.11	0.09	0.06	0.20
t-stat	1.66	1.54	1.72		1.13	0.98	0.66	
no Fw link	0.14	0.13	0.11	0.13		0.06	0.07	0.20
t-stat	1.55	1.41	1.19	1.50		0.68	0.78	
no Tr cost	0.13	0.13	0.12	0.12	0.06		0.05	0.20
t-stat	1.44	1.37	1.29	1.38	0.66		0.54	
no Bw link	0.12	0.12	0.13	0.12	0.09	0.08		
t-stat	1.37	1.30	1.35	1.34	0.99	0.84		

Table 5.7: Test for Multicollinearity for 1987-90 data

Dependent variable: $\ln\left(r_{ij}^{k}\right)$								
	Interactions: $\beta\,[j]$							
	$\beta\,[1]$	$\beta\,[2]$	$\beta\,[3]$	$\beta\,[4]$	$\beta\,[5]$	$\beta\,[6]$	$\beta\,[7]$	
	Agric	Cap	Sk lab	R&D	Fw link	Tr cost	Bw link	R^2
with all vars	0.07	0.24	0.04	0.13	0.04	0.10	0.08	0.27
t-stat	0.80	2.71	0.48	1.48	0.50	1.16	0.83	
no Agric		0.27	0.06	0.16	0.06	0.11	0.06	0.26
t-stat		2.83	0.56	1.58	0.60	1.13	0.68	
no Cap	0.10		0.07	0.18	0.06	0.10	-0.01	0.22
t-stat	1.10		0.63	1.73	0.57	0.98	-0.08	
no Sk lab	0.08	0.27		0.16	0.04	0.11	0.07	0.27
t-stat	0.85	2.75		1.62	0.44	1.14	0.79	
no R&D	0.09	0.28	0.08		0.07	0.12	0.08	0.25
t-stat	0.97	2.87	0.82		0.69	1.21	0.83	
no Fw link	0.08	0.27	0.04	0.16		0.10	0.08	0.27
t-stat	0.86	2.73	0.41	1.56		1.07	0.90	
no Tr cost	0.07	0.26	0.04	0.16	0.02		0.06	0.26
t-stat	0.75	2.64	0.40	1.52	0.67		0.68	
no Bw link	0.06	0.24	0.04	0.15	0.06	0.10		0.10
t-stat	0.64	2.58	0.40	1.48	0.60	1.06		

Table 5.8: Test for Multicollinearity for 1991-94 data

Goodness of fit over time, countries and industries

Correlation between predicted and actual dependent values- Periods

Predicted values are the multiplication of the estimated coefficients by independent variable observations to obtain predicted dependent variable results.

Period	73-76	78-81	83-86	87-90	91-93
Correlation	0.261	0.316	0.346	0.315	0.322

Table 5.9: Correlation between predicted and actual values- Periods

Correlation between predicted and actual dependent values- Countries

Predicted values are the multiplication of the estimated coefficients by independent variable observations to obtain predicted dependent variable results.

Sample period considered is 1991-94

Country	Indonesia	Japan	Korea	Malaysia	Singapore	Thailand
Correlation	0.531	0.557	-0.004	-0.011	0.463	0.161

Table 5.10: Correlation between predicted and actual values-Countries

Correlation between predicted and actual dependent values- Industries

Predicted values are the multiplication of the estimated coefficients by independent variable observations to obtain predicted dependent variable results.

Sample period considered is 1991-94

ISIC	Industry	Correlation
311	Food products	0.968
313	Beverages	-0.380
314	Tobacco	0.854
321	Textiles	0.568
322	Wearing apparel	0.910
323	Leather products	0.612
324	Footwear	0.656
331	Wood products	0.632
332	Furniture	0.787
341	Paper	-0.197
341	Printing and publishing	-0.587
351	Industrial chemicals	-0.166
352	Other chemicals	0.323
355	Rubber products	-0.920
356	Plastic products	0.347
369	Other non-metallic mineral	-0.412
371	Iron and steel	-0.464
381	Fabricated metal	-0.835
382	Machinery	0.855
383	MAchinery electric	0.837
384	Transport equipment	-0.414
385	Professional and scientific	0.674

Table 5.11: Correlation between predicted and actual values-Industries

Test for Heteroscedasticity

Specification estimated with only interaction variables and country and industry fixed effects.

Dependent variable: $\ln\left(r_{ij}^{k}\right)$									
	Interactions: $\beta[j]$								
	$\beta[1]$	$\beta[2]$	$\beta[3]$	$\beta[4]$	$\beta[5]$	$\beta[6]$	$\beta[7]$		
	Agric	Cap	Sk lab	R&D	Fw link	Tr cost	Bw link	R^2	Obs
1973-76	0.18	-0.01	0.09	0.09	0.11	0.00	-0.05	0.52	132
t-stat	2.11	-0.11	1.00	1.06	1.29	-0.02	-0.64		
1978-81	0.19	-0.05	0.19	0.07	0.14	0.04	-0.02	0.50	132
t-stat	2.30	-0.60	2.31	0.91	1.68	0.57	-0.23		
1983-86	0.18	0.07	0.20	0.07	0.12	0.03	0.04	0.45	132
t-stat	2.15	0.80	2.45	0.92	1.51	0.42	0.05		
1987-90	0.14	0.13	0.12	0.12	0.09	0.08	0.06	0.34	132
t-stat	1.51	1.45	1.39	1.36	0.91	0.94	0.67		
1991-94	0.07	0.26	0.05	0.15	0.05	0.11	0.08	0.34	132
t-stat	0.79	2.67	0.47	1.45	0.49	1.35	0.82		

Table 5.12: Regression results for interaction terms with country and industry fixed effects

Significance test for economic geography variables

Hypothesis: The indicated coefficients are all zero.

The test statistic is: F (3, 124).

The probability statistics presented are: Prob >F

	73-76	78-81	83-86	87-90	91-93
F-statistic	0.68	0.92	0.97	1.05	0.98
Prob > F	0.57	0.43	0.41	0.37	0.40

Table 5.13: Joint test of significance of economic geography variables

Correlation between predicted and actual results for comparative advantage and economic geography variables in turn

Equation estimated using only comparative advantage and geography variables in turn and obtaining correlations of the predicted dependent variable values implied compared to actual dependent variable observations.

Theoretical assumption is that the other set of variables in each case are held at their reference value and thus removed from the estimation.

	73-76	78-81	83-86	87-90	91-93
All	0.261	0.316	0.346	0.315	0.322
No Geography Variables	0.240	0.289	0.325	0.294	0.302
No Comparative Advantage Variables	0.117	0.104	0.076	0.050	0.025

Table 5.14: Correlation between predicted and actual- with only Comparative Advantage and Geography Terms respectively

Chapter 6

Conclusion

This thesis wishes to make a original contribution to the debate on the nature of the 'East Asian Miracle'. It wishes to establish the degree to which there has been similarity in some of the aspects of the countries' industrial change. This allows us to consider some aspects of whether there has been a discernible East Asian model of industrial change and its nature.

The manner in which we have considered the issue is to look at industry level data for the rapidly industrialising countries of the region. Much previous work on East Asia has concentrated on aggregate level data or on data at a very weak level of disaggregation. Our work allows us to study at a greater level of detail whether changes within the industrial structure of each economy are being replicated across the region. Subsequently we consider the validity of a number of possible explanations for the industrial change witnessed. A number of different empirical approaches are adopted for the first time with respect to East Asia. A joint comparison of the relative importance of technology and factor endowments in East Asian change is attempted. This is followed by a consideration of economic geography forces as compared to factor endowments as explanators of East Asian industrial movements.

There have been a number of challenges in undertaking this thesis. The primary one has been the considerable difficulty in obtaining suitable data. This explains in great measure the lack of much comparable work already present in the literature. Data is not available from many typical international sources for all countries of concern. Furthermore data present is often of suspect reliability or incomplete. We have tackled the issue by being thorough in the pursuit of reliable data. Import and export data are reliably covered in the OECD Bilateral Trade Database, though only for OECD countries. Revealed Comparative Advantage data used in Chapters 2 was therefore obtained by backing out data for partner countries of OECD countries from the Bilateral Trade Database tables. Input-output data for Chapter 5 proved elusive to obtain in a comparable format across the region. It was eventually acquired due to the recent publication of input-output tables constructed by the 'Industrial Structure of Asia-Pacific Region' project of the Institute of Developing Economies (IDE) based in Japan. Average national hours worked data was obtained from individual ministries in the countries concerned for Korea and Singapore. East Asian purchasing power parity data was obtained through communication with the World Bank. Information which was obtained from recognised international sources had to often be cleaned up extensively. The main example of such incomplete data was the UNIDO Industrial Statistics database, which was used extensively as the only source of comparable East Asian industrial data for various statistics in Chapters 2, 3, 4 and 5. Missing data points were interpolated or extrapolated using existing relevant data, as outlined in the relevant Appendices.

There are also a number of weaknesses to note in the analysis. First, a lack of data has sometimes prevented study to the most useful level of disaggregation. In the analysis of Heckscher-Ohlin versus Ricardian approaches in Chapter 4 disaggregation below the 2-digit level would have been valuable to provide more detail but full data was lacking. Second, it has been necessary in a number of cases to utilise proxies when there has been no available source of particular national data. For example, the skill intensity measure in Chapter 5 was the proportion of non-manual workers in each East Asian industry (proxied by European average data from Eurostat) multiplied by each East Asian sample country's labour compensation as a percentage of total output (from UNIDO). Whenever a proxy has been needed the most similar available data source is used. Any usage is clearly indicated and explained.

A third point of concern is the necessarily small country sample size in much of the econometric analysis. Of the eight countries we are interested in- Hong Kong, Singapore, Taiwan, Korea, Malaysia, Thailand, Indonesia, and China- sufficient data is lacking for Taiwan, Thailand and China in many cases. Nevertheless, we feel that even without these countries in some of the work, a sufficient selection of other countries in different stages of development in the region remain to make the analysis representative. In Chapter 4 we use a sample of 21 years, six countries and nine industries. In Chapter 5 we use 22 years, six countries and 22 industries worth of information. Testing of international economics theory is usually conducted with large samples of world, OECD or European data. However, the fact that we want to consider regional change means we have to work with a restricted country group. Though our sample sizes are small they are still econometrically sufficient for meaningful analysis.

Let us evaluate what we have learnt over the course of this thesis. In Chapter 2 we see first that analysis of regional agglomeration through industrial specialisation indices shows us that countries are reasonably specialised in their industrial structure. This provides us with a starting point that there are indeed distinct industrial structures in the region, making cross-country analysis of its change worthwhile. We subsequently analyse the development of particular industries in the countries through a revealed comparative advantage (RCA) measure. We see that there is considerable change or 'churning' across some industries in all countries. It is possible to obtain an idea of specific industrial trends in change across the region. For instance, newer developing countries gained less-skilled sectors such as rubber, plastics, wood and cork whereas their more developed neighbours did not gain operations of as great a labour-intensity. The computer industry is gained by all countries except the least developed ones. In a more general sense, we obtain an idea of movements in RCA through the numerical calculation and graphical analysis of transition matrices. We conclude not surprisingly that countries witness the greatest mobility in industries in which they are not extremely uncompetitive or competitive. The growth and change witnessed in these industries highlight the possible role played by non-Heckscher Ohlin effects. This chapter sets the scene for the issues to be discussed next. We have seen that there is considerable country specialisation and industrial change in the region. We are given an idea of the nature of the industries which witness change and trends in the comparative advantage profile of industries most susceptible to change in the region.

Chapter 3 provides us with detail on the similarities in change between countries in the region. We are keen to obtain evidence for a discernible pattern of industrial change across the region. We see that the patterns studied in Chapter 2 at a national and industrial level are related across countries. Precisely we see that we can trace a pattern of time precedence in terms of the manner in which industrial structures in the different countries change towards resembling each other. The time precedence is associated with the relative income levels of the countries concerned. We see that the change witnessed can not be fully explained by measures of some factor endowment differences. The ability to conclude this at a more disaggregated level of industry than previously provides a new source of support to the view that East Asian industrial development follows a particular path of change, despite countries' many different characteristics, and that this change may depend on other explanations in addition to factor endowments.

In subsequent chapters we study the applicability of a number of theories common in international economics to the change witnessed in the region. These tests are not dependent on any assumption that industrial change in the region is necessarily similar among countries. A lack of significance in the effects measured would indicate the need for another theory or that there was no connection between the forces of change in the countries. In Chapter 4 we analyse factor endowments and technology explanations for industrial movement. We find evidence for both effects with the latter being less important but still significant. Though there has been a long debate concerning the relative importance of both explanations with respect to the region, this is the first time to our knowledge that such an East Asian analysis has been conducted jointly at the industrial level.

Chapter 5 involves a test for another theory which has been proposed as possibly being a good candidate to explain change in the region. We conduct an examination of economic geography as an explanator with factor endowments considered as the most likely alternative. We see that a subset of economic geography variables, namely forward linkages, has been somewhat significant in the past but is becoming less so over time. Backward linkages are increasing in significance as is the effect of transport costs on firms' decision to be close to markets. Economic geography variables as a group are seen to explain a small proportion of the movements measured with their importance decreasing as a group. Economic geography can not be dismissed as a force however as the specification does not allow for the consideration of the theory in its full form in the absence of monopolistic competition effects. The effects for our results of this simplification, as well as the need to use a skilled labour intensity European proxy, are discussed in terms of significance and bias. It is nevertheless a worthwhile task to econometrically test for some evidence of the economic geography phenomenon in the region that has been mainly conjectured in the past.

Some final conclusions emerge from this analysis. The rapidly industrialising economies of East Asia can be said with greater certainty to display a marked similarity in their patterns of industrial structure. A great deal of the reason for their industrial change stems from dynamic changes in factor endowments. There is however a considerable role for technological upgrading as well, counter to a common view of near exclusive importance for changes in factor endowments. The first test conducted for economic geography elements in a general equilibrium framework for the region indicates that as a group they have not been significant in determining the movement of industry. This does not offer support to the view of such forces as being one of the conduits which spread industrialisation in the region. The particular important economic geography element which determines whether an industry remains in a country in the face of increasing costs, ceteris paribus, is changing over time, with linkages to suppliers being superceded by linkages to demanders of intermediate goods.

This thesis raises a number of issues which would be useful to explore in further work. It would be instructive to contrast East Asian patterns of industrial change with those of other regions to study the presence of regional idiosyncracies in development. Possible candidates would include South America and South/East Africa. It would also be valuable to study how East Asia's industrialisation pattern can be mirrored by other regions. To do this it would be necessary to utilise relevant policy variables to analyse the role of government in supporting and detracting from the forces of comparative advantage, technology and economic geography witnessed.

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