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Ulasan, Bülent (2008) Trade openness and economic growth: a cross-country empirical investigation. PhD thesis, University of Nottingham.

TRADE OPENNESS AND ECONOMIC GROWTH: A CROSS-COUNTRY EMPIRICAL INVESTIGATION

by

Bülent Ulaşan

Thesis submitted to The University of Nottingham
for the degree of Doctor of Philosophy

February 2008

Abstract

In this dissertation, we empirically investigate the relationship between trade openness and economic growth across countries over the period 1960-2000. The main contribution of this dissertation is that we handle the model uncertainty problem by employing model averaging techniques, instead of estimating and reporting a number of cross-country growth regressions. Differently from many previous cross-country growth studies, our findings do not support the proposition that openness has a direct robust relationship with long run economic growth. However, we conclude that economic institutions and macroeconomic uncertainties relating to inflation and government consumption are key factors in explaining economic growth in the long run.

Acknowledgments

I would like to thank Wyn Morgan and Peter Wright for their support and advice throughout the entire program. I could not have completed this dissertation without their support and encouragement. I am also thankful to Paul Newbold who was my supervisor in the first year of my program. I would like to thank my examiners, Michael Bleaney and Ashok Parikh for their helpful comments and suggestions. Special thanks go to Mehmet Eriṣ for his valuable helps. I would like to thank Sultan Gencer, Juan Carlos Cuestas, and Paulo Regis for their motivation and encouragement. I am grateful to the Central Bank of Republic of Turkey who provided scholarship for my PhD. Finally, I would like to thank my parents Veli and Hayriye Ulaṣan, my sisters Pınar and Serim, my brother Mehmet for their support and encouragement. Unfortunately, my father passed away in my third year of the program and my mother passed away on the submission day of this dissertation. This dissertation is dedicated to their memory.

Dedication

To the memory of my parents Veli and Hayriye Ulaşan, with love and gratitude

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List of Abbreviations

2SLS : Two Stage Least Squares

BDW : Brock, Durlauf and West (2003)

BMA : Bayesian Model Averaging

BMP : Black Market Premium

EBA : Extreme Bounds Analysis

ELF : Ethnolinguistic Fragmentation Index

FLS : Fernández, Ley and Steel (2001a,b)

GDP : Gross Domestic Product

GETS : General-to-Specific

GUM : General Unrestricted Model

ICRG : International Country Risk Guide

ICs : Industrialised Countries

IMF : International Monetary Fund

IRLS : Iteratively Reweighted Least Squares

ISI : Import Substituting Industrialisation

IV : Instrumental Variable

MC^3 : Markov Chain Monte Carlo Model Composition

MRW : Mankiw, Romer and Weil (1992)

NTBs Non-tariff Barriers

OECD : Organisation for Economic Co-operation and Development

OLS : Ordinary Least Squares

OPEC : Organization of the Petroleum Exporting Countries

PPP : Purchasing Power Parity

R&D : Research and Development

RLP : Relative Price Level

SAL : Structural Adjustment Loans

SCOUT : Outward Orientation Index of Syrquin and Chenery (1989)

SICs : Semi-Industrialised Countries

SW : Sachs and Warner (1995)

WB : The World Bank

WBWDR87 : The World Bank World Development Report 1987

WLS : Weighted Least Squares

Chapter 1

Introduction

1.1 Why Study Economic Growth?

Economics as a social science explores and explains social and economic phenomenon such as; "*Some countries are very rich and some are very poor. Some economies are growing rapidly and some are not growing at all.*" Economics is also a normative discipline and offers polices in order to solve many economic and social issues. *What is the ultimate goal of economic policy*: Price stability, a balanced government budget, reducing domestic and foreign debt, providing current account surplus or deficit, removing government interventions, openness to international trade and so on.

In my opinion, none of these are important per se, since the main aim of economic policy should be promoting economic growth and development. Unless a convincing and satisfactory link is established between these factors and economic growth, they will not be meaningful as objectives of economic policy. *Why is economic growth so important? Why should we care about economic growth?* The answer is simply that it raises our living standards. Easterly (2001, p.3) starts his elusive quest for the sources of economic growth by emphasising this simple fact:

> We care because it betters the lot of the poor and reduces the proportion of people who are poor. We care because richer people can eat more and buy more medicines for their babies.

There is no doubt that sharing the pie is as important as the growth of the pie in order to improve living standards. However, there is no credible evidence that economic growth leads to income inequality. Rather, many studies document that poverty declines with economic growth.[1] It is obvious that if the degree of income inequality remains the same, both the poor and the rich will be better off if the economy grows. Therefore, whilst one way to reduce poverty is to redistribute income from the rich to the poor, another way is to accelerate economic growth.

1.2 What is the Engine of Growth?

Once we acknowledge the importance of economic growth, a pertinent question arises immediately: *What is the engine of economic growth?* This is question that Adam Smith (1776) directly addressed in his study: *An Inquiry into Nature and Causes of the Wealth of Nations.*

The modern examination of this question by economists started after the publication of two noteworthy studies by Solow (1956) and Swan (1956). The neoclassical growth model developed by these authors emphasised the role played by physical capital accumulation over time and predicted a steady state growth path for each economy. The key conclusion of this model was that the steady state growth rate of

[1] See, for instance Dollar and Kraay (2001), Harrison and McMillan (2007) amongst others.

per capita income is determined by the exogenous rate of technological progress. After a silent period during the 1960s, research on economic growth received renewed interest in the 1970s. The first cross-country growth studies investigated the impact of export or outward orientation on macroeconomic performance. Interest on cross-country growth research then accelerated in the mid 1980s because of theoretical work on endogenous growth and because of the availability of Summers-Heston data set. The studies by Kormendi and Meguire (1985), Barro (1991) and Mankiw et al. (1992) are milestones for the empirical cross-county growth literature.

The recent empirical cross-country growth studies are mainly based on the extended versions of the neoclassical growth model in spite of the contribution of recent endogenous growth models. In this respect, the pioneering work by Mankiw et al. (1992) augments the neoclassical growth model with the inclusion of human capital. The framework suggested by this study has become the workhorse in the empirical cross-country growth literature. Conceptually, there are two main empirical approaches, namely growth accounting and growth regression, quantifying the following relation:

$$Output = F(Production\ Factors,\ Technology)$$

It is obvious that the accumulation of production factors and technological progress (whether exogenous or endogenous) are *proximate* determinants of economic growth. Beyond the proximate determinants, explaining the *fundamental* sources of growth differences across economies is the main question of the empirical cross-country growth literature. To answer this question, the cross-country growth studies apply a wide range of different theories. The most outstanding characteristic of these new growth theories is that they are open-ended, such that the inclusion of one growth theory does not preclude that the causal role of others, as pointed out by Brock and Durlauf (2001). Wacziarg (2002, p.907) nicely summarises this phenomenon:

> All-encompassing hypotheses concerning the sources of economic growth periodically, and with the support of adequately chosen cross-country correlations, enjoy their fifteen minutes of fame. Over the last few decades, the list of proposed panaceas for growth in per-capita income has included high rates of physical-capital investment, rapid human-capital accumulation, low income inequality, low fertility, being located far from the equator, a low incidence of tropical diseases, access to the sea, favorable weather patterns, hands-off governments, trade-policy openness, capital-market developments, political freedom, economic freedom, ethnic homogeneity, British colonial origins, a common-law legal system, the protection of property rights and the rule of law, good governance, political stability, infrastructure, market-determined prices (including exchange rates), foreign direct investment, and suitably conditioned foreign aid. This is a growing and non-exhaustive list.

Whilst the sentiment of Wacziarg (2002) rings true, trade-policy openness has enjoyed more than its fifteen minutes of fame. Openness has been famous as an engine of economic growth, but *"Does openness really deserve its fame?"* This is the question which we explore in this dissertation.

1.3 Openness and Growth: What Does the Evidence Tell Us?

As mentioned above, the empirical cross-country studies of the openness-growth connection date back to the 1970s. The early cross-country work (for instance Balassa (1978, 1985), Feder (1982), Ram (1985, 1987) *inter alia*) investigate the relationship between openness and growth in the framework of neoclassical growth accounting. They consider exports as a proxy for trade openness, and almost all of them conclude that export or outward trade orientation increases economic growth. This issue received renewed interest in the early 1990s, partly because of new analytical tools provided by endogenous growth theories and partly because of a considerable number of liberalisation reforms in developing countries during the 1980s. Like the early cross-country comparisons, these studies find a strong and positive relationship between openness and growth. More to the point, they are considered to provide much stronger and more convincing evidence for the proposition that openness to international trade is beneficial for economic growth (see, for instance, Krueger (1997)).

However, both the early and recent cross-country studies have been subject to criticism, e.g. Edwards (1993) and Rodrik and Rodríguez (2000) heavily criticise the findings of this literature.[2] Their criticisms focus on the lack of robustness. In particular, these surveys emphasise two important drawbacks of the literature: First, the openness measures are poor proxies of the trade policy stance, and in most cases they are correlated with other aspects of macroeconomic policy and growth determinants. Second, most studies investigating the openness-growth link employ simple growth models and ignore other important growth

[2] Edwards (1993) also carefully investigates the detailed multiple country case studies.

theories. More importantly, these papers remind us that we do not have a certain and conclusive theoretical justification concerning the impact of trade openness on economic growth. For instance, Edwards (1993, p.1361) points out that "[t]hese studies have not been able to provide a fully convincing theoretical framework that links commercial policy, trade orientation and growth." Similarly, Rodríguez and Rodrik (2000, p.272) argue that " [t]here is no determinate theoretical link between trade protection and growth once real-world phenomena such as learning, technological change, and market imperfections are taken into account."

In the next section, we discuss the theoretical link between openness and growth.

1.4 Openness and Growth: What Does the Theory Tell Us?

The relationship between openness and economic growth was, until recently, assessed in the framework of traditional Ricardian-Hecksher-Ohlin trade theory. This theory points out that openness to international trade brings only a one-time increase in output, since the country allocates its resources more efficiently after the openness, conditional on comparative advantage. However, this theory does not suggest any certain implications for long run growth. As we noted before, the neoclassical growth model concludes that the growth rate of per capita output is determined by the exogenous technological progress. According to the neoclassical growth model, an increase in the savings rate generates a temporary rise in the growth rate. Of course, openness may impact on the long run growth rate if there is a technology stimulating effect of openness. However, neither the traditional Ricardian-Hecksher-Ohlin trade theory nor the neoclassical growth model provides a theoretical framework for the proposition that openness stimulates technological progress.

In this regard, only the newer endogenous growth theories pay attention to implications of trade openness on long-run growth since openness facilitates easier access to new technology embodied in imported inputs, directs domestic resources towards more research intensive sectors and increases market size. However, as we discuss in the next section, endogenous growth theories do not unambiguously conclude that openness promotes the long run growth.

1.4.1 Openness and Endogenous Growth Theories

Endogenous growth theories emerged to a great extent from the contributions of Romer (1986) and Lucas (1988), stress the role of capital accumulation on long run economic growth. In contrast to the neoclassical growth model, these theories define capital more broadely and included ideas (or knowledge), learning-by-doing and human capital. The crucial aspect of the endogenous growth models is that the accumulation of capital is not subject to diminishing returns and is thus central to long run growth. We can summarise the basic mechanisms of endogenous growth theories by using the following diagram:

$$Ideas \Longrightarrow Nonrivalry \Longrightarrow Increasing\,Returns \Longrightarrow Imperfect\,Competition$$

As pointed out by Romer (1990), ideas as the fundamental premise of endogenous growth models are different from other economic goods in some aspects: They are nonrival. That is, once an idea is produced it can be used by different persons and firms simultaneously. In addition, ideas are at least partially excludable such that access to ideas can be restricted by their owner, at least for some time period. The nonrivalrous and partly excludable features of ideas have two important implications for economic growth: First, ideas can be accumulated without bound on a per capita basis; Second, ideas spill over across economic units.

As long as an idea has productive value, output will not be subject to constant returns to scale with respect to all production inputs. In other words, if the stock of knowledge and other inputs double, then the level of output will more than double. The inclusion of ideas as a productive input into production function results in another important conclusion. In the presence of increasing returns to scale, factors are not paid their marginal products. This means that standard competitive market assumption will not be valid.

In summary, the inclusion of ideas as nonrival production inputs and hence increasing returns to scale and imperfect competitive market environment play an important role in the endogenous growth models. Introducing human capital and learning-by doing into this framework brings about some extra complexities, yet basic mechanisms remains the same.[3]

What are the implications of endogenous growth theories for the relationship between openness and economic growth? First of all, according to endogenous growth models, economic policy can affect the rate of growth in the long run as pointed by Rebelo (1991). In this regard, the models of Rivera-Batiz and Romer (1991) and Grossman and Helpman (1991, Chapters 6 and 9) provide a firmer theoretical framework linking trade policy to long run economic growth.

[3]See, for instance, Aghion and Howitt (1999) and Jones (2005).

For simplicity, these models consider a small economy producing and trading two final goods at given world prices. These final goods are produced by two production factors; namely labour and intermediate inputs. There are three types of agents in this model: First, in the final-goods sector producers combine labour and intermediate inputs in order to produce final goods; Second, research and development (R&D) firms use resources to invent new varieties of intermediate inputs (or to increase product quality); Third, on the demand side there are households trying to maximise their utility in the framework of a conventional instantaneous utility function, subject to budget constraint.

Each final good is produced according to the conventional Cobb-Douglas production function with constant returns to scale. We can write the production function for the final good $i, i = 1, 2$

$$Y_i = A_i D_i^{\beta} L_i^{1-\beta}, \quad 0 < \beta < 1 \tag{1.1}$$

where Y is output, A is an arbitrary constant reflecting the overall measure of productivity, D is an index of the intermediate inputs and L is labour input employed in sector i. Since each sector employs different type of labour, the production function in equation (1.1) can be expressed for good 1 and good 2 as follows

$$Y_1 = A_1 D_1^{\beta} H_1^{1-\beta}, \quad 0 < \beta < 1$$
$$Y_2 = A_2 D_2^{\beta} U_2^{1-\beta}, \quad 0 < \beta < 1$$

where H is the skilled labour (or human capital) and U is unskilled labour. That is, the first final good is intensive in skilled labour. In addition to the final goods sector, the R&D sector employs skilled labour in order to increase the number of intermediate inputs. Firms may enter freely into the R&D sector, but they have monopoly power because of patent protection of ideas. Thus, intermediate inputs can be sold to the final goods sector at a price that is higher than their marginal costs. The profitability of production of new type of intermediate inputs determines the rate at which new ones are produced. As can be seen from the production function of final goods in (1.1), the faster the rate at which new intermediates are supplied, the higher will be the rate at which production of final goods sector increases. Since the R&D sector also employs skilled labour, the higher the fraction of economy's skilled labour that works in this sector, the greater is the rate at which new intermediates are invented and hence the faster the rate of economic growth. Therefore, in these models, activity in R&D sector directly determines the economic growth.

In this framework, Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991) point out that openness to international trade has four different effects on the long run economic growth:

i) Communication Effect: Openness to international trade provides channels for communications with foreign counterparts that facilitate the transmission of technology.

ii) Duplication Effect: In the absence of international trade some ideas and technologies are duplicated in many countries. Openness encourages firms to invent new and distinct ideas and technologies preventing duplication of R&D effort.

iii) Allocation Effect: Trade openness leads countries to specialise according to traditional (Ricardian- Hecksher-Ohlin) comparative advantages which are determined by factor endowment. Hence, the relative domestic prices of factors will change after the trade openness (due to the Stolper-Samuelson theorem). If a country has a comparative advantage in a sector which is unskilled labour intensive (e.g. final good 2), trade openness reduces the domestic relative wage of skilled labour compared to unskilled labour. This leads to a rise in the level of R&D activities, and hence in the long run growth rate because the cost of R&D decreases and/or the fraction of skilled labour endowment employed in R&D increases. Exactly, the opposite is true in a country that specialises in skilled labour intensive goods (say final good 1).[4]

iv) Integration Effect: Trade openness increases the size of the market available to firms. Assuming intermediates are traded across countries as well as final goods, the enlarged market size of the R&D sector raises R&D activity and hence economic growth since this sector is subject to increasing returns to scale. On the other hand, after trade openness, the domestic R&D sector will face foreign competition and hence this sector may lose market share at home leading to a slowdown in economic growth. For instance assuming intermediates are not traded, Feenstra (1996) concludes that the integration effect is not beneficial to smaller countries. Alesina et al. (2000, 2005) develop a theoretical model such that there is an inverse relation between openness to international trade and country size.

It is obvious that, among these different effects, only the communication and duplication effects necessarily raise economic growth. How-

[4]In this regard, the study by Matsuyama (1992) provides a two sector-agriculture and manufacturing- model of endogenous growth in which the engine of growth is learning-by-doing in the manufacturing sector. Due to the assumption that income elasticity of demand for the agricultural good is low, this model establishes a positive link between agricultural productivity and economic growth for the closed economy case, while it predicts a negative link for the open economy case. That is, if a country specialises in manufacturing according to traditional comparative advantages, the openness to international trade raises long run economic growth. If a country joins international trade specialising in agriculture, then trade openness leads to a decrease in the long run growth rate.

ever, the allocation and integration effects are not unambiguously positive. Therefore, it is possible to conclude that the influence of openness to international trade on long run economic growth depends on the magnitude and dominance of these different effects.

1.4.2 New Trade Theories

The 1980s witnessed the development of "new trade theories", in which market structures are characterised by imperfect competition and increasing returns. These new theories seek to explain intra-industry trade. Krugman (1986, p.5) argues that "[t]he classical case for free trade may have been more in tune with the working of the economy in 1880 or even 1950 than with the world economy of 1984. In part it is because we have become more sophisticated about how the markets actually work. In either case the point is that although economists may continue to advocate free trade, they will have to update their arguments if they expect to retain their credibility". As a result of the changing character of international trade, in particular the imperfectly competitive market structure, Krugman (1986) and others point out that comparative advantages are determined by neither underlying country characteristics (natural resource and factor endowments) nor by the static advantages of large scale production. Rather, comparative advantages are determined by the knowledge or technology generated by firms through R&D and experience or learning by doing.

The key message of this literature is that when a country undertakes international trade, the government may increase aggregate welfare by implementing an interventionist trade policy. The main body of this literature evaluates international trade and trade policy in terms of aggregate welfare and thus it might be worth remembering that whilst welfare and growth are related, they are in essence different concepts. However, in the light of the new trade theory it is possible to reach some useful conclusions about economic growth. Moreover, since industrial sectors of many developing countries are imperfectly competitive, the new trade theory also has important implications for these countries as pointed out by Rodrik (1988) and Krugman (1989).[5] Therefore, if certain high technology sectors generate large technological spillovers to the rest of the economy, one can conclude that promoting these sectors through protection, export subsides, tax allowances and so on may have the potential to increase GDP. For instance, Krugman (1984) provides a model in favour of trade protection in order to support exports and hence production. His model is based on two important assumptions: First, markets are both oligopolistic and segmented; Second, there are some scale economies in the form of static economies of scale (i.e. a declining marginal cost curve) or of dynamic scale economies (i.e. learning-by-doing or competition in R&D). Using a multi-market Cournot model, Krugman (1984) demonstrates that protecting import-competing sectors increases scale economies of domestic firms while reducing those of foreign competitors. Due to the economies of scale, protection leads to an expansion of the market share of domestic firms in both domestic and international markets. Krugman (1984) argues that this model is more satisfactory in explaining the successful exporting performance of East Asian countries such as Japan.

In summary, both endogenous growth models and new trade theories provide powerful analytical tools linking openness with growth. However, these models do not necessarily predict that openness leads

[5]However, others such as Srinivasan (1989) and Corden (1989, 1990) question this claim. According to these authors, increasing returns and imperfect competition are irrelevant to developing countries.

to economic growth in all circumstances and for all countries. In other words, whether openness causes economic growth depends on country specific conditions. Despite these facts, there is a common presumption that openness leads to higher output level and growth in developing countries. In our opinion, this presumption stems mainly from the bad reputation of import substituting industrialisation (ISI) experiences in developing countries during the post-war era. In the next section, we briefly summarise ISI experience and discuss the main criticisms of this development strategy.

1.5 Industrialisation, Economic Development and Trade Policy: A Brief Review

The role of industrial strategy has always been a crucial issue in economic development. The most important reason is that almost all economists and policy makers have considered industrialisation as a necessary condition of economic growth and development during the most part of the 20th century. In spite of this consensus, a debate arises from different industrialisation strategies. The role of the trade policy is given particular emphasis in this debate as noted by Greenaway et al. (2002).

Through the 1950s, economists and policymakers reached a consensus that an inward-oriented ISI strategy was the best way for developing countries to stimulate industrialisation and hence for achieving economic and social development. The most important reason is that the static comparative advantage theory does not reflect the true opportunity costs of internationally traded goods due to the differences in income and price elasticities of primary and manufactured goods as argued by Prebisch (1959). This means that the growth rate of per capita income in developing countries (or in periphery according to Prebisch's terms) should be lower than that in industrial centres if both blocks grow under a balanced international trade. If per capita income grows at the same rate in two blocks, the demand in the periphery for industrial exports grows at a higher rate compared to the growth rate of its primary exports. This leads developing countries to chronic trade deficits against industrial centres. In order to prevent a trade deficit, Prebisch (1959, p.254) suggests that, "[e]ither the rate of increase of demand for imports would have to fall, by means of import-substitution, or industrial exports would have to be added to primary ones, or a combination of two."

The other important premise of ISI strategy is the infant industry argument. This argument was accepted by the majority of economists including both classical and neoclassical ones as a major exception for free international trade as noted by Baldwin (2004). However, during the 1950s, Prebisch (1959) and others argued that infant industry argument can be applied to the whole industrial sector rather than a single industry (Bruton (1989)). Therefore, the ISI strategy was always implemented with trade protection, since substitution of imports with domestic production required protection of domestic market from foreign competition.

During the post-war area, many developing countries, especially those in Latin America and Asia followed the advanced stage of the ISI strategy which aims substitution of imported capital goods and durable consumer goods. Since this stage required the larger scale investment projects and the superior technology, the ISI strategy led to a considerable increase in imported inputs and so a growing demand for foreign exchange. Especially, trade deficits and hence foreign debt stock of developing countries increased sharply due to oil crises during the 1970s. The story came to an end with debt crises and growth collapses in the late 1970s and the early 1980s. In response to debt crises, more than 100 developing countries launched liberalisation programs since the beginning of the 1980. [6]

The ISI strategy has been heavily criticised by many authors.[7] Before evaluating these criticisms, we should remind ourselves of some simple stylized facts about the economic growth over the 1960-2000 period. Table 1.1 reports the growth statistics by decades and regions. The most outstanding fact is that except for East and South Asia, the growth rate in both aggregate and per worker levels is higher over the period 1960-1980 than 1980-2000. Therefore, the claim that the ISI strategy led to economic stagnation may be mistaken. We briefly discuss the important criticisms on the ISI strategy.

ISI Discriminates against Exports

The most common criticism is that an ISI strategy discourages exports. According to Krueger (1997), the reason for this is the consideration of that both global income and price elasticities of primary products are low. Therefore, export earnings would not grow rapidly. In addition, many developing countries followed fixed exchange rate regimes in order to make imports of capital goods cheaper and so to increase investments. The result was real appreciation of domestic currency, exchange control regimes and a considerable bias against exporting

[6] Most of these liberalisation efforts were brought into practice under the supervision of the World Bank Structural Adjustment Loans (SAL). See Greenaway and Milner (1993) for details and see Rodrik (1992) for a critique of the SAL programs.

[7] See, for instance, Balassa (1989), Krueger (1980, 1997, 1998), Bhagwati and Srinivasan (2002), Panagariya (2002).

Table 1.1: Economic Growth by Region and Period, 1960-2000

	Annual Growth in Output (%)				
	1960-70	1970-80	1980-90	1990-2000	1960-2000
World	5.1	3.9	3.5	3.3	4.0
Industrial Countries	5.2	3.3	2.9	2.5	3.5
Latin America	5.5	6.0	1.1	3.3	4.0
Africa	5.2	3.6	1.7	2.3	3.2
Middle East	6.4	4.4	4.0	3.6	4.6
South Asia	4.2	3.0	5.8	5.3	4.6
East Asia[a]	6.4	7.6	7.2	5.7	6.7

	Annual Growth in Output per Worker (%)				
	1960-70	1970-80	1980-90	1990-2000	1960-2000
World	3.5	1.9	1.8	1.9	2.3
Industrial Countries	3.9	1.7	1.8	1.5	2.2
Latin America	2.8	2.7	-1.8	0.9	1.1
Africa	2.8	1.0	-1.1	-0.2	0.6
Middle East	4.5	1.9	1.1	0.8	2.1
South Asia	2.2	0.7	3.7	2.8	2.3
East Asia[a]	3.7	4.3	4.4	3.4	3.9

Source: Bosworth and Collins (2003)
[a] China is excluded.

sectors.

Whilst it is true that the ISI experiences during 1950-1980 period discriminated against exports, this is more the result of the methods of implementation of the ISI strategy, not the strategy itself. The ISI strategy has anti-export bias for primary products, not for manufactured exports because of the differences of income elasticities.

ISI Creates Rent-Seeking Activity

Krueger (1974) stressed rent-seeking as a negative by-product of the ISI experiences. According to this argument, economic resources were used to obtain valuable import-licenses which provides quota-rent to their owners. This kind of activity not only led to ineffective use of economic resources but also had a negative effect on income distribution.

However, Krueger's argument about rent-seeking is debatable. It is obvious that rent-seeking, or more generally corruption has a detrimental effect on long run economic growth (see for instance Mauro (1995), Keefer and Knack (1997, 2002)). What is not clear is that the ISI strategy necessarily leads to corruption. Why did some import-substituting countries such as those in Latin America and Africa suffer from corruption while some others, for instance some East Asian countries did not? As we note in Chapter 6, the relationship between corruption and economic growth includes many different factors, such as institutional environment, legal structure, ethnolinguistic fragmentation, religious and cultural affiliates, abundance of natural resources and so on. Therefore, explaining corruption as an inevitable result of the ISI stragey does not seem satisfactory.[8]

Export Orientation Brings Higher Productivity

Probably the most important criticism on the ISI strategy emphasises the positive effect of exports on economic growth and development. In other words, outward or export-oriented industrialisation is suggested as an alternative to and better development strategy than industrialisation via import-substitution. Since the beginning of the 1980s, economists have argued that exports increase the rate of growth by extending the market, improving the technology and increasing the

[8] In her seminal paper, Kureger (1974) gives Turkish economy as an example of rent-seeking as well as India. But, we can give a similar example from the same economy for the open trade policy period. During the 1980s, a considerable amount of tax allowances was given to exporters. This incentive was an important reason for the export success of Turkish economy in this period. However, many firms gained extra profits via imaginary exports. Yeldan (1996) indicates that these rent-seeking activities are an important reason for the deterioration of public finance during the late 1980s and early 1990s.

productivity (See for instance Balassa (1989), Falvey and Yu (2005)). This argument is based on the learning-by-exporting hypothesis, such that exporters of developing countries may increase productivity as a result of contact with their foreign counterparts. Second, export orientation stimulates innovation by reducing the internal slack in firms (X-efficiency), while the ISI strategy increases entrepreneurial slack in protecting import-competing sectors, (X-inefficiency) (Holmes and Schmitz Jr. (2001)). Third, in a world where trade barriers are substantial, exporters are more able to overcome with the trade impediments due to their ability to adopt new and more efficient technologies compared to protecting the import-competing sectors. The reason is again that exporters have strong incentives to cut managerial slack as pointed out by Falvey and Yu (2005).

Even though these arguments are strong, it seems that they are not conclusive. In particular, the key premise that foreign competition leads to X-efficiency is not clear. Indeed this premise contradicts the standard profit-maximising-firm assumption in economics. Even if we accept that protection of import-competing sectors increases X-inefficiency, by the same logic this raises the X-efficiency in exporting sectors as pointed out by Rodrik (1995). Moreover any economic policy encouraging exports must increase the slack in exporting firms. Similarly, if a world where trade impediments are significant leads exporters to be more efficient, then a world with free international trade must encourage entrepreneurial slack in exporters.

Therefore, there is no *a priori* reason to accept that exports induce superior technology and hence increase productivity due to the competition in foreign markets. Indeed, until recently the relationship between exports and productivity improvement has not been well understood in economic theory in spite of the substantial empirical literature which provides a positive correlation between these two.[9] These studies show that exporting firms and/or sectors are more productive, have better technology and are more capital intensive, yet they are generally silent concerning the exact mechanism and causality between exports and productivity. In this regard, Clerides et al. (1998) argue that it is highly likely that larger and more efficient firms become exporters due to the additional (sunk) costs of exporting. Using data on Colombia, Mexico and Morocco, these authors conclude that the association between exporting and productivity stems mainly from the self-selection of more-efficient firms into the export market rather than learning by exporting. Similarly, Bernard and Jensen (1999, 2004) provide evidence for U.S. plants and firms and Delgado et al. (2002) document evidence for Spanish sectoral levels in favour of self-selection hypothesis.

In sum, most of the criticisms against the ISI strategy concern the policy making process in developing countries, rather than the strategy per se. In this context, the outward or export orientated strategy has also paid little attention to difficulties related to the policy decisions and policy changing mechanisms in developing countries. Moreover, as indicated by Shapiro and Taylor (1990), import-substitution precedes production for exports. In spite of theoretical possibility, it is unlikely that a country will export every product at the same day it starts to produce. Thus, in reality there is always a lag between domestic production and exports. In our opinion, these two strategies are actually complementary, rather than being alternatives to each other.

[9] Nishimizu and Robinson (1984), Handoussa et al. (1986), Chen and Tang (1987), Aw and Hwang (1995), Tybout and Westbrook (1995), Aw et al. (2000) and Delgado et al. (2002) are few examples amongst others.

1.6 Summary and Overview

In this chapter, we have briefly reviewed the modern literature on the link between trade openness and economic growth. In light of this review, it is possible to highlight two important results as follows:

- We do not have a theoretical justification for the proposition that trade openness unambiguously leads to economic growth. Hence, this is basically an empirical issue.
- Previous empirical cross-country studies on the openness-growth connection are subject to methodological and econometric problems. In particular, they fail to provide a satisfactory measure for openness and generally ignore the model uncertainty problem.

In this dissertation we empirically investigate the relationship between trade openness and economic growth across countries over the period 1960-2000. The contributions of this dissertation are threefold: First, in contrast to previous studies, which mainly focus on the 1970-1990 period, this dissertation analyses the openness-growth link over a much longer time period. This enables us to account for both trade policy stance and growth dynamics in the long run. Second, we employ a myriad of openness measures suggested in the literature and so provide a wider picture to evaluate existing openness variables. Third, this dissertation handles the model uncertainty problem by employing model averaging techniques, instead of estimating and reporting a number of cross-country growth regressions.

This dissertation consists of seven chapters including this introduction. Chapter 2 reviews the previous empirical cross-country growth literature. Chapter 3 describes the general theoretical framework which constitutes the basis for most cross-country growth work. The model uncertainty problem and its possible solutions are also discussed in this chapter. Chapter 4 estimates the augmented neoclassical growth model suggested by Mankiw et al. (1992) for 1960-2000 in order to provide a benchmark model for investigating the relationship between long run economic growth and openness. Chapter 5 investigates the empirical relationship between openness and growth in a sample of countries employing a wide range of measures. Chapter 6 applies Bayesian model averaging technique to the cross-country data to take into account model uncertainty while investigating openness-growth link. Finally, Chapter 7 concludes.

Chapter 2

Trade Openness and Economic Growth: Assessment of Cross-Country Empirical Literature

2.1 Introduction

Even though economists have discussed the impact of trade openness on long run economic growth for a long time, there is not a complete consensus. This still continues now, especially after the contribution of Rodrik and Rodríguez (2000). There are several reasons for this: First, during the twentieth century, except its last two decades protectionist theories and policies were very popular in the majority of developing countries. Moreover, these theories and policies were in general supported by multilateral institutions such as IMF, WB and OECD and industrialised countries especially during the 1950s and the 1960s; Second, defining openness raises some conceptual and methodological problems. It is possible to say that the impact of trade openness on economic growth is assessed according to the debate on the merits of alternative trade regimes and this issue became increasingly confused through the late 1980s. In other words, what is meant by trade openness is not clear and some times the definition is very sensitive to the assumptions made by the authors. Some authors define openness in narrow terms including only export orientation without considering trade barriers on imports while others define the openness in broad terms encompassing the exchange rate and domestic policies as well as removing trade barriers on import and subsidies on exports. Third, lack of detailed and adequate data creates another source of disagreement. This is especially true for the broad cross-country econometric studies and led researchers to country case studies, particularly during the 1970s.[1]

The main objective of this chapter is to review the empirical literature on the relationship between trade openness and economic growth. Our review is focused on the cross-country work rather than the detailed country case studies. The main reason is that it is difficult to reach broad generalisations from the country case studies, although they provide valuable information on the relationship between trade policy and growth. In addition, it is possible to say that the main body of the literature on the openness-growth connection consists of the cross-country studies.

The organization of the chapter is as follows. Section 2 reviews the early cross-country growth studies carried out in the 1970s and the 1980s. Section 3 discusses the recent cross-country growth work. Finally, Section 4 summarises and concludes.

[1]See, for instance Little et al. (1970), Balassa (1971), Krueger (1978), Bhagwati (1978).

2.2 The Early Cross Country Comparisons

At the beginning of the 1970s, the relative benefits of outward oriented export-led and inward orientated import substitution strategies received much attention. A number of cross-country empirical studies tested the hypothesis that export oriented policies are better for economic growth. Almost all of these studies provided evidence that developing countries following export oriented policies experienced higher growth rates than the inward oriented countries.

The cross-country studies from the 1970s through the 1980s investigated the effect of exports on economic growth by using the neoclassical production function. The theoretical arguments behind the claim that exports promote growth were based on two different channels. The first is that exports increase the factor productivity in export oriented sectors due to the optimal resource allocation according to comparative advantage, greater capacity utilisation, economies of scale and an exploitation of superior technology (*direct effect*). Secondly, exports create positive externalities for non-export sectors by generating technological improvements and efficient management in response to foreign competition (*indirect effect*). Thus an increase in the volume of exports stimulates economic growth because of its direct and indirect effects.

In this framework, empirical studies employed the neoclassical production function and then included exports as a third input, with capital and labour in order to explain cross-country differences in rates of economic growth such that

$$Y_t = F(K_t, L_t, X_t) \tag{2.1}$$

where Y is level of output, K is capital stock, L is labour stock and

X is exports at time t (for simplicity the time subscript t is dropped). In this specification, X replaces the technology variable in the original neoclassical production function. In other words, technology is implicitly assumed to be a function of exports. It is very easy to rewrite this production function in terms of growth rates of variables by totally differentiating. Differentiation of equation (2.1) with respect to time, division by Y and rearrangement of terms yield

$$\frac{\dot{Y}}{Y} = (\frac{F_K K}{Y})(\dot{K}/K) + (\frac{F_L L}{Y})(\dot{L}/L) + (\frac{F_X X}{Y})(\dot{X}/X) \tag{2.2}$$

where a dot over the variables indicates a time derivative and F_K, F_L and F_X are the factor marginal products. Substituting $\alpha_K = (F_K K/Y)$, $\beta_K = (F_L L/Y)$ and $\gamma_X = (F_X X/Y)$ gives the basic growth equation for cross-country comparisons;

$$\frac{\dot{Y}}{Y} = \alpha_K(\dot{K}/K) + \beta_L(\dot{L}/L) + \gamma_X(\dot{X}/X) \tag{2.3}$$

where α_K, β_L and γ_X are the elasticity of output with respect to capital, labour and exports, respectively. Since the rate of growth of capital is not known for most countries, equation (2.3) can be written in terms of the investment-income ratio by replacing $\alpha_K(\dot{K}/K)$ by the $\dot{K}/Y$, as follows

$$\frac{\dot{Y}}{Y} = \lambda(I/Y) + \beta_L(\dot{L}/L) + \gamma_X(\dot{X}/X) \tag{2.4}$$

where λ is the marginal product of capital and I is the gross investment. The last equation is used in the early empirical research to examine the impact of exports on economic growth.

Using this framework, a highly influential paper by Balassa (1978) pooled data on ten semi-industrialised countries and concluded the following regression result (t-statistics in parentheses): [2]

$$(\dot{Y}/Y) = \underset{(3.33)}{0.15} + \underset{(2.40)}{0.23}K_F + \underset{(1.99)}{0.97}L + \underset{(3.57)}{0.04}X, R^2 = 0.77$$

where K_F is the average current account balance that represents investment-income ratio and X current dollar value of exports. In addition to this regression, Balassa (1978) reported two other regression results in which the current dollar value of exports is replaced by the purchasing power of exports and by the incremental export-GNP ratio, respectively. The results obtained in all three regressions show that exports contributed significantly to the rate of growth as well as explanatory power of estimated equations. Balassa (1978, p.188) used these findings to point out that "[e]xport growth favourably affects the rate of economic growth over the contribution of domestic and foreign capital and labour, the estimates presented in this paper provide evidence on the benefits of export-orientation as compared to polices oriented towards import substitution."

However, the sample size of Balassa (1978) is small for such strong claims. In addition, the sample includes high growth performers such

[2] During this period, another highly influential paper is the work by Michaely (1977) in which Spearman rank correlations between rate of export and growth rate of per capita GDP were used in order to investigate the impact of export expansion on growth performance. Since exports are part of the GDP, in order to remove autocorrelation between growth rates of exports and per capita GDP, Michaely (1977) employed the growth rate of the proportion of exports in GDP. Using the sample of 41 developing countries, he concluded that Spearman rank correlation coefficient is 0.38 and significant at 1 percent level for the 1951-1973 period. Moreover, Michaely (1997) indicates that the correlation coefficients are stronger for more developed countries while weaker or absent for less developed ones. Michaely (1977) assessed this result as evidence that higher exports growth yields higher economic growth, yet this happens if countries achieve some minimum level of development. After publishing the paper by Michaely (1977), many studies (for example Balassa (1978); Tyler (1981)) used Spearman rank correlation for testing the hypothesis of that export expansion yields the higher growth as well as the regression analysis. However, this approach has two important shortcomings. *First*, excluding the other determinants of economic growth yields biased results. *Second,* the causality between export growth and economic growth is not clear.

as Taiwan and South Korea and poor performers such as India and Chile. To meet these criticisms Tyler (1981) extended Balassa's (1978) study for 49 middle-income developing countries (six OPEC countries excluded) for the 1960-1977 period and confirmed his results.

Feder (1982) developed an alternative approach to assessing differential of factor productivities between exports and non-exports sectors. He assumes that economy consists of two distinct sectors such that one produces goods for the domestic market whilst the other produces exportable products. Instead of an aggregate production function, he expresses the two sectors's output as a function of capital and labour allocated to sectors at time t such that (again for simplicity time subscript t dropped)

$$N = F(K_N, L_N, X) \tag{2.5}$$

$$X = G(K_X, L_X) \tag{2.6}$$

where K_N and K_X are capital stocks, and L_N and L_X are labour stocks in non-exports and exports sectors, respectively, and X indicates the volume of export. As can be seen, output of the non-exports sector depends on the volume of exports as well as labour and capital. Assuming that the ratio of relative marginal productivities of capital and labour deviates from unity by a factor δ between exports and non-exports sectors, then the following equation is obtained

$$(G_K/F_K) = (G_L/F_L) = 1 + \delta \tag{2.7}$$

where the subscripts denote partial derivatives, i.e. F_K and G_K are the marginal productivities of capital and F_L and G_L are the marginal labour productivities in non-exports and export sectors, respectively. As can be seen, δ measures the productivity differential of capital and labour between two sectors. If $\delta = 0$, then there is no productivity differential between the sectors and capital and labour allocations are at an optimum. However, if productivity is higher in the exports sector due to reasons (the direct effect of export on growth) mentioned above, then $\delta > 0$. Differentiation of equations (2.5) and (2.6) gives

$$\dot{N} = F_K I_N + F_L \dot{L_N} + F_X \dot{X} \tag{2.8}$$

$$\dot{X} = G_K I_X + G_L \dot{L_X} \tag{2.9}$$

where I_N and I_X are sectoral gross investments, $\dot{L_i}$ is the sectoral change in labour stock ($i = N, X$) and F_X is the marginal productivity of exports in the non-export sector. Positive externalities of exports to non-export production are captured by F_X, i.e. the indirect effect of exports on growth. Since by definition, output level denoted by Y, is the sum of the production of two sectors, then it follows that

$$\dot{Y} = \dot{N} + \dot{X} \tag{2.10}$$

Defining total investment $I(\equiv I_N + I_X)$ and change in total labour stock $\dot{L}(\equiv \dot{L}_N + \dot{L}_X)$, and assuming that the marginal productivity of labour in a given sector is a linear function of output per labour (Y/L) in the economy such that $F_L = \alpha(Y/L)$ and $G_L = \beta(Y/L)$, where α and β are constants, then manipulating expressions in (2.8), (2.9) and (2.10) yields

$$\frac{\dot{Y}}{Y} = \mu(I/Y) + \beta(\dot{L}/L) + [(\delta/1+\delta) + F_X](\dot{X}/X)(X/Y) \tag{2.11}$$

where $\mu = F_K$. Equation (2.11) is the basis of Feder's (1982) empirical research. By using the sample of 31 semi-industrialised countries (SICs henceforth) over the 1963-1973 period, Feder (1982) estimates equation (2.11) and concludes that there are substantial differences in marginal factor productivities between export and non-export sectors and the export sector provides positive effects on productivity in other sector. Moreover, Feder (1982) decomposes the direct and indirect effects of exports on economic growth while adding the growth rate of exports as an additional variable into the equation (2.11)[3] and concludes that indirect or externality effect of exports is large. Therefore, Feder (1982) points out that even after the optimal resource allocation according to the comparative advantage, exports continue to stimulate economic growth due to the externality affect.

Following the study by Feder (1982), subsequent works employed either neoclassical production function approach expressed by equation (2.4) or Feder's equation (2.11) and formed a consensus in favour of export oriented trade polices (see Table 2.1). It is fair to say that the main objective of these studies was to increase the sample size in order to reach broader and stronger results. Not only did these studies employ larger sample of developing countries but also they divided their samples into low-income developing countries and middle-income developing countries. The rationale for this separation was to test the hypothesis of whether a minimum level of development is necessary in order to benefit export orientation. Moreover, many studies report

[3]In order to decompose higher factor productivity in exports sector, i.e. $\delta > 0$ and externality effect of exports, i.e. F_X, Feder (1982) assumed that exports affect the production of non-exports sector with constant elasticity such that

$$N = F(K_N, L_N, X) = X^{\theta}(K_N, L_N)$$

This implies that marginal productivity of exports in non-exports sectors is $F_X = \theta(N/X)$, where θ is a parameter. Then equation (2.11) can be rewritten as follows

$$\frac{\dot{Y}}{Y} = \mu(I/Y) + \beta(\dot{L}/L) + [(\delta/1+\delta) - \theta](\dot{X}/X)(X/Y) + \theta(\dot{X}/X)$$

cross-country regression results for pre-1973 and post-1973, to answer the question of whether export orientation yielded its theoretical benefits during the period of oil shocks of 1970s, when the world economic environment significantly deteriorated.[4]

[4]For instance, Ram (1987) using a large sample of 88 developing countries estimated both equations (3.4) and (3.11) separately for the period 1960-1982. His estimations were also based on the different samples namely low income and high income developing countries and on different time periods such as periods 1960-1972 and 1973-1982. Further Ram (1987) provided the time series estimations of individual countries over the 1960-1982 period. Both results of individual country estimates and those of cross-country regressions for different samples and time periods are consistent in the manner that exports have a positive impact on growth. The coefficients of exports variable in both model are positive and significant for the majority of countries over the period 1960-1982. Similar results are obtained from cross-country estimates for all samples and periods except for the sample of low income developing countries over the 1960-1972 period and the size of exports variable is higher in the period 1972-82.

Table 2.1: Summary of Early Cross-Country Studies

Study	Sample	Period	Dependent variable	Openness Measure	Methodology	Result
Michaely (1977)	41 DCs	1950-73	Per capita GNP growth	Growth of Exports ratio	Spearman Rank Correlations	Significant, +. Zero for low income DCs
Balassa (1978)	10 SICs	1960-73 1960-66 1966-73	GNP Growth	Exports, Growth of Exports ratio	OLS, Equation (2.4)	Significant, +.
Heller & Porter (1978)	41	1950-73	Nonexport-GNP growth	Growth of Exports ratio	Spearman Rank Correlations	Significant, +. Close to zero for low income DCs.
Tyler (1981)	41 DCs	1960-77	GDP Growth	Export Growth	OLS, Equation (2.4)	Significant, +.
Feder (1982)	31 SICs	1964-73	GDP Growth	Export Growth times Export ratio	OLS, Equation (2.11)	Significant, +.

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Table 2.1 – *Continued*

Kavoussi (1984)	73 DCs	1960-78	GNP Growth	Export Growth	OLS, Equation (2.4)	Significant, +.
Balassa (1985)	43 DCs	1973-79	GNP Growth	Export Growth	OLS, Equation (2.4)	Significant, +. Higher for post-1973 peirod
Rana (1988)	43 DCs	1966-73 1973-79	GNP Growth	Export Growth & Export growth times Export ratio	OLS, Equations (2.4) & (2.11)	Significant, +. Smaller for post-1973 period.
Jung & Marshall (1985)	37 DCs	1950-81	GNP growth	Export Growth	Granger Causality Test	Significant, + for 4 DCs. Casuality is significantly from output growth to export growth for 10 DCs.
Kohli & Singh (1989)	31 SICs	1960-70 1970-81	GDP Growth	Export growth times Export ratio	OLS, Equation (2.11)	Significant, + for 1960-70. Insignificant, + for 1970-81 period.

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Table 2.1 – *Continued*

Singer & Giray (1988)	52 & 51	1967-73 1977-83	GNP Growth	Export Growth	Spearman Rank Correlations	Significant, +. Weak for 1977-83 period.
Ram (1985)	73 DCs	1960-70 1970-77	GNP Growth	Export Growth	OLS, Equation (2.4)	Significant, +. Larger for 1960-77 period & for middle income DCs.
Kormendi & Meguire (1985)	47	1950-77	Per capita GDP growth	Per capita Export Growth	OLS, Cross-Country Growth Regression	Significant, +.
Ram (1987)	88 DCs	1960-82 1960-72 1973-82	GDP Growth	Export Growth & Export growth times Export ratio	OLS, Equations (2.4) & (2.11)	Significant, + except low income DCs for 1960-72 period. Higher for 1973-82 period.
Edwards (1989)	28	1960-82 1982	GDP Growth	Intervention index by Leamer (1988)	WLS, Endogenous growth model	Significant, -.

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Table 2.1 – *Continued*

Syrquin & Chenery (1989)	108	1960-70 1970-82	GDP Growth	Outward Orientation Index	Growth Accounting	On average +.
Esfahani (1991)	31 SICs	1960-73 1973-81 1980-86	GDP Growth, Export Growth, Import Growth	Export Growth	2SLS, Equation (2.11)	Significant, +. Once import included insignificant.

Note: DCs and SICs refer to developing countries and semi-industrialised countries, respectively. OLS, WLS and 2SLS denote ordinary least squares, weighted least squares and two stage least squares, respectively.

As pointed out by many authors (Taylor (1991)), Edwards (1989, 1993), Rodrik (1995), Pritchet (1996), Harrison (1996), Frankel and Romer (1999) are few examples) these studies have numerous theoretical and methodological drawbacks. We briefly, but systematically summarise these drawbacks as follows.

Definition of Trade Liberalisation

According to the literature during the 1970s and 1980s, trade "liberalisation" was defined as a narrow term including only "export promotion" or "outward orientation" without considering direct barriers on imports and other domestic polices (such as subsidy policy) that can affect international trade. The most important reason for this definition is that the impact of trade policy on economic growth was assessed according to relative superiority of two alternative strategies for economic growth namely, inward-looking import substitution growth on the one hand and outward-oriented export-led growth on the other. Since import substitution strategy had always been implemented with trade protection and most of the import substitution experiences had anti-export bias particularly through exchange rate policy, an outward oriented economy was considered as liberalised with regard to its trade regime.

Moreover, what is meant by outward orientation was not clear and became increasingly confused through the late 1980s. For instance, Krueger (1997) uses outward trade policy to mean open trade policy. Balassa (1989) defines this term as a policy regime that provides similar incentives to sell in both domestic and foreign markets. The World Bank (1987, p.78) defined outward orientation in a very similar way: "[A]n outward oriented strategy in which trade and industrial policies do not discriminate between production for the domestic market and exports, nor between purchases of domestic goods and foreign goods." According to this definition, one can easily claim that a country removing all trade barriers on imports, but introduces subsidies for exporters would not be classified as an outward oriented country since it discriminates in favour of exports against imports.

Theoretical Link between Trade Policy and Growth

Using a definition of trade liberalisation equivalent to export orientation, the early literature established a theoretical link between trade policy and growth mainly based on export side of international trade. Put differently, the early literature emphasised the role of exports compared to the importance of imports due to the dynamic effects of exports on growth such as economies of scale, learning by exporting and especially generating technological improvements. By the end of the 1970s, the argument of that physical capital formation is vital for economic growth was replaced by the idea of that technological change and productivity increases are key to growth. Since the beginning of the 1980s, many development economists argued that exports increase the rate of growth through the extending market, inducing technology and increasing productivity (see for example, Balassa (1989) and Krueger (1997)).

However, using theoretical framework of the early literature in order to argue that export expansion leads to higher economic growth is not conclusive. First, exploiting economies of scale and greater capacity utilisation are static effects of exports on economic growth. These effects run in a short period after the export expansion, yet do not provide higher steady state growth rates.[5] Second, there is no *a priori* reason for the belief that exports induce superior technology and hence increase productivity, as noted in Chapter 1. Similarly, the effect of exports on economic growth through physical capital accumulation is not clear. In other words, there is no clear answer of why export expansion leads to an investment boom theoretically.

It is obvious that firms can obtain or improve new technology and thus increase productivity through several sources. Pack and Page (1994) suggest seven different sources. These are importing of goods and services with embodying technology, foreign direct investment, purchasing licenses for domestic production or the use of new process, reverse engineering, obtaining knowledge from purchasers of exports, obtaining knowledge from nationals who were educated and/or worked abroad and finally R&D activities. As mentioned before, the early literature did not pay attention to the role of imports as much as that of exports. However, imports probably are more important than exports in obtaining knowledge and technology and hence in increasing productivity and economic growth. In this point, it is more likely that exports have an indirect effect through removing or easing foreign exchange constraints to finance imports.[6]

Moreover, the most important point is that the claim that exports or imports is good for growth is different from the claim that trade

[5]Export orientation does not necessarily require economies of scale. For instance, in Taiwan, suggested a good example for the success of export orientation by the early literature, the considerable part of manufactured products are produced and exported by a large number of small and medium size firms. According to Park (1990), in 1986, 98 percent of Taiwan's firms had less than 300 workers, and approximately half of these firms employed 5 or less employees.

[6]Esfahani (1991) points out that in many developing countries contribution of exports to GDP growth is a result of their role in increasing the supply of foreign exchange and hence imports due to the import rationing in most of these countries. Therefore, he emphasises the importance of distinguishing between foreign exchange shortage reducing and externality effects of outward oriented polices.

liberalisation brings higher growth. The latter is inconclusive and, as pointed out in the previous chapter (Section 1.4), theoretically the impact of trade liberalisation on economic growth is ambiguous.

Causality and Simultaneity between Export Orientation and Growth

As a natural result of definition of trade liberalisation in narrow terms and the inadequate theoretical link between growth and exports, the causal relationship between export orientation and economic performance is not clear. That is, whether countries grow faster as a result of higher export performance or countries export more because of faster growth remains an open question. Very few studies addressed this issue during the 1970s and 1980s. According to Jung and Marshall (1985), a reverse causality between exports and economic growth is possible as follows: learning and technological change which may be unrelated to any special export promoting incentives in a few industries may foster economic growth, even in the absence of export promoting incentives.[7] Given this rapid expansion in these industries, it is highly unlikely that domestic demand for these industries grows as much as production. This leads producers in these sectors to sell their goods in export markets. In this situation, causality occurs from economic growth to exports growth.[8] Employing Granger casuality test for 37 developing countries over the 1950-1981 period, Jung and Marshall (1985) provide statistical evidence in favour of export orientation yielding higher economic growth for only four countries namely Indonesia, Egypt, Costa Rica and Ecuador. Jung and Marshall (1985) suggest these results

[7]The booms in these industries my be related to the accumulation of human capital, cumulative production experience, foreign technology transfer through licensing or direct investment or physical capital accumulation.

[8]In addition, a negative correlation between economic growth and export growth is plausible since output expansion may increase domestic demand and thus a decrease in exports

cast some doubts on the previous evidence in favour of export orientation. Leamer (1994) claims that the Granger casuality test which Jung and Marshall (1985) employ is not an appropriate technique to make clear the casuality between exports and economic growth. However, this does not remove the importance of their question and arguments. Rather, as mentioned above, a reverse casuality from investment and productivity to exports is more likely.

Undoubtedly, when cross-country growth regression is specified in the form of equation (2.4) and/or equation (2.11), a simultaneity problem is clear due to the fact that exports are a component of GDP. This link is also possible between GDP and imports since countries whose income levels are higher may import more. For instance Frankel et al. (1996) indicate that a country may import more if the foreign consumption goods are superior than domestic ones. In addition, many developing countries import capital and intermediate goods in order to increase their physical capital accumulation. This implies that countries with higher income for reasons other than trade will import more. However, the degree of this problem is likely to be higher in the case of exports than of imports. Therefore, a positive association between GDP growth and the ratio of exports to GDP is almost inevitable. This point is heavily criticised by Taylor (1992, p.110-111): "[s]howing a positive regression coefficient of output growth on exports growth has become a thriving cottage industry in recent years ... [T]he results from regressing one trending variable on another are statistically significant but the rationale is hardly convincing."

It is well-known fact that, in the case of simultaneity problem between dependent variable and explanatory variable, the estimation of regression equation by ordinary least squares (OLS henceforth) produces inconsistent estimates of coefficients. Indeed, as we will discuss in the next chapters simultaneity is an important problem and in spite of many suggestions by econometric theory for solving this problem, a solution is not easy in the context of cross-country growth regressions.

Esfahani (1991) is the one of the few early cross-country works dealing with simultaneity problem. According to Esfahani (1991) the previous studies examining the relationship between growth and exports neglected the role of exports in providing foreign exchange for imported intermediate and capital goods, especially in semi-industrialised countries and put too much emphasis on the externality effects of exports. If exports reduce or eliminate the foreign exchange constraint for imports (i.e. import shortage), regressing growth of GDP on exports by OLS yields biased results due to the simultaneity problem. In order to overcome this problem and to differentiate the externality effect and import shortage reducing effect of exports, Esfahani (1991) adds intermediate goods, aggregating imported and domestically produced intermediates into the production functions of non-exports and exports sectors expressed in equations (2.5) and (2.6), respectively. Then, he specifies a second equation that relates exports growth to GDP growth. Esfahani (1991) also specifies a similar equation for import growth and estimates the three equation system of GDP, export and import growth by two stage least squares for the periods 1960-1973, 1973-1981, and 1980-1986 using a sample of 31 SICs with and without an import growth term. His estimation results show that when the import growth enters the regressions, the coefficient of the export variable loses its significance and even its sign becomes negative. Esfahani (1991, p.111) uses these results to point out that “[m]ost SICs have on average suffered from import ‘shortage’ and their exports have mainly provided foreign exchange relieving this input constraint." Moreover he concludes that this reducing import shortage effect is stronger for the period 1973-1981 than for the periods 1960-1973 and 1980-1986.

Measuring Trade Orientation

The assessment of early cross-country studies up to now shows that the ratio of export to GDP is not a good indicator of trade orientation, or more precisely openness to international trade. In spite of the importance of imports, almost no study employed the ratio of trade volume (exports plus imports) to GDP during the 1970s and 1980s. Even though the ratio of trade volume in GDP is not a perfect measure for openness, it is a better measure compared to the ratio of exports or the ratio of imports in GDP.

More importantly, very few studies attempted to use direct measures for trade policy in this period. For example Balassa (1985) constructs a trade orientation index defined in terms of deviations of actual from hypothetical values of per capita exports. He concludes that this variable significantly and positively effects economic growth. As can be seen, Balassa's trade orientation index is again based on export orientation.

Three measures of outward orientation or trade policy were developed through the 1980s and have been used by the recent round of cross-country studies in the next section. These are outward orientation index by the World Bank World Development Report (1987), trade intervention index by Leamer (1988) and trade orientation index by Syrquin and Chenery (1989).

World Bank World Development Report 1987(WBWDR87 hereafter) classifies 41 countries according to their trade orientation for the periods 1963-1972 and 1973-1985. The classification are based on four criteria namely effective rate of protection, direct trade controls such as quotas and import licensing schemes, export incentives and degree of exchange rate overvaluation. Then by using these criteria the report classifies countries as strongly outward, moderately outward, moderately inward and strongly inward.

Table 2.2 displays the WBWDR87 classification of developing countries according to the trade orientation. As can be seen, there are only three East Asian countries namely Hong Kong, South Korea and Singapore classified as strongly outward in both periods. On the other hand some countries changed their status over the periods 1963-1972 and 1973-1985. Countries such as Chile, Turkey, Uruguay shifted to more outward trade polices while others such as Sri Lanka and Tunisia moved in the opposite direction between two periods. Countries such as Argentina, Dominican Republic, Bangladesh, India, Ethiopia, Ghana and Zambia are strongly inward looking during the two periods. Although the report accepts some disagreements concerning two intermediate subgroups namely moderately outward and inward countries, it concludes that extreme cases are more conclusive. After this classification, WBWDR87 concludes that the macroeconomic performances of outward oriented countries are better than those of inward oriented ones simply comparing some specific indicators such as average annual growth rates of real GDP and of per capita GDP, gross domestic saving rate and so on.

As can be seen from Table 2.2, there is a strong positive association between growth rate of per capita GDP and outward orientation during both periods. For instance, three countries Singapore, Hong Kong and South Korea classified strongly outward have the highest

Table 2.2: Outward Orientation Index by World Bank World Development Report (1987)

country	1963-1973			1973-1985			1983-1985	
	Trade orientation	Exports ratio (%)	Growth†	Trade orientation	Exports ratio (%)	Growth†	Owti[a]	Owqi[b]
Argentina	SI	6.65	0.033	SI	7.98	-0.010	0.294	0.055
Bangladesh	SI	8.41	-0.024	SI	5.16	0.024	0.409	0.497
Bolivia	MI	na	0.009	SI	na	-0.007	0.129	0.042
Brazil	MO	7.03	0.056	MO	8.86	0.021	0.159	0.047
Burundi	SI	10.49	0.040	SI	11.23	-0.006	0.221	0.006
Cameroon	MO	22.36	-0.006	MI	27.06	0.046	0.261	0.143
Chile	SI	13.37	0.017	MO	21.85	0.003	0.213	0.098
Colombia	MO	12.93	0.030	MI	14.35	0.016	0.310	0.520
Costa Rica	MO	26.82	0.029	MI	32.73	-0.001	0.157	0.703
Cote d'Ivoire	MO	35.82	0.034	MI	39.18	-0.008	na	na
Dominican Republic	SI	18.58	0.027	SI	21.42	0.019	na	na
El Salvador	MI	25.74	0.019	MI	29.89	-0.016	0.133	0.043
Ethiopia	SI	na	0.016	SI	9.65	-0.020	0.200	0.174
Ghana	SI	19.05	0.037	SI	11.21	-0.018	0.330	0.200
Guatemala	MO	17.44	0.029	MI	18.91	0.006	0.084	0.823
Honduras	MI	27.86	0.025	MI	30.99	0.006	na	na
Hong Kong	SO	82.16	0.072	SO	91.15	0.050	0.000	0.001
India	SI	4.02	0.012	SI	5.92	0.023	1.319	0.888
Indonesia	MO	12.71	0.035	MI	26.18	0.047	0.137	0.101
Israel	MO	25.18	0.047	MO	39.87	0.010	na	na
Kenya	MI	29.92	0.030	MI	28.37	0.002	0.275	0.203
Korea, Republic of	SO	12.57	0.068	SO	30.03	0.057	0.137	0.100
Madagascar	MI	15.64	0.003	SI	13.93	-0.018	0.255	0.007
Malaysia	MO	39.81	0.038	MO	49.54	0.039	0.087	0.045
Mexico	MI	7.67	0.037	MI	11.73	0.018	0.082	0.064
Nicaragua	MI	28.02	0.013	MI	26.15	-0.021	0.148	0.684
Nigeria	MI	10.71	0.011	SI	19.98	-0.012	0.447	0.016
Pakistan	SI	9.60	0.042	MI	11.24	0.029	0.411	0.075
Peru	SI	16.58	0.027	SI	17.88	-0.011	0.409	0.370
Philippines	MI	18.10	0.022	MI	22.38	0.002	0.221	0.467
Senegal	MI	23.15	-0.013	MI	33.07	0.001	0.189	0.049
Singapore	SO	na	0.073	SO	na	0.052	0.016	0.005
Sri Lanka	SI	29.76	0.018	MI	29.33	0.028	0.280	0.080
Sudan	SI	15.41	-0.015	SI	10.24	0.004	0.331	0.075
Tanzania	SI	na	0.045	SI	na	0.004	0.172	0.284
Thailand	MO	16.63	0.048	MO	21.33	0.041	0.294	0.055
Tunisia	MI	21.66	0.043	MO	33.77	0.032	0.218	0.543
Turkey	SI	4.78	0.027	MO	7.78	0.018	0.133	0.872
Uruguay	SI	13.90	0.008	MO	18.49	0.002	0.207	0.030
Yugoslavia	MI	na	na	MI	na	na	0.091	0.370
Zambia	SI	51.42	0.008	SI	38.45	-0.020	0.183	0.000

Note: SO is strongly outward orientation; MI is moderately outward orientation; SI is strongly inward orientation; MI is moderately inward orientation.

†: Annual growth rate of per capita GDP. *Source*: Heston, Summers and Aten (2002)

[a] Own-import weighted tariff rates on intermediate inputs and capital goods. *Source*: Barro and Lee (1994a)

[b] Own-import weighted non-tariff frequency on intermediate inputs and capital goods. *Source*: Barro and Lee (1994a)

growth recorded amongst the countries. However, WBWDR78 does not provide a clear data source concerning the classification criteria namely effective rate of protection, direct controls and export incentives. Instead report only indicates that data source for classification is the World Bank database and the background paper by Greenaway.[9] With the consideration of the difficulties about comparable and reliable data sources particularly for direct trade controls across countries, this implies that report classification is mainly based on subjective information rather than objective measures. Therefore, report classification includes some inconsistencies: Firstly, defining South Korea as strongly outward especially for the period 1963-1972 does not seem plausible.[10] The last two columns in Table 2.2 present the own-import weighted tariff rates and non-tariff frequency ratios for the period 1983-1985, respectively. When the countries are ranked according to these two measures in a descending way, South Korea takes a place as 13th country for the import tariff, 22nd country for the non-tariff barriers. Countries such as Malaysia, El Salvador and Bolivia are considered less outward oriented than Korea even though both tariff rates and non-tariff barriers of these countries have lower than those of South Korea (*Note* that the export ratio in Malaysia is also higher than that ratio in South Korea in both periods). The same thing is true for Indonesia, which is classified as less outward than South Korea although the exports ratio and trade policy measures of both countries are almost equal to each other during the two periods. Similarly, Turkey and Tunisia whose non-

[9] See, Greenaway and Nam (1988).

[10] World Bank World Development Report (1987, p.82) defines a country as strongly outward oriented in which "[T]rade controls are either nonexistent or very low in the sense that any disincentives to export resulting from import barriers are more or less counterbalanced by export incentives. There is little or no use of direct controls and licensing arrangements, and the exchange rate is maintained so that the effective exchange rates for importables and exportables are roughly equal."

tariff coverage ratios are considerably higher classified as moderately outward in 1973-1985 period. On the other hand Zambia with a relatively low tariff rate and zero non-tariff frequency as well as relatively higher export ratios is defined as strongly inward in both periods.

Leamer (1988), using three digit SITC data (for 183 commodities), estimated net exports and trade intensity ratios for 53 countries. His estimation is based on a multi-product Hecksher-Ohlin model. The difference between the actual and predicted intensity ratios is defined as a openness measure by Leamer (1988). This measure of openness takes into account only trade restricting policies and thus the greater the difference between actual and predicted values implies the less intervention or more openness to trade. Yet, due to the trade promoting policies, Leamer (1988) develops another measure based on the extent of trade distortion by the policy. These measures have many desirable features. The latter takes into account all kind of trade distortions and both are objective measures that evaluate countries' trade policy stance. However, as pointed out by Leamer (1988) the most important shortcoming is that predicted trade intensity ratios are estimated in the absence of actual trade barriers. Leamer (1988) also only calculated these measures for 1982. Edwards (1989) is the first author who used Leamer's openness and intervention measures.

A final trade orientation or openness measure is trade orientation index of Syrquin and Chenery (1989, SCOUT hereafter). Syrquin and Chenery (1989) firstly classify countries as large or small according to their population in 1965. They then divide them into two groups based on the predominance of primary or manufactured goods in their exports. Subtracting the predicted difference between shares of primary and manufactured exports in the total merchandise exports from the actual shares, Syrquin and Chenery (1989) conclude a trade orientation index:

$$SCOUT = (X_P - X_M) - (\hat{X}_P - \hat{X}_M) \tag{2.12}$$

where X_P and X_M, the share of primary and manufactured exports in the total merchandise exports, respectively. $\hat{X}_P$ and $\hat{X}_M$ are the predicted values. Primary and manufactured exports are estimated in the framework of separate regressions based on country size (small and large) and period (pre- and post-1973) over the period 1965-1980 by Syrquin and Chenery (1989). Countries with positive values of SCOUT classified as primary oriented while those with negative values of SCOUT as manufacturing oriented. In the second step, Syrquin and Chenery (1989) classify countries according to their actual share of merchandise exports in GDP relative to the predicted share for 1965 and 1980, again in the framework of separate regressions by size and period. A country with a relatively high export level is considered as outward oriented while a country with a relatively low level export is assessed as inward oriented. In the final step, combining these two classifications, the authors define countries according to four categories namely primary outward oriented, primary inward oriented, manufactured outward oriented and manufactured inward oriented. Obviously, even though the relative export level is influenced by trade polices, this trade orientation index is not solely based on trade policy measures since export level is predicted by country size and time period. However, an important advantage of this classification with respect to WBWDR87 is that SCOUT takes into account initial conditions and country differences in terms of size. In addition it allows to construct a dummy variable over the period 1965-1980 for the cross-country comparisons.

Heterogeneity among Countries

Another important issue in the early cross-country growth works is the heterogeneity of countries. This is particularly important for policy evaluation. Consider the cross-country growth regression in equations (2.4) or (2.11). Obviously, early cross-country works assumes that countries are homogeneous in terms of regression parameters. However, it is very difficult to accept this assumption. Put differently, almost all early works concludes that export expansion brings higher economic growth. However, interpreting regression results such that effects of exports growth are exactly the same for Korea and Turkey or Argentina seems very unrealistic.

Heterogeneity among countries is another important difficulty in any cross-country growth study and dealing with this problem is not easy. Early studies generally divide their sample into two sub samples as low income and middle or high income developing countries. Yet, the main motivation for this separation is to answer whether a minimum level of development is necessary for the benefiting from export expansion. In other words, the concern about heterogeneity among countries is not very clear. Moreover, criteria for classification of countries is not satisfactory. As pointed out by Edwards (1993) in many studies, a country with a per capita income of US $ 360 (in 1978 values) or less was defined as a low income developing country. After this arbitrary classification the early literature estimated cross-country growth regression for two samples and then just compared the parameters. No study attempted to employ formal econometric tests of parameter stability. At a very simple level, there are many remaining questions. Is the impact of export orientation on economic growth the same for different regions? For small or large countries? For countries that are landlocked? The early literature is completely silent on these questions. Obviously, these questions are closely related to another important drawback concerning the model selection.

Model Selection

As mentioned before, most early cross-country studies worked on a linearised neoclassical production function. However, as has long been recognised in the literature, the results of such growth models are highly likely to suffer from omitted variables. At a very simple level, no study considered the initial (income) conditions in spite of the well-known convergence prediction of the neoclassical growth model.

As will be shown in Chapter 3, probably the most important problem in cross-country growth regressions is identifying a model which represent the true production function across countries, at least on average. This is particularly important if policy implications are to be drawn from the results of cross-country growth regressions. If there are other variables which are important for economic growth, then the problem of omitted variable bias may be large. More importantly, if other variables are interacted with the openness variable, a cross-country growth regression including only the openness variable as well as capital and labour yields misleading results.

2.3 The Recent Cross-Country Work

Since the late 1980s the impact of trade liberalisation on economic growth has generated renewed interest. There are two important reasons for this. First, the new endogenous growth theories pay much more attention to international trade and provide some analytical links between trade policy and economic growth. Second, the 1980s witnessed a considerable number of liberalisation reforms in most developing countries, which has continued up to present. An important result of this liberalisation period is that economists have the opportunity to compare pre-liberalisation period with post-liberalisation period.

Almost all studies in this period concluded a strong positive relationship between trade openness and economic growth. The outstanding feature of these studies is that they employ new openness measures directly addressing trade policy and trade orientation. Moreover, these studies substantially benefit from the contributions of Barro (1991) and Mankiw et al (1992) to cross-country growth empirics. Thus, accounting for important growth determinants researchers tested to openness-growth link properly. For instance employing an openness measure based on international price deviations, Dollar (1992) concludes that openness is positively associated with economic growth. Edwards (1992, 1998) provides strong evidence supporting that more open countries grow faster. In his later study, out of nine alternative openness and trade intervention measures, eight are found to be significant with the expected signs.[11] Ben-David (1993) finds absolute convergence in per capita income in a sample of open countries whilst closed countries do not tend to converge. Bend-David (1996) also shows that countries tend to converge to income level of their trading partners and hence undertaking to trade, poor countries catch up their richer trading partners. Lee (1993), constructing a composite indicator on the basis of "free trade openness" (which is equal to import share in the absence of trade barriers) shows that the import-weighted tariff rate

[11] The list of openness measures employed by Edwards (1998): The Sachs and Warner (1995) openness dummy, The World Development Report (1987) Outward Orientation Index, Leamer's (1988) openness index, average black market premium, average import tariff on manufacturing, average coverage of non tariff barriers, The Heritage Foundation index of distortions in international trade, collected trade taxes ratio and, Wolf's (1993) index of import distortions.

and the black market premium are harmful for economic growth. Introducing a new openness measure, perhaps the most influential paper by Sachs and Warner (1995) concludes a large positive effect of openness on growth. These authors also confirm Ben-David's (1993) result such that open countries tend to converge whilst closed ones do not. Harrison (1996) shows that various openness measures are significantly correlated with economic growth when a fixed effects growth model is estimated using panel data. Vamvakidis (1999) obtains a similar result between openness and investment in fixed effects growth regressions. Another influential study is Frankel and Romer (1999). Using geographic component of trade as an instrument, Frankel and Romer (1999) show that the international trade and per capita income (hence economic growth) is strongly and positively associated and argue that the casuality for this association runs from trade to income level.

Amongst the recent cross-country studies, four papers deserve special emphasis and hence we detail them in what follows:

Dollar (1992)

An important feature of this study is that Dollar (1992) developed a measure of outward orientation of economy based on two separate indices namely real exchange rate distortion and real exchange rate variability.

Dollar (1992) uses data of international relative price levels prepared by Summers and Heston (1988) in order to construct his outward orientation measure. The Summers- Heston data include relative price levels of the same consumption goods in different countries. By using the United States as the benchmark country, Summers and Heston (1988) define the index of relative price level (RPL) for country i as follows

$$RPL_i = 100 \times eP_i/P_{US} \tag{2.13}$$

Where e is the exchange rate defined as dollars per unit of domestic currency and P_i is the consumption price index for country i. As noted by Dollar (1992), the expression in (2.13) is very similar to usual real exchange rate formulation. In the case of free international trade, *law of one price* were held for all internationally traded goods and the measure in expression (2.13) would be 100 for each country. In this framework, cross country variation of these price levels could be used as a measure of inward or outward orientation induced by trade policy. However, because of existence of non-tradable goods and of their different prices across countries, this measure will not be equal to 100 even in the case of free international trade. To overcome this difficulty, Dollar (1992) suggests regressing price levels on country factor endowments due to the fact that if factor prices are not equalised, prices of non-tradables differ across countries according to their relative factor endowments. Then, the actual price level divided by this predicted price level is defined as an index of real exchange rate distortion and average value of this index over ten years (1976-1985 period) is used to remove short-term fluctuations.[12] In addition, Dollar (1992) develops a measure of variability of real exchange rate, simply coefficient of variation of each country's distortion index during the same period and indicates that Asian countries have low variability while the Latin American countries

[12]Dollar (1992) uses real per capita GDP as a proxy of factor endowment and population density as a rough measure of land availability compared to labour force. In order to estimate the relationship between price level and factor endowments, different regression equations are estimated by Dollar (1992). Assuming that regression of RPL on the level and square of real per capita GDP as well as regional dummies for Latin America and Africa and year dummies reflects the true relationship between price level and endowments, Dollar (1992) concludes that Africa is extremely and Latin America mildly inward oriented while Asia is moderately outward oriented.

show considerably higher variability.

By using these indices, Dollar (1992) concludes that his outward orientation measure is highly correlated with per capita GDP growth in a large sample of 95 countries for the period 1976-1985 and suggests liberal trade policies for better economic performance. The following view belongs to Dollar (1992, p.540): "[T]hese results strongly imply that trade liberalisation, devaluation of the real exchange rate, and maintenance of a stable real exchange rate could dramatically improve growth performance in many poor countries."

However, Dollar's (1992) study is criticised by Rodrik and Rodríguez (2000) in many aspects. First, even if the law of one price always holds, the impact of equivalent taxes on import and export on relative price level will be different. As can be easily seen from equation (2.13) an import tax will raise domestic prices of import competing goods relative to world prices and so, RPL_i will increase. On the other hand, an equivalent export tax will decrease RPL_i since domestic price of exportable goods declines compared to world prices. In this case, the country is assessed as an outward oriented by Dollar (1992). That is why, Dollar's distortion index is affected by the different kinds of trade restrictions and it fails in the case of trade restriction on exports (both tax and subsidy). Second, the assumption that law of one price is always held in the case of free trade has some practical flaws. Dollar's time horizon (1976-1985 period) may not be enough to eliminate deviations unrelated to trade barriers from the law of one price and it is possible to consider the cross country differences in price levels as a result of monetary and exchange rate polices instead of trade restrictions. Finally, Dollar's (1992) growth regression excludes other important determinants of growth.

Levine and Renelt (1992)

The most important characteristic of this study is that Levine and Renelt (1992) directly address the model uncertainty problem in the cross-country growth studies. For this purpose, the authors employ a variant of Leamer's (1983) extreme bounds analysis in order to test the robustness of coefficient estimates for a wide range of policy indicators to alterations in the other explanatory variables. Using the various measures of trade openness, Levine and Renelt (1992) conclude no robust relation between openness and long run economic growth. They also carry out the same analysis for the investment rate and show that the only trade share is robustly and positively associated with investment rate. Levine and Renelt (1992) evaluate this result as evidence that openness affects economic growth by stimulating capital accumulation rather than via the productivity channel.[13]

Sachs and Warner (1995)

Undoubtedly, among the recent cross-country growth studies, the most influential work is the paper by Sachs and Warner (1995). Their methodology is different from the previous studies in two aspects: First, they construct a single openness measure covering all major kind of trade restrictions; Second, they examine growth performance within the subset of open economies as well as within open and closed economies. Sachs and Warner (1995) define a country as closed trade policy if it has at least one of the following criteria for the 1970-1989 period:[14]

[13]The study by Levine and Renelt (1992) and the extreme bound analysis are detailed in Chapter 3.

[14]According to Sachs and Warner (1995, p.25-26), these five criteria are chosen in order to take into account all of major types of trade restrictions: "[T]ariffs and non-tariff barriers (mainly quotas) are most obvious. The black market premium (BMP) is a measure

- Non-tariff barriers (NTBs) covering 40 percent or more
- Average tariff rates is 40 percent of total exports or higher
- Black market premium for exchange rate exceed 20 percent, on average, during the 1970s and the 1980s
- A socialist country
- A state monopoly on major exports.

Their openness measure is defined as a dummy variable such that a value of zero indicates a closed economy while the value of one is for an open economy. In order to test the proposition that openness improves growth performance, Sachs and Warner (1995) estimate various growth regressions and conclude that their openness measure gives a high and statistically significant result in each regression.[15]

In summary, Sachs and Warner (1995) argue that their regression results provide strong evidence that protectionist trade policies directly have a negative impact on overall growth performance and indirectly affect the rate of accumulation of physical capital. The Sachs-Warner openness measure has been used in many subsequent cross-country

of exchange control: a large BMP is evidence of the rationing of foreign exchange, which tends to be a form of import control. The socialist classification is used as an indicator to cover countries like Poland and Hungary, which relied on central planning rather than overt trade policies (for example, tariffs) to maintain a closed economy. Exports controls are symmetrical with import controls in their effects on closing an economy, as A.P. Lerner first established. The sub-Saharan African countries relied extensively on export monopolies on foodstuffs, in part to maintain low domestic prices of food for urban areas."

[15]Especially, the regression result, in which average income growth is regressed on initial level of income, investment rate, primary and secondary school enrolment rates, government consumption spending as well as openness measure indicates that the open economies grow, on average by 2.45 percentage points more than closed ones. In addition, Sachs and Warner (1995), conduct another growth regression including a composite dummy variable representing extreme political conditions as well as the other explanatory variables mentioned above. The regression result indicates that the variable related to political conditions is statistically significant at 10 percent level and suggests that property rights, safety from violence and freedom are additional important determinants for higher growth.

growth studies. For instance Edwards (1998), Wacziarg (2001), Greenaway et al. (2002) using this measure as well as other openness indicators, they all find a positive relationship between openness and growth. Moreover, Sachs-Warner openness variable is found to be one of the robust growth determinants in the studies taking into account model uncertainty and/or model selection problem (such as Sala-i-Martin (1997a), Sala-i-Martin et al. (2004), Hoover and Perez (2004), and Hendry and Krolzig (2004)). Finally, Wacziarg and Welch (2003) update and extend the Sachs-Warner openness dummy over the 1990-2000 period. These authors conclude that this variable is no longer significant in the 1990s. However, they investigate the time paths of growth within countries over the 1950-1998 period and conclude that after the trade liberalisation countries experienced, on average, increases in their annual growth rates by 1.5 percentage points compared to pre-liberalisation period. However, this result is questionable since Wacziarg and Welch (2003) attribute all growth accelerations to trade liberalisation ignoring the fact that other factors may also stimulate economic growth. In addition, many trade liberalisation efforts are accompanied by other macroeconomic policy changes, such as IMF structural reforms or the World Bank Structural Adjustment Loans (SAL) programs. Since these reforms are generally launched after economic recessions, whether data evidence by Wacziarg and Welch (2003) reflects the long run relationship between trade openness and economic growth or business cycle effect remains unanswered. For instance, using a dynamic panel framework and three different openness indicators, including the Sachs-Warner openness measure Greenaway, Morgan and Wright (1998, 2002), conclude that the positive effect of liberalisation on output level is lagged and relatively modest. The authors find a J

curve response such that output first decreases and then increases.

On the other hand, the Sachs-Warner openness measure is strongly criticised by Harrison and Hanson (1999) and Rodrik and Rodríguez (2000). Using the components of the Sachs-Warner openness measure separately, Harrison and Hanson (1999) replicate the Sachs-Warner analysis. They find that the effects of tariffs and non-tariff barriers on economic growth are small and statistically insignificant. The authors show that the significance of the Sachs-Warner openness measure is driven by other factors which are not directly related to trade policy, namely socialist country dummy and the black market premium. Rodrik and Rodríguez (2000) find a similar result. In order to highlight which components explain the strength of the Sachs-Warner openness measure, Rodrik and Rodríguez (2000) reconstruct the openness dummy according to only the criteria on socialist country dummy, tariffs and non-tariff barriers and conclude that the Sachs and Warner openness dummy is insignificant when this variable is used in the growth regressions. However, the authors show that the Sachs-Warner openness measure is strongly significant when they employ the openness dummy based only on the information relating to the black market premium and state monopoly of major exports. Rodrik and Rodríguez (2000) argue that the export monopoly component of the Sachs-Warner openness variable acts like a sub-Saharan Africa dummy since the Sachs-Warner analysis is based on the World Bank (1994) study including only 29 African economies which were subject to structural adjustment programs during the period 1987-1991. This leads to two important shortcomings about sample selection in Sachs-Warner's variable and so causes biased regression results: First non-African economies with state monopoly on major exports (e.g. Indonesia) and second, the other African countries which were not under structural adjustment programs from 1987 to 1991 (e.g. Mauritius) are neglected. Therefore, it may be concluded that the criterion on a state monopoly on major exports, one of the most important sources of explanatory power of Sachs and Warner's (1995) openness dummy is not a good measure for trade policy and can cause biased regression results. In addition, Rodrik and Rodríguez (2000) indicate that the existence of large black market premium is as a result of policy failures and bad macroeconomic conditions. Since these conditions are associated with poor growth performance, this component has a considerable effect in the explanatory power of growth regression. However, the authors claim that it is more reasonable to accept that the black market premium is a good measure for macroeconomic imbalances rather than trade policy.

Frankel and Romer (1999)

Emphasising the simultaneity problem between trade and income in cross-country growth regressions, Frankel and Romer (1999) directly question whether trade causes growth. The authors argue that countries' geographic characteristics are a powerful determinant of bilateral trade. Thus, assuming countries' geographic characteristics are not affected by their income or by government polices and other factors that influence income, Frankel and Romer (1999) offer an IV for actual trade to GDP ratios on the basis of predicted trade shares from a gravity model for bilateral trade in order to overcome the simultaneity problem between income and trade.

They first estimate a bilateral trade equation and then aggregate the fitted values for each country to estimate a geographic component of countries' overall trade as an IV. Therefore, different from the conventional gravity equations for bilateral trade, their trade model includes only geographic characteristics: countries's size (measured by area and population), their distances from another, whether they share a common border, and whether they are landlocked. More formally, Frankel and Romer (1999) estimate the following gravity equation:

$$\begin{aligned}\pi_{ij} = log(T_{ij}/GDP_i) = {} & a_0 + a_1 log(D_{ij}) + a_2 log(N_i) + a_3 log(A_i) \\ & + a_4 log(N_i) + a_5 log(A_i) + a_6(L_i + L_j) \\ & + a_7 B_{ij} + a_8 B_{ij} log(D_{ij}) + a_9 B_{ij} log(N_i) \\ & + a_{10} B_{ij} log(A_i) + a_{11} B_{ij} log(N_j) \\ & + a_{12} B_{ij} log(A_j) + a_{13} B_{ij}(L_i + L_j)\end{aligned} \tag{2.14}$$

where T_{ij} is bilateral trade between countries i and j, D_{ij} is distance between them, N is population, A is area, L is a dummy for landlocked countries, and B is a dummy for a common border between two countries. Frankel and Romer (1999) construct the IV for country i by aggregating the predicted values of country i's trade with country j, $\hat{\pi}_{ij}$ which is obtained from the equation (2.14) as follows

$$\hat{T}_i = \sum_{j \neq i} e^{\hat{\pi}_{ij}} \tag{2.15}$$

Assuming income level as a function of both domestic and international trade, Frankel and Romer (1999) regress per capita GDP on international trade and within country trade (which is measured by country size). Both OLS and IV estimates show that coefficient of trade share is positive and statistically significant. The outstanding finding is that the coefficient of openness in IV estimates in which trade share is treated endogenous and hence predicted trade share is used as an instrument is found to be higher than it is in the OLS estimates. In light of these findings, Frankel and Romer (1999) argue that simultaneity is not a serious problem in appraising the effect of openness on growth as many have thought and international trade raises the income level and thus economic growth.

However, geographical component of international trade is correlated not only with trade but also independently with economic growth since geography affects income level directly and through other channels than just trade. Therefore, the positive effect of the Frankel-Romer predicted trade share on economic growth might not be a result of international trade per se. Rodrik and Rodríguez (2000) show that the result by Frankel and Romer (1999) disappears once geographical variables such as absolute latitude and fraction of land area in tropics are included into regression. Irwin and Terviö (2002) extend the Frankel-Romer analysis throughout the 20th century and confirm their result. However, this result is not again robust to inclusion of absolute latitude.

Ongoing Debate on Primacy of Institutions, Geography and Openness

As mentioned before, one important criticism of Rodrik and Rodríguez (2000) is that empirical studies investigate the openness-growth connection in the framework of simple growth model ignoring other important growth determinants. Therefore, the recent empirical research has turned to examining the relationship between openness and growth accounting institutions and geography. More clearly, applying "kitchen sink" exercises, these studies carry out a "horse race" among geographical, institutional and trade-related determinants of economic growth. Generally they estimate the variants of following the kitchen sink regression model:

$$log(GDP\ per\ capita)_i = \pi_0 + \pi_1 Openness_i + \pi_2 Institutions_i + \pi_3 Geography_i + \pi_4 Other\ Controls_i + \varepsilon_i \quad (2.16)$$

As can be seen, the dependent variable in this regression is the level of per capita GDP rather than growth rate. This is based on the assumption that initial income levels were very similar across countries in the distant past and thus the current cross-country income differences have been a result of different growth performances over the very long run. Therefore, it may be possible to capture the long-run growth determinants from the specification in (2.16).[16] The other important point is that it is very difficult to attribute this specification to reflect the true casual relationship between income and institutions or trade since except geography both trade and institutions are endogenous. In order to overcome this problem, a two stage least squares (2SLS) estimation procedure on the basis of first stage regressions in which institutions and trade are regressed on all other exogenous variables is employed in these studies. They generally use settler mortality rate in the countries colonized by Europeans suggested by Acemoglu et al (2001) and Frankel and Romer (1999) predicted trade share as IV for the present institutions and international trade, respectively.

In this regard, Easterly and Levine (2003) estimate the income level regressions in (2.16) employing various measures of endowments of tropics, germs and crops, institutions and macroeconomic policies.

[16] Obviously this approach implicitly assumes that countries are currently in and/or very close to their steady-states.

They measure macroeconomic policies by three indicators namely fraction of open years based on Sachs and Warner (1995), Dollar's (1992) real exchange rate distortion index, and inflation rate. Easterly and Levine (2003) conclude that institutions have a strong influence on economic development. However, their findings indicate that geography affects development through institutions. In other words, geography does not have an independent and direct effect on development. Similarly, macroeconomic polices do not have any effect on development once institutions are controlled.

Alcalá and Ciccone (2004) argue that international trade is a significant and robust determinant of aggregate productivity when country size, geography and institutional quality are taken into account. The key insight of this study, these authors measure openness by which they refer to as "real openness." According to Alcalá and Ciccone (2004), the traditional measure of openness as the ratio of imports plus exports in current prices to GDP in current prices may be a misleading variable for reflecting openness. The reason is that productivity increases due to international trade are greater in the tradable sector than those in nontradable sector (Balassa-Samuelson hypothesis). Assuming demand for nontradables is relatively price inelastic this leads to a rise in the relative price of nontradbales and hence a decrease in standard measure of openness which Alcalá and Ciccone (2004) call as "current openness." In order to overcome this drawback, these authors suggest real openness as an alternative way for measuring openness: Real openness is defined exports plus imports in US dollar relative to GDP in purchasing power parity (PPP) US dollar. Alcalá and Ciccone (2004) argue that real openness is a better measure of openness with respect to current openness in the presence of trade driven productivity gains. However, Rodrik et al. (2004) put forwards some conceptual and empirical problems about this measure.

Giving less emphasis on geography, Dollar and Kraay (2003a,b) examine the interaction amongst the growth, institutions and trade. These authors find that in the second stage regression the significance of both trade and institutions coefficients disappear when they instrument for both trade and institutions using the instruments suggested by the literature and once outlying countries are dropped.[17] The reason is that instruments for trade and institutions themselves are highly correlated and both sets of instruments have strong explanatory power on both endogenous variables. Thus, their main argument is that disentangling the partial effects of institutions and trade on growth in the long run is subject to a serious identification problem. In order to overcome this problem, adapting the approach of Caselli et al. (1996) and using appropriate lags of the endogenous variables as instruments, Dollar and Kraay (2003a) estimate the regressions of changes in decadal growth rates on instrumented changes in trade and changes in institutional quality and conclude a strong effect of trade and a small impact of institutions on economic growth. Dollar and Kraay (2003a) assess these results as evidence of important joint role of both trade and institutions in the long run, but relatively larger role for trade over the short run.

Rodrik, Subramanian and Trebbi (2004) estimate equation (2.16) in order to highlight the respective contributions of institutions, geography and trade in determining income level by using settler mortality rate and Frankel-Romer predicted trade shares as instruments for institutions and trade, respectively. Their main finding is that trade has

[17] These authors construct Frankel-Romer predicted trade shares using a gravity model where bilateral trade as a fraction of GDP at PPP rather than current prices is regressed. Therefore, their instrument for openness is identical to real openness once the geographical characteristics of the countries are controlled.

no direct effect on income while geography at best weak direct effects, once institutions are controlled. According to their regression results, international trade is often found to be insignificant with a negative coefficient estimate, whereas geography variable (absolute latitude) enters the regressions with an insignificantly positive coefficient. Moreover, the authors carry out some robustness checks on the side of trade. Especially, they replace their trade variable which is equal to the ratio of imports plus exports in current prices to GDP in current prices with real openness suggested by Alcalá and Ciccone (2004). However, this does change their main finding such that the coefficient estimate of trade variable is again insignificantly negative. In addition, Rodrik et al. (2004) put forward some conceptual and empirical arguments against the real openness. Their main criticism is that the positive correlation between real openness and income level is spurious. The most important reason is that all productivity gains whether or not related to international trade lead to an increase in the price of non-tradables at home and thus the price level of an economy with respect to others. Adjusting for this by GDP in PPP makes the real openness upward biased. Since the traditional trade ratio in current prices does not suffer from this problem, these authors do not find real openness as a compelling measure.

Finally, Jeffrey Sachs (2003) points out that absolute latitude used in these papers is not appropriate for measuring the effect of geography. Employing malaria incidence rate as a proxy, he shows that geography directly affects the income level after controlling institutions.

Undoubtedly, these studies provide valuable information in order to understand relative contributions of openness, institutions and geography to income level and hence economic growth. However, these studies are still subject to model uncertainty as pointed out by Durlauf et al. (2007) since they are based on specific choices of growth determinants.

Time Period

Most of the recent cross-country studies are based on the 1970-1990 period while investigating openness-growth connection. Of course, the important reason is that until recently, Penn World Tables (Version 5.6) covered the 1950-1992 period. However, some researchers still focus on the period 1970-1990 in spite of the available data over the period 1950-2000 period (Penn World Tables Version 6.1). For instance, Warner (2003) stresses that time period for empirical investigation, especially for tariff-growth connection, should be 1970-1990 since the majority of developing countries liberalised their trade regimes during the late 1980s and early 1990s.

However, given the available data, investigating the relationship between openness and growth over the 1970-1990 period may be troublesome. First, as pointed out by Vamwakidis (2002), during the 20th century protectionism was a general rule except its last two decades. Looking at historical data from 1870 to 1990, Vamwakidis (2002) finds no evidence for a positive growth-openness connection before 1970 whilst he concludes a positive association between these two over the 1970-1990 period. According to Vamwakidis (2002), the positive growth-openness connection during the 1970-1990 period is an exception.[18] Therefore, investigating openness-growth connection after 1970 may lead to biased results. The reason is that most developing countries experienced rel-

[18]According to Vamwakidis (2002), the correlation between openness and growth is negative for the period 1920-1940. Similarly, using data on 35 high and low income countries, Clemens and Williamson (2002) investigate tariff-growth connection over the period 1870-1990 and find that tariff rate and economic growth is positively associated pre-1950 period. In particular, this association is strong and statistically significant for the period 1873-1912.

atively higher growth performance during the 1960s and hence a time period starting from 1970 does not include the growth information of the 1960s. Second, the post-1990 experience also provides impor-

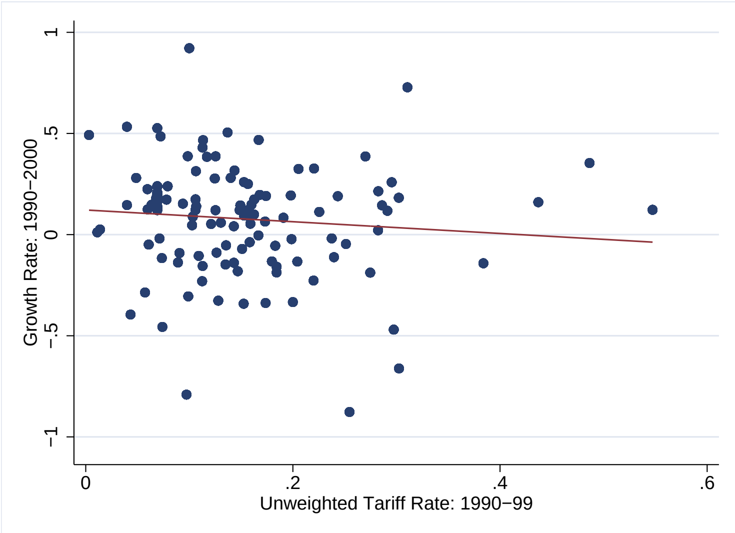
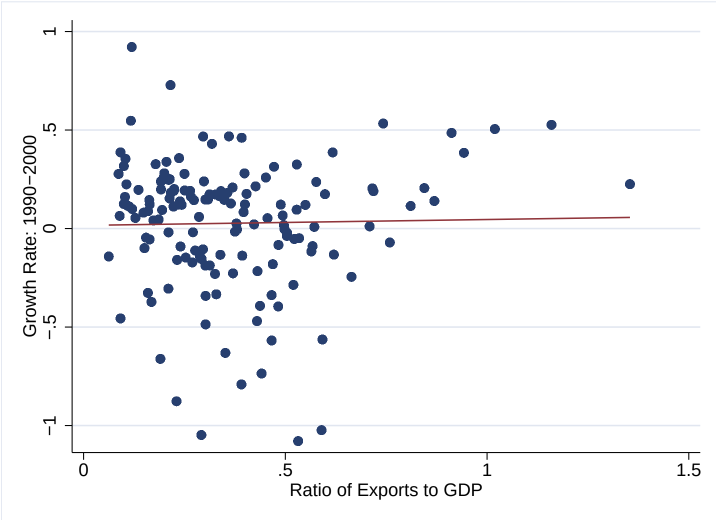
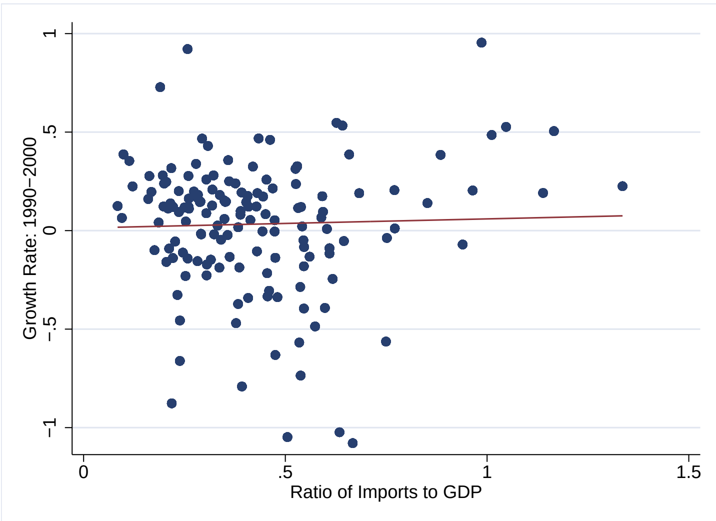


Figure 2.1: Growth rate versus Tariff rate: 1990-2000

tant information on the openness-growth connection. For instance, Rodríguez (2007) argues that data evidence does not show significant differences in growth rates between open and closed economies after 1990. Figure 2.1 display the graphical visualization of the relationship between growth rate of per worker GDP and unweighted tariff rate provided by Wacziarg and Welch (2003) over the period 1990-2000. As can be seen, there is no significant association between these two. Similarly, neither imports nor exports are significantly correlated with economic growth during the 1990s (see figure 2.2). Hence, excluding the 1990s from the data analysis again may lead to biased results. Therefore, we believe that the 1960 to 2000 is a more plausible period for investigating the openness-growth link because it is sufficiently long to reflect both changes in trade policy stance and growth dynamics in the long run.



(a) Growth rate versus Exports: 1990-2000



(b) Growth rate versus Imports: 1990-2000

Figure 2.2: Trade and Growth in the Nineties

2.4 Summary and Conclusion

In this chapter, we have reviewed the empirical cross-country growth studies on the openness-growth connection. Most of the previous studies, especially those in the 1980s and the 1990s concluded that openness influences economic growth significantly and positively in the long-run. These studies were subsequently used to support policy recommendation of trade liberalization. However, a close look at these studies highlights some stylized facts:

- A myriad of openness measures have been suggested in the empirical work. This reflects the fact that none of them adequately captures all elements of openness, and as noted by Pritchet (1996) in many cases the correlations among them are weak. Indeed, most openness variables in the literature generally tend to measure only one aspect of trade policy. More importantly, these variables often fail to classify countries according to their degree of openness. Of course, overcoming of these problems is challenging due to the complex nature of trade policy, disagreements between the economists what determines openness and the lack of good data across countries and over time.

- The substantial part of existing studies focuses on the period 1970-1990. Given the available data for a longer time period, it is highly likely that investigating the openness-growth connection over the 1970-1990 period leads to biased results.

- The causality between openness and growth has remained unclear. In our opinion, providing a clear and decisive causal relationship from cross-country growth studies is almost impossible due to the lack of valid instrumental variables. Moreover, as Rodrik (2005) points out that the endogeneity problem between growth and a policy variable in the cross-country growth regressions is a bigger problem because policy interventions are also a response to larger market failures or poor growth performance.

- Model uncertainty is an important problem since most studies tend to investigate openness-growth relation employing simple growth models. As Rodrik and Rodríguez (2000) argue, given a wide number of growth theories and their proxies, the strong results in favour of openness may arise from model misspecifation and/or openness measures may be acting as a proxy for other macroeconomic policies or other important factors such as institutions and geography.

In conclusion, it is possible to say that the cross-country studies fail to provide a robust and convincing evidence on the relationship between openness and growth and this issue is still highly controversial.

Chapter 3

Cross-Country Growth Empirics and Model Uncertainty

3.1 Introduction

This chapter aims to describe the basic framework used in subsequent chapters and then to highlight model uncertainty in the empirical cross-country growth literature. Following the seminal studies by Kormendi and Meguire (1985), Barro (1991) and Mankiw et al. (1992), a large number of empirical works have emerged to explain cross-country growth differences, with the hope of providing some policy suggestions for economic growth. This renewed interest arose from recent developments in the theory of endogenous growth and the increasing availability of multi-country growth data sets, e.g. the Penn World Tables, (Summers and Heston (1988, 1991)).

However, as pointed out by Temple (1999a) and Barro and Sala-i-Martin (2004), in spite of recent theoretical developments, the empirical studies are mainly based on extended versions of the neoclassical growth model. An important reason for neglecting endogenous growth theory in cross-country growth empirics is that the inclusion of technological change (via learning by doing, production of new ideas and R&D activities) in the neoclassical growth model is difficult, since standard competitive market assumptions will not be valid. Furthermore, endogenous growth theories have less explanatory power for understanding cross-country growth differentials even though growth economists have reached a general consensus that whilst basic technological change is the most important determinant for understanding why the world economy as a whole has been growing indefinitely in per capita terms. For instance Barro (1997, p.8) argues that "[I]t is surely an irony that one of the lasting contributions of endogenous growth theory is that it stimulated empirical work that demonstrated the explanatory power of the neoclassical growth model." Therefore, the neoclassical growth model firstly developed by Solow (1956) and Swan (1956) is a starting point of most cross-country growth studies.

The key aspect of the neoclassical growth model is the assumption of a neoclassical production function with constant returns to scale and diminishing returns to each input (both capital and labour). Taking rates of saving, population growth and technological progress as exogenous, the neoclassical growth model emphasises the accumulation of physical capital over time in determining the steady state growth path for each economy. Despite its simplicity, the neoclassical growth model has many testable predictions concerning sources of economic growth and cross-country growth differences.[1] In this context, a seminal study by Mankiw, Romer and Weil (1992) augments the neoclassical model with the accumulation of human capital. Furthermore, this

[1]See Mankiw (1995) for a nice summary of these well-known predictions.

study provides a coherent theoretical framework for empirical cross-country growth studies and a large body of empirical cross-country growth literature is based on Mankiw, Romer and Weil (1992). Islam (1995) and others further adapt the framework of Mankiw, Romer and Weil (1992) for panel estimation.

However, as we noted in Chapter 1, the accumulation of physical and human capital, population growth and technological progress are *proximate* determinants of economic growth. In other words, even though these factors explain a considerable part of cross-county growth differences and in spite of the common consensus concerning these factors as potential growth determinants, these facts bear a pertinent question: *Why are countries different in terms of proximate growth determinants?* In their ability to answer this question, recent endogenous growth theories are not superior to the neoclassical growth model. In other words, recent endogenous growth models (for instance Romer (1990), Grossman and Helpman (1991)) suggest that a country that allocates more resources to innovative activities and/or R&D sectors will have a higher growth rate in the long run. However, which factors determine the incentives and preferences of resource allocation for innovation remains unanswered. That is why growth economists have investigated the deeper sources of economic growth and suggested many new theories in order to explain growth differences across countries.

The most striking feature of these new growth theories is that they have always had an empirical basis. A typical study, firstly presents a theory, then suggests a proxy variable for that theory and finally concludes a cross-country growth regression including this new theory as well as the proximate determinants.[2] Whilst recent efforts provide

[2]Typically such cross-country growth regressions include the initial income level, the investment ratio and a measure of human capital such as primary and secondary school

valuable information, such studies are subject to many econometric problems (e.g. model uncertainty, endogeneity, outliers, measurement errors, parameter heterogeneity).

Probably, the most important of these problems is model uncertainty. There are two important reasons for this. First, unlike the proximate determinants of growth, there is no common consensus among the new growth theories. Whilst almost all studies include the same proximate determinants, the new growth theories change from study to study. In other words, there is no clear answer as to which of these new growth theories is more important. Indeed, it is likely that new growth theories are complementary, not exclusive, as Durlauf (2002) points out. The consequence of this is that a vast number of explanatory variables appears in the empirical cross-country growth literature.[3] Second, we have a limited number of observations since the number of countries in the world is limited. Furthermore, when running cross-country growth regressions, many observations are missing due to data availability. [4]

The objectives of this chapter are threefold: First, it describes the general theoretical framework which constitutes the basis for the most empirical cross-country growth works. Second, it addresses the model uncertainty problem which is indeed immense but generally ignored in the empirical cross-country growth literature. Third, the chapter highlights the importance of model uncertainty for policy evaluation.

enrolment rate, as well as some proxy variables for the new theory. Regressions of this kind are also known as "Barro type regression" due to the pioneering work by Barro (1991).

[3]Another reason for this proliferation is the difficulties arising from construction of proxy variables for new theories. For instance, a theory pointing out that openness to international trade is important for economic growth does not provide a clear answer as to how we measure openness.

[4]As noted by Sala-i-Martin (2001), empirical cross-country growth works are subject to small sample econometrics. Therefore, the econometric problems discussed in cross-country growth empirics are common to other applied studies with small samples.

The rest of the chapter is organised as follows. Section 2 describes the basic framework for the recent cross-country growth literature. Section 3 deals with the model uncertainty problem. Section 4 briefly evaluates cross-country growth studies in terms of policy evaluation. Section 5 concludes.

3.2 Empirical Framework

In this section, we provide a theoretical framework for cross-country growth regression. Special emphasis is focused on Mankiw, Romer and Weil (1992) since this study suggests a benchmark equation for much of the subsequent cross-country growth literature.

Following the standard notation, we denote the level of output by $Y(t)$, labour stock by $L(t)$ and level of labour-augmenting technology by $A(t)$ at time t. Assuming that production function exhibits constant returns to scale and labour and technology grow exogenously at rates n and g such that $L(t) = L(0)e^{nt}$ and $A(t) = A(0)e^{gt}$, output per unit of labour; $y(t) = Y(t)/L(t)$ and output per unit of effective labour; $\tilde{y}(t) = Y(t)/A(t)L(t)$ are defined. As indicated by many authors both Solow-Swan or Ramsey-Cass-Koopmans versions of the neoclassical growth model for closed economies conclude that the growth rate of per capita output is inversely related to initial level of per capita output.[5] This implies that

$$\lambda = -\frac{\partial(\dot{\tilde{k}}(t)/\tilde{k}(t))}{\partial log\tilde{k}(t)} \tag{3.1}$$

where $\tilde{k}$ denotes the physical capital stock per unit of effective labour and λ measures the speed of convergence (defined as how much the

[5] See for instance, Barro and Sala-i-Martin (1992), Mankiw et al. (1992), Mankiw (1995), Islam (1995), Durlauf et al. (2005).

growth rate decreases when the capital stock increases proportionally). Notice that in equation (3.1), the speed of convergence is defined with a negative sign since the derivative is negative due to the marginal diminishing return to capital. Therefore, λ must be positive, and its size depends on the parameters of the model. The other important point is that λ is not constant. This means that λ decreases monotonically while capital stock converges to its steady-state value. Put differently λ is implicitly a function of $\tilde{k}(t)$ and becomes zero when the capital stock reaches its steady-state level. Therefore, we denote speed of convergence in the neighborhood of steady-sate by λ^*. Since the production function is assumed to have constant returns to scale, equation (3.1) can be applied for the output per unit of effective labour, i.e. speed of convergence can be alternatively defined for $\tilde{y}(t)$:

$$\lambda = -\frac{\partial(\dot{\tilde{y}}(t)/\tilde{y}(t))}{\partial log\tilde{y}(t)} \tag{3.2}$$

Equation (3.1) implies that the first-order Taylor approximation of $log\tilde{k}(t)$ around the steady state yields

$$\dot{\tilde{k}}(t)/\tilde{k}(t) \cong -\lambda^*[log(\tilde{k}(t)/\tilde{k}(t)^*)] \tag{3.3}$$

Similarly, equations (3.2) and (3.3) imply that

$$\dot{\tilde{y}}(t)/\tilde{y}(t) \cong -\lambda^*[log(\tilde{y}(t)/\tilde{y}(t)^*)] \tag{3.4}$$

As can be seen, equations (3.3) and (3.4) are first-order differential equations. Equation (3.4) can be written more explicitly as follows

$$\frac{dlog\tilde{y}(t)}{dt} = \lambda^* log\tilde{y}(t)^* - \lambda^* log\tilde{y}(t) \tag{3.5}$$

Solving (3.5) gives

$$log\tilde{y}(t) = (1 - e^{-\lambda^* t})log\tilde{y}(t)^* + e^{-\lambda^* t}log\tilde{y}(0) \tag{3.6}$$

Equation (3.6) can be expressed for output per labour instead of output per unit of effective labour as follows

$$logy(t) - logA(t) = (1 - e^{-\lambda^* t})log\tilde{y}(t)^* + e^{-\lambda^* t}logy(0) - e^{-\lambda^* t}logA(0) \tag{3.7}$$

and so

$$logy(t) = gt + (1 - e^{-\lambda^* t})log\tilde{y}(t)^* + (1 - e^{-\lambda^* t})logA(0)) + e^{-\lambda^* t}logy(0) \tag{3.8}$$

Subtracting the logarithm of the initial level of output per capita from both sides of equation (3.8) and dividing by time t yields the following growth equation

$$t^{-1}(logy(t) - logy(0)) = g + \eta[log\tilde{y}(t)^* + logA(0) - logy(0)] \tag{3.9}$$

where $\eta = t^{-1}(1 - e^{-\lambda^* t})$. The left-hand side of equation (3.9) shows the growth rate of output per labour between 0 and t.[6] As can be seen from equation (3.9), the growth rate of per capita output may be decomposed into two main factors. The first one is the growth rate of technological progress, g. The second one is the distance between initial level of output per unit of effective labour and its steady state

[6]Notice that the growth rate in equation (3.9) is defined per unit of time. If the unit of time is a year, the left-hand side of equation (3.9) measures the average growth rate of output per labour *annually*. On the other hand one can construct the growth rate as the log difference between initial and end of period values such that $logy(t) - logy(0)$ since equation (3.9) is based on the log-linear approximation of output per unit of effective labour in the vicinity of steady state. As long as it is explicitly expressed, both approaches are in essence the same, and choosing between these two depends on the researchers' preferences.

value, $log\tilde{y}(t)^* - log\tilde{y}(0)$. In order to show the second factor more explicitly, equation (3.9) can be written as

$$t^{-1}(logy(t) - logy(0)) = g + \eta[log\tilde{y}(t)^* - log\tilde{y}(0)] \qquad (3.10)$$

It can be seen from equation (3.10) that, the growth rate of per capita output is inversely related to the initial level of output per unit of effective labour while it is positively related to the steady state level of output per unit of effective labour and hence its determinants. As time approaches infinity, i.e. as an economy converges to its steady state, the effect of the second factor vanishes, and at the steady state, is equal to zero. This means that in the long run, the growth rate of per capita output is determined by the rate of technological progress, g.

If we assume that rate of technological progress, g and the determinants of the steady state level of output per unit of effective labour are constant across countries, then each economy approaches the same steady state in the long run. That is why, countries with a lower initial level of output per unit of effective labour grow faster than those with a higher initial level of output per unit of effective labour during the transition period. This result is known as the *absolute convergence hypothesis* and predicts that countries tend to catch up those with higher initial values of capital labour ratio and per capita output. However, if the countries have different values of g and determinants of steady state value of output per unit of effective labour, then steady states will be different across countries. Therefore, each economy will converge to its own steady state rather than a common steady state, and the speed of this convergence will be inversely related to the distance of the initial level from the steady state. This property is a result of the assumption of diminishing returns to capital, so that economies which have less capital per head relative to its steady state level tend to have higher rates of return and so faster growth. In this situation, the neoclassical growth model implies *conditional convergence* instead of absolute convergence in the sense that an economy with a lower initial value of per capita output tends to generate higher growth rate of per capita output if g and determinants of the steady state value of output per unit of effective labour are the same across countries or their effects are controlled .

Equations (3.9) and (3.10) are the basis for the estimation of cross-country growth regressions in the empirical growth literature. Adding an error term μ, which is independent from all right-hand side variables, yields the following cross-country growth regression

$$t^{-1}(logy_i(t) - logy_i(0)) = g_i + \eta log\tilde{y}_i(t)^* - \eta logy_i(0) + \eta logA_i(0) + \mu_i \tag{3.11}$$

where subscript i denotes the country i. This last equation is the basic cross-country growth regression in discrete time which is derived from continuous time neoclassical Solow-Swan growth model.

In this context, the seminal study by Mankiw, Romer and Weil (1992, MRW hereafter) augments the Solow-Swan version of neoclassical growth model by adding the accumulation of human capital. They assume a Cobb-Douglas production function such that production at time t in country i is given by

$$Y_i(t) = K_i(t)^\alpha H_i(t)^\beta (A_i(t)L_i(t))^{1-\alpha-\beta} \tag{3.12}$$

where the notation here is again standard such that Y is output, K is physical capital, H is the stock of human capital, L is labour, and A is level of technology. MRW (1992) assumes that $\alpha+\beta<1$, which means that there are decreasing returns to both kinds of capital. Labour stock and the level of technology are assumed to grow exogenously at rates n and g, respectively as before.

The production function in equation (3.12) can be written in its intensive form. More clearly, it can be expressed in terms of per unit of effective labour since it has constant returns to scale.

$$\tilde{y}(t)=\tilde{k}(t)^{\alpha}\tilde{h}(t)^{\beta} \tag{3.13}$$

where $\tilde{h}$ is the stock of human capital per unit of effective labour and the remaining variables are as before. The model assumes that a constant fraction of output is invested in both physical and human capital such that s_K is the fraction of income invested in physical capital and s_H is the fraction of income invested in human capital. Defining δ as the depreciation rate of both physical and human capital, yields

$$\dot{\tilde{k}}(t)=s_K\tilde{y}(t)-(n+g+\delta)\tilde{k}(t) \tag{3.14}$$

$$\dot{\tilde{h}}(t)=s_H\tilde{y}(t)-(n+g+\delta)\tilde{h}(t) \tag{3.15}$$

Equations (3.14) and (3.15) imply that the economy converges to a steady state defined as follows

$$\tilde{k}(t)^{*}=\left(\frac{s_K^{1-\beta}s_H^{\beta}}{n+g+\delta}\right)^{1/1-\alpha-\beta} \tag{3.16}$$

$$\tilde{h}(t)^{*}=\left(\frac{s_K^{\alpha}s_H^{1-\alpha}}{n+g+\delta}\right)^{1/1-\alpha-\beta} \tag{3.17}$$

Substituting equations (3.16) and (3.17) into the production function gives the steady state level of output per unit of effective labour:

$$\tilde{y}(t)^* = \left[\frac{s_K^\alpha s_H^\beta}{(n+g+\delta)^{\alpha+\beta}} \right]^{1/1-\alpha-\beta} \tag{3.18}$$

Using the definition of speed of convergence expressed in equation (3.2) with the equations from (3.13) to (3.18), the convergence coefficient in the vicinity of the steady state can be defined by[7]

$$\lambda^* = (1-\alpha-\beta)(n+g+\delta) \tag{3.19}$$

λ^* measures how rapidly a country's output per unit of effective labour approaches its steady state value in the neighbourhood of the steady state. For instance, if we assume that the sum of rates of population growth, technological progress and depreciation is seven percent and capital shares are one-third, then λ^* would be equal to 0.023. This means that 2.3 percent of the gap between a country's steady state and its current income level is eliminated each year and halfway to convergence takes approximately 30 years, in the absence of any other shocks.[8]

In order to get a cross-country growth regression, we need to substitute expression (3.18), i.e. steady state level of output per unit of

[7]See Appendix for derivation of convergence coefficient in the augmented neoclassical growth model.

[8]According to the equation (3.6), the half-way convergence to steady state requires the condition $1 = 2e^{-\lambda^* t}$. Therefore, the half-life convergence to steady state is $log(2)/\lambda^*$. Similarly, elimination of a three-quarter gap must satisfy the condition $1 = 4e^{-\lambda^* t}$, and takes $2log(2)/\lambda^*$. For instance in the example above, three-quarters of convergence to steady state takes $2log(2)/0.023 = 60.3$ years.

effective labour into equation (3.11). This produces

$$t^{-1}(logy_i(t) - logy_i(0)) = g + \eta\frac{\alpha}{1-\alpha-\beta}logs_{i,K} + \eta\frac{\beta}{1-\alpha-\beta}logs_{i,H}$$
$$- \eta\frac{\alpha+\beta}{1-\alpha-\beta}log(n_i + g + \delta) - \eta logy_i(0)$$
$$+ \eta logA_i(0) + \mu_i \tag{3.20}$$

As can be seen from the last equation, MRW assume that rates of technological progress and of depreciation are constant across countries. On the other hand, logarithm of initial level of technology is assumed to be different across countries and be equal to the sum of a fixed parameter, a and a country specific shock, ε_i such that

$$logA_i(0) = a + \varepsilon_i \tag{3.21}$$

According to MRW, the level of initial technology represents not only the technology but also the resource endowment, institutions, climate and so on. Therefore, initial differences across countries are reflected by the term ε_i. Substituting equation (3.21) into equation (3.20) yields the following cross-country growth regression;

$$t^{-1}(logy_i(t) - logy_i(0)) = g + \eta a - \eta logy_i(0) - \eta\frac{\alpha+\beta}{1-\alpha-\beta}log(n_i + g + \delta) +$$
$$\eta\frac{\alpha}{1-\alpha-\beta}logs_{i,K} + \eta\frac{\beta}{1-\alpha-\beta}logs_{i,H} + \mu_i + \eta\varepsilon_i \tag{3.22}$$

The most critical assumption of MRW (1992, p.411) is that "[t]he rates of saving and population growth are independent of country-specific factors shifting the production function." This means that $s_{i,K}$, $s_{i,H}$, and n_i are independent from the country specific shocks ε_i and thus, a cross-country growth regression expressed as in equation (3.22) can be estimated by OLS.

The cross-country growth regression in equation (3.22) can be written in its reduced form

$$\varrho_i = \pi_0 + \pi_1 logy_i(0) + \pi_2 log(n_i + g + \delta) + \pi_3 logs_{i,K} + \pi_4 logs_{i,H} + \upsilon_i \quad (3.23)$$

where

$$\begin{aligned}
\varrho_i &= t^{-1}(logy_i(t) - logy_i(0)) \\
\pi_0 &= g + \eta a \\
\pi_1 &= -\eta \\
\pi_2 &= -\eta \frac{\alpha + \beta}{1 - \alpha - \beta} \\
\pi_3 &= \eta \frac{\alpha}{1 - \alpha - \beta} \\
\pi_4 &= \eta \frac{\beta}{1 - \alpha - \beta} \\
\upsilon_i &= \mu_i + \eta \varepsilon_i
\end{aligned}$$

Equation (3.22) and its reduced form in (3.23) are the basis of the augmented neoclassical growth model. MRW estimated the augmented neoclassical growth model for 98 countries (oil producing countries are excluded) over the 1960-1985 period. The share of investment in GDP and the fraction of working-age population enrolled in secondary school are used as proxy variables for s_K and s_H, respectively. All right-hand side variables, except the initial level of GDP per worker are entered into the regression as period averages instead of their initial value.[9] Regression results show that the average growth rate of GDP

[9]Note that theory does not provide a clear answer for choosing between period averages and initial values, since these variables are considered as constant over the period and

per worker is positively correlated with the investment to GDP ratio and secondary school enrolment rate and negatively with the initial income level and population growth. Moreover, MRW estimate the augmented neoclassical model imposing the restriction that coefficients on $log(n + g + \delta)$, $logs_K$ and $logs_H$ add up to zero. Finding that this restriction is not rejected, MRW conclude the regression estimates of $\lambda^* = 0.0142$, $\alpha = 0.48$ and $\beta = 0.23$, which denote the convergence rate, physical and human capital shares in the vicinity of the steady-state, respectively. According to MRW, their estimation results produce a lower convergence rate than the standard neoclassical growth model excluding human capital and remove some anomalies which are not captured by the standard model. In other words, with the inclusion of human capital, differences in saving, education and population growth produce a consistent explanation for cross-country growth variations.

Even though MRW provide a coherent framework to explain cross-country growth differences, it is subject to a number of criticisms. The most important one is that it is unlikely that variations in the initial level of technology are uncorrelated with the right-hand side variables. As mentioned before, the initial level of technological efficiency is omitted from the cross-country regression since it is not observed. Yet, if initial income, saving rates and population growth are correlated with the initial technological efficiency, then coefficient estimates of regressors will be biased. As suggested by Islam (1995), one solution to this problem is to employ panel data estimation methods. Since the initial level of technology is time invariant, it can be considered as a country fixed effect. Islam (1995), Caselli et al. (1996) Lee et al. (1997) amongst others apply the augmented neoclassical growth model on panel data.

exogenous. Yet, the common practice in the literature is to use average values over the period.

An outstanding result of these studies is that they find a higher rate of conditional convergence compared to cross-sectional studies. In addition, they generally conclude that other explanatory variables, especially human capital, either are insignificant or have wrong signs.

The second criticism is that the secondary school enrolment rate is not an appropriate proxy for the investment rate in human capital. An important issue concerning school enrolment rates is that this variable is sometimes used as a proxy for level of human capital sometimes as a measure of change in human capital. It is however more appropriate to use school enrolment rate as a flow variable for human capital as indicated by Barro (1991) and Barro and Lee (1994b). Indeed, in the cross-country growth literature there are many studies (such as Barro (1991), Levine and Renelt (1992), Sala-i-Martin (1997a,b), Sala-i-Martin et al. (2004)) as well as Mankiw et al. (1992) that employ school enrolment rate as a proxy for accumulation of human capital and find that school enrolment rate is positively and significantly associated with economic growth. However, there are also other studies strongly criticizing these findings. For instance Bils and Klenow (2000) argue that strong empirical relation between growth and school enrolment rate is spurious since it is more likely that both variables are correlated with other omitted factors such as openness to international trade or institutions. In addition, according to these authors there is the possibility that this relation reflects reverse causality. Similarly, Pritchett (2001) points out secondary school enrolment rate is an extremely poor proxy for growth in average years of schooling because school enrolment rates, especially those in developing countries, substantially increase over the time period in the cross-country growth analysis. Due to these criticisms, there is a tendency in the literature about the schooling years per person published by Barro and Lee (1994a, 2000) as a more reliable measure for the level of human capital. However, some studies such as Benhabib and Spiegel (1994) and Pritchett (2001) employ average years of schooling as a measure of human capital stock and conclude that the relationship between change in years of schooling and growth of per capita income is insignificant and mostly negative. One possibility for this adverse relation is outlier effect. Temple (1999b) concludes a positive and significant relation between change in schooling year and growth when a number of extreme observations are omitted. Another possibility is that these studies are based on growth accounting framework rather than standard cross-country growth regression and hence their regression results may have suffered from omitted variable bias. However, in spite of these possibilities, an important conclusion from these studies is that neither school enrolment rates nor average years of schooling are good proxies for human capital. The most important reason is that they do not directly measure cognitive skills of labour force. This leads some researchers to employ alternative variables measuring directly the quality of labour force such as teacher-student ratio or math and science test scores.[10] On the other hand, some authors (for example Temple (1999a), Benhabib and Spiegel (1994), Krueger and Lindahl (2001), Bils and Klenow (2000), Klenow and Rodríguez-Clare (1997), Hall and Jones (1999), Acemoglu (2007)) suggest measures of human capital based on returns to schooling or some measures based on the findings of other micro studies, specifically Mincerian approach to human capital.[11]

[10] For instance Hanushek and Kimko (2000) employing international math and science test scores from 31 countries conclude a significant and positive correlation between this variable and growth. Similarly, Jones and Schneider (2006) find that national average IQ test score is positively correlated with growth. Their finding is robust such that IQ test score passes a Bayesian model averaging test at 99.8 significance level.

[11] According to this approach, human capital is an exponential function of years of

There is no doubt that the relation between growth and schooling (hence human capital) is a complex one. We expect a positive relation between these two due to the fact that education directly increases productive skills of labour force. In addition, schooling can stimulate economic growth through other channels such as reducing corruption, better conflict management, increasing health quality and so on. However, an increase in school attainment is necessary but not sufficient condition for accumulation of human capital. As pointed by Pritchett (2001) institutional environment and demand for human capital are important factors. Yet, it is more likely that schooling significantly contributes to the level of human capital since it teaches how to learn and thus help to adapt and use new technological advances (Phelps (1995)). Therefore, variables measuring school attainment can still be used as a proxy for human capital, especially in the absence of better data.[12] MRW argue that if secondary school enrolment rate is proportional to saving rate for human capital (a reasonable assumption), then it can be used in the cross-country growth regressions. Of course problems such as data quality or measurement error associated with school enrolment rate are important. However, it may be worth reminding that all proxy variables in the cross-country literature are not free of these problems. As pointed out by Mankiw (1995), many variables in the literature are crude proxies at best.

Thirdly, the assumption that the rate of technological progress is constant across countries is criticised. According to MRW, technology differs across countries due to the differences in initial level of

schooling.

[12] Recently, Cohen and Soto (2007) have provided a new data set for average years of schooling over the period 1960-2000 as an alternative to schooling years published by Barro and Lee (2000). These authors replicate the previous studies which concluded negative and insignificant relation between growth and schooling and find that their new series is positively and significantly correlated with growth.

technology, not differences in technological improvements. Put differently, they consider that technology is a public good freely and equally spreading over the world. Therefore, differences in growth are a result of differences in saving rates and population growth. However, as pointed out by Temple (1999), there is no logical reason to expect that countries with initially different levels of technology experience the same rate of technological improvement. For instance, Lee, Pesaran and Smith (1997) point out that rates of technological progress vary across countries, even among industrial ones. Therefore, it seems difficult to explain growth miracles after the Second World War, such as Japan and South Korea, as purely a result of capital accumulation. On the other hand, one may conclude that this assumption is less unrealistic in the long run. More clearly, even if the level of technology is different across countries, in the long run the rate of technological progress will be the same over the world since countries try to access all technology available everywhere.[13]

Finally, some authors (for example Hall and Jones (1999), Frankel and Romer (1999), and Acemoglu et al. (2001)) suggest that the theoretical framework provided by MRW can be used for income level regression instead of growth regressions.[14] Even though this suggestion seems reasonable since the primary objective of growth studies is to explain growth and ultimately income differences across countries, the disadvantages of income level regressions are twofold. First, the

[13]Of course, the fact that the level of technology grows at the same rate across countries in the long run does not necessarily mean that one can assume a common rate of technological progress for any given sample. See Temple (1999) and Aghion and Howitt (1999) for further discussion.

[14]Taking the logarithm of the steady state value of output per unit of effective labour expressed in equation (3.18) and rearranging it, produce the following level regression

$$log\frac{Y_i^*(t)}{L_i^*(t)} = a + gt - \frac{\alpha+\beta}{1-\alpha-\beta}log(n_i+g+\delta) + \frac{\alpha}{1-\alpha-\beta}logs_{i,K} + \frac{\beta}{1-\alpha-\beta}logs_{i,H} + \varepsilon_i$$

possible endogenity problem between the dependent variable and regressors is more obvious and finding good instruments in order to solve this problem is almost impossible. Second, this approach explicitly requires the assumption that countries are in their steady states.

Despite these problems, the large body of empirical cross-country growth literature consists of extended versions of the baseline specification in equation (3.23). A recent extension of this specification occurs through adding proxy variables suggested by the new growth theories as

$$\varrho_i = \pi_0 + \pi_1 log y_i(0) + \pi_2 log(n_i + g + \delta) + \pi_3 log s_{i,K} + \pi_4 log s_{i,H} + \psi Z_i + \upsilon_i \tag{3.24}$$

where Z is a vector of additional explanatory variables. The extended versions of the augmented neoclassical growth model in (3.24) can be rewritten in its generic form which is sometimes useful as follows

$$\varrho_i = \gamma + \pi X_i + \psi Z_i + \upsilon_i \tag{3.25}$$

where γ is constant term and X_i is a vector of explanatory variables suggested by the augmented neoclassical growth model, i.e. proximate determinants of growth. However, there are some unclear points in the extended versions of MRW, as argued by Temple (1999a).

Firstly, whether recent extensions attempt to explain differences in initial level of technology or to allow differences in the rate of technological progresses across countries is unclear. Put differently, whether Z_i determines the steady state level of income or long run growth rate is not defined. As can be easily seen, the only difference between the cross-country growth specification by MRW and its recent extensions is that the term $g + \eta a + \eta\varepsilon_i$ in equation (3.22) is replaced by the term

$g + \eta a + \psi Z_i + \eta \varepsilon_i$ in equation (3.24). This would lead one to interpret the introduction of ψZ_i to relate to initial differences in the level of technology, since extended versions of MRW ignore the fact that the term $log(n_i + g + \delta)$ should be replaced with the term $log(n_i + g_i + \delta)$ if new growth theories affect the rate of technological progress. Of course, allowing new growth theories to affect the rate of technological progress is not easy since this makes the cross-country growth regression nonlinear via the term $log(n_i + g_i(Z_i) + \delta)$.

Secondly, if Z_i is correlated with the initial level of technology, then Z_i enters the cross-country growth regression with the expected sign even if Z_i does not have any effect on the long run growth rate. For instance, if initially more efficient countries are more open to international trade, then an openness variable will have a positive sign even though openness does not affect growth in the long run. Yet, in spite of these facts, one can claim that Z_i has an effect on the long run growth rate. The reason is that many cross-country growth works cover 20 or 30 years and it is not reasonable to assume that countries experience the same rate of technological progress over the time period. As suggested by Durlauf, Johnson and Temple (2005), whether Z_i affects the income level or growth rate in the long run depends on the researcher's prior beliefs.

However, even if it is plausible to assume that the interpretation of Z_i depends on the researcher's beliefs, another important problem related to Z_i remains. As mentioned earlier, while the X_i variables are generally constant in empirical cross country studies, there is no consensus about the Z_i variables in the literature. Therefore selecting Z_i variables is problematic and the selection differs from one study to another and thus raise the model uncertainty problem in cross-country growth regressions.

3.3 Model Uncertainty and Cross-Country Growth Regressions

Probably the most fundamental and controversial problem with cross-country growth regressions is model uncertainty and this issue has been acknowledged by many authors since the important work by Levine and Renelt (1992).[15] Indeed, model uncertainty is a crucial problem for any kind of empirical work in economics. However, the degree and solution to this problem become more severe and difficult in the context of cross-country growth regression since, as pointed out by Brock and Durlauf (2001, p.234), growth theories are fundamentally open-ended in the sense that " [t]he idea that the validity of one causal theory of growth does not imply the falsity of another." Thus new growth theories suggest a wide range of different explanations for cross-country growth differences such as quality of institutions, political stability, resource curse, population heterogeneity, the role of geography and so on. For instance, a recent survey by Durlauf, Johnson and Temple (2005) concludes that 145 different proxies have been found to be statistically significant in at least one study. This implies that identification of explanatory variables is a very important task and thus the problem of omitted variable bias in a particular cross-country regression is immense. However, it is impossible to simply run a cross-country growth regression including all variables suggested by new growth theories due to large number of growth variables and the small sample at hand, that is the limited number of countries in the world. Furthermore, the

[15] See for instance Mankiw (1995), Sala-i-Martin (1997a,b), Temple (1999a, 2000), Brock and Durlauf (2001).

number of countries in a particular cross-country growth regression is considerably less than the actual number of countries because of data availability. Of course, in the empirical cross-country growth literature, there is no study attempting to employ all possible variables. Rather, many studies chose a subset of explanatory variables and then report a selected model with the results of diagnostic test to provide robust evidence for one or more of the variables of interest. However, during the last decade this approach has been criticised since the results of these studies are very sensitive to included and/or excluded variables. The main difficulty in these studies is that several different models may all provide reasonable representations of the data, but lead to very different conclusions about what causes economic growth. Under these conditions, presenting results of a single preferred model can often be misleading.

Brock, Durlauf and West (2003, p.268) characterise the model uncertainty in a more general context. These authors suggest that "[i]t is useful in specifying a model space to consider several distinct levels of model uncertainty and build up the space sequentially. " They then highlight three basic aspects of model uncertainty: First and most importantly, "theory uncertainty" stems from disagreements over alternative theories used to explain the phenomenon. Of course, this disagreement is closely related to the absence of strong empirical evidence that would be conclusive for ranking alternative theories; The second is "specification uncertainty". Many empirical proxies for a particular variable give rise to this kind of uncertainty. Therefore, specification uncertainty is sometimes referred to as "proxy uncertainty". However, specification uncertainty encompasses the possible nonlinearities and lag length of variables as well as proxy uncertainty; The third is "heterogeneity uncertainty" stemming from the heterogeneity among different observations. For example, in the growth context, the effect of a particular theory and/or variable on Kenya will undoubtedly be different from that on the United Kingdom. This is why one needs to clarify whether there is heterogeneity in the growth process among the countries or regions being considered. Different specifications of heterogeneity among countries and regions produce different models and raise model uncertainty.

In short, theory, specification and heterogeneity uncertainties related to the model selection process produce different models.[16] Therefore, specifying the model space is the first step in handling the model uncertainty problem. However, the specification of the model space is generally based on the researcher's judgment. For example, whilst one researcher may interpret model uncertainty as proxy uncertainty, another may emphasise only heterogeneity uncertainty in the context of cross-country growth study.

Levine and Renelt (1992) is the first study to take into account model uncertainty in the empirical cross-country growth literature. Employing a variant of Leamer's extreme bounds analysis (Leamer (1983), Leamer and Leonard(1983)), these authors test the robustness of coefficient estimates for a large number of policy indicators as other explanatory variables alter. To illustrate the basic mechanism of a modified version of extreme bounds analysis (EBA hereafter) employed by Levine and Renelt (1992), consider the generic representation of cross-country growth regression expressed in equation (3.25) in the following

[16]As mentioned before, cross-country growth regression is a very good case for all levels of model uncertainty. However, it is worth recalling that other applied works in economics are not free from model uncertainty as defined here.

form

$$\varrho_i = \gamma + \pi X_i + \delta p_i + \psi Z_i + \upsilon_i \quad (3.26)$$

where X is the vector of variables always included in the regressions and consists of the initial level of real GDP per capita in 1960, the investment share of GDP, the initial secondary school enrolment rate, and the average annual rate of population growth; Z is a subset of variables chosen from a pool of over 50 variables suggested by previous growth studies and p is the variable of interest.

In order to carry out an EBA test, Levine and Renelt (1992) firstly run the benchmark regression including only X variables and the variable of interest, p. In the second step, the authors compute the regression results for all possible linear combinations of one to three variables from the pool of variables and determine the highest and lowest values for the coefficient estimate of variable of interest, $\hat{\delta}$, and its the corresponding standard error, $\hat{\sigma_\delta}$. The rationale for choosing up to three Z variables from the pool is to avoid the possible multicollinearity problem which inflates the standard errors of coefficient estimates. In addition, Levine and Renelt (1992) restrict the number of pool variables to seven which are used as fiscal, trade, monetary, macroeconomic uncertainty, and political stability indicators in the literature.[17] Otherwise, it is highly likely that the variable of interest loses its significance. Finally, for every variable of interest, they further restrict the pool of variables such that some variables are dropped from the pool if they measure the same phenomenon with respect to the variable of interest. Therefore, in this study, EBA is restricted such that total number of

[17] The pool of variables are the average rate of government consumption expenditures to GDP, the ratio of exports to GDP, the average inflation rate, the average growth rate of domestic credit, the standard deviation of inflation, the standard deviation of domestic credit growth and an index of the number of revolutions and coups.

explanatory variables included in any regression to be eight or less. In this regard, Levine and Renelt (1992) identifies the upper extreme bound as the highest value of $\hat{\delta}$ plus two times its standard error and define the lower extreme bound as the lowest value of $\hat{\delta}$ minus two times its standard error over all possible models for the variable of interest and then conclude the EBA test such that the variable of interest, p is robust if its coefficient is significant and has the same sign at the extreme bounds ($\hat{\delta} \pm 2\hat{\sigma_{\delta}}$). If the coefficient of variable of interest does not remain significant and/or changes its sign, then EBA test indicates that this variable is fragile.

In short, Levine and Renelt (1992) investigate the robustness of the relationship between growth and a variable of interest according to the stability of the sign and statistical significance of the estimated coefficient over all possible models. Using more than 50 variables over the 1960-1989 period, Levine and Renelt (1992) find that only the initial level of income and the share of investment in GDP are robustly correlated with growth. In other words, except for these two, they conclude that all variables are fragile.[18]

Sala-i-Martin (1997a,b) criticises Levine and Renelt (1992) and argues that the EBA test is too extreme as they conclude a variable is fragile if the coefficient estimate loses its statistical significance and/or changes its sign even in one regression. Sala-i-Martin (1997a,b) suggests that one should consider the whole distribution of $\hat{\delta}$, and assign a level of confidence for the robustness test instead of labelling a variable as robust or fragile according to extreme bounds. In order to compute the cumulative distribution function of $\hat{\delta}$, he calculates the weighted

[18]In addition, Levine and Renelt (1992) carry out the same analysis for the investment rate and conclude that only trade ratio is robustly and positively associated with investment.

averages of all estimates of δ and its corresponding standard error for each model as follows

$$\hat{\delta} = \sum_{i=1}^{M} \omega_i \hat{\delta}_i \tag{3.27}$$

$$\hat{\sigma_\delta} = \sum_{i=1}^{M} \omega_i \hat{\sigma}_{\delta,i} \tag{3.28}$$

where $\hat{\delta}$ and $\hat{\sigma_\delta}$ are the weighted averages of the coefficient of variable of interest and of its standard error over all possible models, respectively. The weights, ω_i are the critical point of the analysis and calculated as a proportion of the integrated likelihoods of each model as follows

$$\omega_i = \frac{\ell_{\delta i}}{\sum_m^M \ell_m} \tag{3.29}$$

where ℓ_m is the likelihood of each of the M models. Notice that $\sum_m^M \omega_i = 1$. As can be seen, the weighting scheme gives higher weights to the regressions or models which are more likely to be the true model. In order to measure the robustness of each variable, Sala-i-Martin (1997a) calculates the cumulative distribution function as follows: First, he assumes that $\hat{\delta}$ has a normal distribution over models, so he uses the normal distribution tables; Second, he relaxes the assumption that $\hat{\delta}$ has a normal distribution and calculates the cumulative distribution function as the weighted sum of a normal cumulative distribution function. The weights are again proportional to likelihoods. For the sake of comparability with Levine and Renelt (1992), Sala-i-Martin (1997a,b) allows the model to include three fixed variables namely income level in 1960, life expectancy in 1960 and primary school enrolment rate in 1960. Combining these fixed variables with a variable of interest and a trio from the pool consisting of 59 variables, Sala-i-

Martin (1997a) estimated nearly 2 million regressions. Differently from Levine and Renelt (1992), he tries every three combinations of doubtful variables in order to reduce computational burden. Therefore, his regressions always contain seven explanatory variables. Sala-i-Martin (1997a,b) argues that if 95 percent of cumulative distribution function of $\hat{\delta}$ lies on each side of zero, then that variable can be considered robust. Put differently, a variable is robust if its statistical significance and sign hold over 95 percent of all possible models. Unlike Levine and Renelt (1992), Sala-i-Martin (1992a) concludes that 21 of 59 variables are robustly correlated with growth. In his subsequent work, Sala-i-Martin (1997b) introduced the average investment rate between 1960 and 1990 as an additional fixed regressor. The reason for including average investment rate in the later study is to highlight the channels through which the variable of interest affects growth, namely via effects on the level of efficiency. Therefore, Sala-i-Martin (1997b) estimates two million more regressions combining four fixed variables with the variable of interest and again trios from remaining 59 variables and concludes that 17 of 59 variables are robustly correlated with growth.[19]

Even though the Levine and Renelt (1992) and Sala-i-Martin (1997a,b) versions of EBA provide useful information concerning the model uncertainty problem in the cross-country growth literature, these studies are subject to important drawbacks. Firstly, EBA is heavily criticised by McAleer et al. (1985) and Hendry and Mizon (1990). One criticism is that extreme bounds depend on the selection of doubtful variables. In other words, different selections yield different extreme bounds. Generally, most of EBA applications classify the variables

[19]Sala-i-Martin (1997a,b) also carried out his approach for fixed variables in order to gain same confidence about their robustness and found that initial income level, initial primary school enrolment, initial life expectancy and average investment rate are all robust determinants of growth.

as fixed and doubtful variables as in the case of Levine and Renelt (1992). This classification is sometimes arbitrary, even though it is reasonable and defendable in the study by Levine and Renelt(1992). Secondly, extreme bound levels can come from models which are unreasonable in some ways or even clearly poor. For instance McAleer (1994) criticises Levine and Renelt (1992) since they present summary statistics of extreme bounds without diagnostic tests and also ignoring functional form misspecification. Therefore, Granger and Uhlig (1990) propose *reasonable EBA* such that extreme bounds may come from models having R^2 values very close to maximum achievable value of R^2 over the model space. If this is done, then models with relatively low goodness-of-fit will be eliminated. Similarly, Temple (2000) suggests reporting a table listing models with the results of diagnostic tests instead of presenting only upper and lower extreme bounds. Thirdly and perhaps most importantly, if one of the doubtful variables is important in explaining the dependent variable, then fragile results are inevitably obtained. More clearly, while testing for the sensitivity of a particular variable of interest over all possible models, that key variable will be sometimes omitted. Models excluding key varible(s) certainly affect the sign and statistical significance of $\hat{\delta}$. Therefore, it is possible to conclude that EBA is useful but not efficient and so overstates model uncertainty. On the other hand one may argue that Sala-i-Martin (1997a,b) version of EBA is more reasonable than Levine and Renelt (1992), but statistical properties of this approach, especially the weighting scheme of models, are unclear since they are not based on a formal statistical theory (as Barro and Sala-i-Martin (2004) point out).

In summary, both versions of EBA fail to provide satisfactory solutions to the problem of identifying the true determinants of growth. Two approaches recently appeared in the literature. The general-to-specific modelling (GETS henceforth) approach[20] is based on the idea that the true model can be characterised by a sufficiently rich regression. This means that a regression including all possible regressors has all the information about the dependent variable. However, the information presented by the *general regression* can be represented by a parsimonious regression called the *specific regression*. Of course, this specific regression must have some desirable properties such that it must be well defined, it should encompass every other parsimonious regression and so on. In short, the GETS approach starts with the general model and then searches for a specific model comparing all possible models in the model space according to some statistical criterion. Bleaney and Nishiyama (2002), Hoover and Perez (2004), and Hendry and Krolzig (2004) apply this approach to cross-country growth regressions.

The paper by Bleaney and Nishiyama (2002) is, in essence, based on the encompassing test among three non-nested models for cross-country growth regressions suggested by Sachs and Warner (1997b), Barro (1997) and Easterly and Levine (1997). Even though these three models have some common explanatory variables, Bleaney and Nishiyama (2002) conclude that none of them dominates each other according to non-nested hypothesis testing procedures. This means that a model encompassing these three models fits the data better. Therefore, they combine the explanatory variables of the three models and eliminate them according to the GETS approach to derive a specific model which passes a battery of statistical tests successfully. According-

[20] It is some times referred to as London School of Economics (LSE) methodology.

ing to Bleaney and Nishiyama (2002), this model cannot be improved by adding or omitting any variable, and can be used as a benchmark model in order to test new growth theories.

Hoover and Perez (2004) and Hendry and Krolzig (2004) apply the GETS methodology directly to the data set employed by Sala-i-Martin (1997a,b) after some adjustment.[21] In both studies, a linear model including the number of revaluations and coups, the ratio of equipment investment, fraction of confucians, fraction of open years according to Sachs and Warner (1995) criteria and fraction of protestants as explanatory variables of growth is estimated.[22]. An interesting point concerning the results of these two studies is that the R^2 values of the regressions are found to be 0.42 and 0.44, respectively. This implies that the selected models explain less than 50 percent of the cross-country growth differentials. In addition, theoretically important variables, such as initial income level and variables relating to human capital, are not included in the final model.

One important criticism of the GETS methodology is that there can be several simplification paths from the general model and there is no guarantee that a particular simplification path leads to the true model. That is why, the GETS approach is some times referred as "sophisticated data mining", as Hendry (1995) points out. However, Hoover and Perez (2004) and Hendry and Krolzig (2004) argue that the GETS approach employed in their papers is based on multiple-path searching program in order to handle this objection. In other words, both studies implement the GETS approach by employing the automated search

[21] The original data set used by Sala-i-Martin (1997a,b) contains 64 variables (including the dependent variable) for 138 countries. After a number of variables and countries are dropped from the data set in order to provide a complete data matrix, the resulting data set includes 126 countries and 61 variables and the dependent variable.

[22] Hendry and Krolzig (2004) also apply the GETS methodology on the data set used by Fernández et al. (2001b).

algorithm first suggested by Hoover and Perez (1999) and improved by Krolzig and Hendry (2001), in order to take into account competing models derived from different search paths and to select one on the basis of encompassing tests. In particular, the *PcGets* algorithm developed by Hendry and Krolzig (2005) is effective in reducing searching costs when the initial model is more general than needed.

The selection process of the specific model is based on six stages: First, assuming the true model is nested in a sufficiently rich model, a general unrestricted model (GUM) is formulated. In the second and third stages, a set of mis-specification tests and selection criteria are applied for final selection between mutually encompassing congruent models and then the GUM is estimated to check the congruence of the specification. Therefore, after the second and third stages, the GUM is reformulated as a baseline general model for the next steps. Fourth, a pre-search reduction process is carried out. In other words, the highly insignificant variables are eliminated using a less stringent significance level in order to simplify large dimensional problems. Thus, this stage is optional, not necessary. The fifth and main stage consists of multiple-path reduction searches. In this stage, many possible reduction paths are undertaken from each feasible initial deletion and each reduction is diagnostically evaluated for the congruence of the final model. That is, after a particular reduction path, if all diagnostic tests are successfully passed and all remaining variables are statistically significant, then that model is considered as a terminal specification. Next another reduction path is searched and hence another terminal model is selected and so on. After all possible paths are investigated and all terminal models are determined, encompassing tests are carried out for each union of terminal models to find an undominated encompassing contender.

The union of surviving terminal models which is referred to as the smaller GUM is employed for a new multiple-path reduction search. The search process continues until a unique model, called the specific model, emerges. In the sixth and final stage, the significance of every variable in the final model is evaluated in two overlapping sub-samples for reliability of the specific model. [23]

The second approach is Bayesian model averaging (BMA hereafter) which was developed by, *inter alia*, Madigan and Raftery (1994), Hoeting (1994), Chatfield (1995), Draper (1995), Raftery et al. (1997).[24] The basic idea of BMA is to incorporate the model uncertainty into statistical inference such that the true model is considered as an unobservable random variable. In this regard, BMA takes into account model uncertainty over a variable of interest making inferences based on the weighted averages of all possible models. Therefore, differently from the GETS approach, the main aim of BMA is to provide a better parameter estimate of the variable of interest rather than to find the best model. Fernández et al. (2001b), Brock and Durlauf (2001), Sala-i-Martin et al. (2004), Eris (2005), Masanjala and Papageorgiou (2005, 2007), Durlauf et al. (2006, 2007) are examples of the application of BMA in the cross-country growth context.[25] BMA is detailed in Chapter 6 in which we empirically investigate the openness-growth connection applying this approach on the cross-country growth data.

Even though we prefer BMA in this dissertation, we do not purport

[23]While applying the *PcGets* algorithm, one can set any selection criteria for the significance levels, from strong to weak. The program also provides two basic strategies for these, namely liberal and conservative strategies. Both strategies are based on the critical values depending on sample size and for large samples on the number of possible explanatory variables. If there are many potentially irrelevant variables and few relevant variables, the conservative strategy is suggested. Conversely, for few irrelevant and many relevant variables, liberal strategy is better (Granger and Hendry (2005)).

[24]The basic paradigm for BMA was presented by Leamer (1978). See Hoeting et al. (1999) for the historical development of BMA.

[25]The approach in Sala-i-Martin (1997a,b) is close in spirit to that of BMA.

that we have a negative view about the GETS approach. Obviously, both approaches are valuable statistical techniques for tackling model uncertainty and have their own advantages and disadvantages.[26] There is no doubt that the GETS approach is particularly useful if one needs a specific model for some purpose, e.g. forecasting.[27] On the other hand, one advantage of BMA is that it provides a better framework for policy evaluation as discussed in the next section.

3.4 Model Uncertainty and Policy Evaluation in Cross-Country Growth Regression

Undoubtedly, the most important aim of cross-country growth studies is to explain growth differences across countries and to suggest policy implications which may be effective in promoting growth. Brock and Durlauf (2001, p.230) argue that "[I]n emprical macroeconomics, efforts to explain cross-country differences in growth behavior since World War II become a predominant area of research. The implications of this work for policymakers are immense... [I]n turn, the academic community has used this new empirical work as the basis for strong policy recommendations." However, as indicated by Brock and Durlauf (2001),

[26]There is a vast statistical literature debating classical versus Bayesian approaches on model uncertainty and model selection problem. See, for instance Chatfield (1995), Hoover and Perez (1999), Pötscher (1991), Granger and Hendry (2005), Hansen (2005). It is obvious that the solution of the matter is beyond the scope of this dissertation. Yet, we just remind that classical econometric model selection methods such as the GETS approach suffer from four conceptual errors namely parametric vision, the assumption of true data generating process, evaluation based on fit, ignoring the effect of model uncertainty on subsequent statistical inference as noted by Chatfield (1995) and Hansen (2005). Although BMA directly takes into account the impact of model uncertainty on inference, as discussed in Chapter 6, specifying appropriate priors over different models is challenging.

[27]Another advantage of the GETS approach is that it is labour saving as noted by Hendry and Krolzig (2005). For instance, according to Hendry and Krolzig (2004), implementation of GETS approach to Sala-i-Martin (1997a,b)'s data set by *PcGets* takes approximately two hours, including stacking the data.

Brock et al. (2003), Easterly (2005) and Rodrik(2005) this literature largely fails with respect to the perspective of policy evaluation. While Rodrik (2005) points out the endogeneity problem between the policy variable and economic growth, Easterly (2005) argues that the strong effects of policies obtained from cross-country growth regressions are mainly a result of extreme observations. Brock and Durlauf (2001) and Brock et al. (2003) emphasise the difficulty of macroeconomic policy evaluation in the presence of model uncertainty.

According to Brock and Durlauf (2001) and Brock et al. (2003), policy analysis can be carried out on the basis of two factors, namely the policy maker's preferences and a conditional distribution of the outcome of interest given the policy and available information. The authors argue that standard practice in the cross-country growth literature is uninformative from the perspective of policy evaluation since it fails to appropriately define the policy maker's preferences and ignores model uncertainty. Hence, Brock and Durlauf (2001) and Brock et al. (2003) propose that cross-country growth work for policy recommendations requires an explicit decision-theoretic formulation. Using the findings of modern statistical decision theory[28], these authors integrate model uncertainty into policy analysis.[29] In this section, we briefly summarise the implications of model uncertainty for policy evaluation in the context of cross-country growth regressions.

Recall the generic representation of cross-country growth regression

[28]Wald (1950), Brainard (1967), Chamberlain (2000) Sims (1980), Berger (1985), Manski (2000), Heckman (2001) Sims (2002) are few examples.

[29]Although Brock and Durlauf (2001) and Brock et al. (2003) focus mainly on the cross-country empirical growth work, the framework developed by these authors are explicitly subject to other macroeconomic empirical analysis in formulating policy recommendations in the presence of model uncertainty. For a more general context concerning the issue see Brock and Durlauf (2006) and Brock et al. (2007). In terms of policy analysis, a related direction of the literature is carried by Hansen and Sargent (2001) that emphasise the robust control theory to analyse macroeconomic policy under the model uncertainty.

expressed in equation (3.26). The key question in the context of policy evaluation is how a policy maker can use the cross-country growth regressions in order to formulate policy recommendations for enhancing the growth in country i.[30] Suppose that variable p in equation (3.26) represents a policy variable of interest which can be controlled by the policy maker. The standard answer to this question in the growth literature is to make policy suggestions according to the hypothesis tests for the coefficient corresponding with the policy variable of interest. More precisely, a policy maker recommends a change in the magnitude of the policy variable p for stimulating growth in country i according to the statistical significance of δ, typically assessed at 5 percent level, using a single model and a given data set. Obviously, this policy evaluation is conditional on the model employed by policy maker as well as data set.

The first problem with this kind of policy analysis in the context of cross-country growth regressions is that it neglects theory, specification and heterogeneity uncertainties. Secondly, even if model uncertainty can be eliminated, policy analysis based on statistical significance is problematic from the perspective of policy maker's preferences. In order to explain these problems more clearly, following the notation of Brock and Durlauf (2001) we define the policy maker's preferences in terms of utility (or objective) function as

$$V(\varrho_i, O_i) \tag{3.30}$$

where ϱ_i is growth rate of per capita GDP in country i, as previously

[30] As noted by Eris (2005), the term "policy maker" is used in a broader sense in the manner that he or she may be an economist suggesting a government to implement a particular policy, say openness to international trade, using some cross-country growth regression.

defined, and O_i indicates the set of characteristics in country i affecting policy maker's utility. In the context of policy maker's utility function, implementing or suggesting a policy change which is effective for enhancing growth depends on comparisons of policy maker's utilities in alternative settings. More clearly, if the policy maker believes that a particular policy variable has some effect in increasing growth, then he faces two options: either implementing or not implementing a policy change. Therefore, denoting the level of policy variable by p, policy maker's decision set will be $A = \{0, dp_i\}$, where dp_i represents the policy change and for simplicity it is assumed to be positive. The objective of empirical work is to develop a decision rule which is conditional on observable data D. Since the cross-country growth regression in equation (3.26) is linear, the effect of a marginal change in p is δ. Therefore, the growth rate in country i will be $\varrho_i + \delta dp_i$ in the case of a policy change while it is ϱ_i in the absence of policy implementation. Policy evaluation requires comparison of expected utilities of policy maker with and without policy change

$$E(V(\varrho_i + \delta dp_i, O_i)|D) - E(V(\varrho_i, O_i)|D) \tag{3.31}$$

where E represents the expected value operator. The standard approach in the empirical cross-country growth literature is to compute this comparison selecting one model as if it is true model and applying a statistical significance test. A statistically insignificant coefficient is taken to mean that a particular policy is not important for economic growth while the statistical significance is used as strong evidence that the policy is important for economic growth. This kind of decision rule is implicitly assumed that the policy maker's utility function is defined by

$$E(V(\varrho_i + \delta dp_i, O_i)|D) - E(V(\varrho_i, O_i)|D) = [\widehat{\delta}(dp_i) - 2\hat{\sigma_\delta}(dp_i)] \geq 0 \tag{3.32}$$

where $\widehat{\delta}$ and $\hat{\sigma_\delta}$ denote the OLS coefficient estimate of policy variable p and its corresponding standard error, respectively. Obviously both are conditional on a particular model. Then one would suggest policy implementation in the form of dp_i if the t-statistic in OLS regression is equal or greater than 2 (2 is selected according to typical assessment of statistical significance level at 5 percent). However, policy analysis based on significance level is troublesome in many ways even if the model used in OLS regression is true as argued by Brock and Durlauf (2001), Durlauf (2002) and Brock, Durlauf and West (2003). We emphasise two important problems: First, the policy maker evaluates a particular policy only using the mean and variance of the policy variable. However, the whole probability distribution of δ might be important for policy analysis. For instance, a policy maker may be more sensitive to negative growth rates than positive ones or the effect of growth on poverty can be asymmetric and a typical policy maker tries to act in socially acceptable way. Second, even if the policy maker takes into account only the mean and variance of policy variable of interest, policy analysis based on statistical significance considers the effect of policy change on the component of growth rather than the effect of the policy change on growth per se. In other words, a statistically significant coefficient of estimate shows the marginal effect of the policy variable on growth and does not provide a clear answer whether policy change should be implemented.

The message of these criticisms is that one should define more appropriate utility functions and assess a policy change under alternative policy scenarios.[31] Obviously, this policy evaluation will be based on a particular model only if policy maker is certain that the model at hand is true. Yet, since he is not certain about the true model, this adds another uncertainty to the uncertainty over parameter δ. In the case of model uncertainty, the policy maker will not want to evaluate a policy change according to a particular model. Instead, he or she will want to make expected utility comparison expressed in equation (3.31), conditioning on data. This means that comparison of expected utilities for a given policy should be based on the assumption that the true model is not known. Since calculation of expected utility information expressed in equation (3.31) contains all information for policy evaluation, in the absence of information about the true model, this expression explicitly requires accounting for model uncertainty since expected utilities are conditional on only data not on possible models. Therefore, this requires us to modify the expected utility comparison equation as

$$E(V(\varrho_i + \delta dp_i, O_i)|D) - E(V(\varrho_i, O_i)|D) = \\ \sum_k P(M_k|D)E(V(\varrho_i + \delta dp_i, O_i)|D, M_k) - \sum_k P(M_k|D)E(V(\varrho_i, O_i)|D, M_k) \tag{3.33}$$

[31] Brock and Durlauf (2001) and Brock et al. (2003) explore policy implications of cross-country growth analysis employing some alternative utility functions such as risk neutrality, ambiguity aversion and so on. According to these authors, the utility functions that they examine are not particularly compelling, but they are useful to illustrate in order to interpret growth regressions for policy analysis in the presence of model uncertainty. For instance, these authors indicate that EBA employed by Levine and Renelt (1992) corresponds to an extreme risk aversion utility for policy maker. More compactly, according to EBA a policy change is implemented only if

$$E(V(\varrho_i + \delta dp_i, O_i)|D) - E(V(\varrho_i, O_i)|D) > 0$$

for every model in the model space. See Eris (2005) for a nice treatise showing what kind of decision rules arise under the considerations of different assumptions for the policy maker's utility functions and policy robustness preference parameters accounting model uncertainty.

where $P(M_k|D)$ is the probability that model M_k is the true causal relationship between the growth rate and explanatory variables for given data, D. Therefore, the last equation explicitly accounts model uncertainty and as mentioned before, the aim of any policy relevant empirical work is to compute these expected utilities.

As can be seen, equation (3.33) illustrates that the expected utility comparison depends on the weighted averages of the coefficient of the policy variable, and expected utility calculations are independent of a particular model. Rather, the true model as an unobservable random variable is integrated to this calculation. Hence, the second important message is that identifying a particular model(s) according to some model selection criteria does not have any intrinsic value from the perspective of policy evaluation in the presence of model uncertainty. In contrast, the standard practice in the literature evaluates a policy change according to a particular model and sometimes compares the coefficient estimates with those obtained from modified specifications of that model in order to provide robustness of data analysis. This kind of policy analysis not only does ignore model uncertainty but also does not provide a clear information for policy evaluation. For instance, if the estimated coefficient of a policy variable is large in one regression while small in another, drawing a conclusion concerning the policy variable of interest is unclear. However, the calculation in equation (3.33) clearly removes this kind of concerns since each possible model is integrated into the calculation. This methodology, known as 'model averaging' in the statistics literature, is a coherent way not only in order to handle model uncertainty but also for policy evaluation.

3.5 Conclusion

In this chapter, we reviewed the recent cross-country growth literature aiming at explaining growth differences across countries using regression analysis and other statistical methods. Even though this literature was mainly inspired by endogenous growth theories, the neoclassical growth model, especially its augmented version by Mankiw et al. (1992) is still the workhorse for cross-country growth empirics. For instance Mankiw (1995) argues that "[I]f the goal is to explain why standard of living is higher today than a century ago, then neoclassical model is not very illuminating. . . [A] more challenging goal is to explain the *variation* in economic growth that we observe in different countries in different times (p.280). . . [E]ndogenous growth models provide a plausible description of worldwide advances in knowledge. The neoclassical growth model takes world wide technological advances as given and provides a plausible description of international differences (p.308)."

The most outstanding feature of the recent empirical cross-country growth literature is that a large number of factors have been suggested as fundamental growth determinants. Together with the small sample property, this leads to an important problem, model uncertainty: Which factors are more fundamental in explaining growth dynamics and hence growth differences are still the subject of academic research. Recent attempts based on general-to-specific modeling or model averaging are promising but have their own limits.

Closely related to model uncertainty, and indeed the ultimate goal of the literature is policy evaluation. In spite of the fact that model uncertainty has been recognised since the important work by Levine and Renelt (1992), it is very surprising that cross-country studies have been used for policy analysis without paying attention to model uncertainty. It is obvious that any policy recommendation derived from a particular cross-country growth regression is troublesome since in the presence of model uncertainty it is conditional on the selected model.

Although we emphasise model uncertainty in this chapter, other econometric problems, especially parameter heterogeneity and outliers are equally important in this literature. Due to these problems, cross-country growth empirics can be considered as a mix of economic theory and statistics and it might be more reasonable to refer to it as "growth econometrics" as Durlauf et al. (2005) point out.

In conclusion, given the challenging econometric problems, the results of cross-country growth studies have been controversial in terms of robustness. The implications of this are threefold: First, it is more plausible to accept cross-country growth studies as a wider picture of growth process. This means that combining findings of this literature with detailed case studies is a worthwhile task. Second, it may be more useful to shift research agenda towards more practical or pragmatic issues rather than the international growth differences as suggested by Pritchett (2000). Third, introducing new statistical tools and better proxy variables will make cross-country growth studies more informative.

3.A Appendix: Derivation of Convergence Coefficient in the Augmented Neoclassical Growth Model

Recall the intensive form of three factor Cobb-Douglas production function expressed in equation (3.13). The growth rate of output per unit of effective labour is given by (for simplicity the time subscript t is dropped)

$$\dot{\tilde{y}}/\tilde{y} = \alpha\dot{\tilde{k}}/\tilde{k} + \beta\dot{\tilde{h}}/\tilde{h} \tag{3.34}$$

The last equation shows that the growth rate of output per unit of effective labour is the weighted average of the growth rates of physical and human capitals per unit of effective labour. We previously depicted the evaluation of economy in equations (3.14) and (3.15). Substitute the equations (3.14) and (3.15) into equation (3.34). This yields

$$\begin{aligned}\dot{\tilde{y}}/\tilde{y} = \alpha[s_K e^{-(1-\alpha)log\tilde{k}} e^{\beta log\tilde{h}} - (n+g+\delta)] \\ +\beta[s_H e^{\alpha log\tilde{k}} e^{-(1-\beta)log\tilde{h}} - (n+g+\delta)]\end{aligned} \tag{3.35}$$

Taking the log approximation of first-order Taylor series around the steady-state gives

$$\begin{aligned}\dot{\tilde{y}}/\tilde{y} = \{\alpha[s_K e^{-(1-\alpha)log\tilde{k^*}} e^{\beta log\tilde{h^*}}][-(1-\alpha)] \\ +\beta\alpha[s_H e^{\alpha log\tilde{k^*}} e^{-(1-\beta)log\tilde{h^*}}]\}(log\tilde{k} - lo\tilde{g}k^*) \\ +\{\alpha\beta[s_K e^{-(1-\alpha)log\tilde{k^*}} e^{\beta log\tilde{h^*}}] \\ +\beta[s_H e^{\alpha log\tilde{k^*}} e^{-(1-\beta)log\tilde{h^*}}][-(1-\beta)]\}(log\tilde{h} - log\tilde{h^*})\end{aligned} \tag{3.36}$$

Due to the fact that at the steady-state $\dot{\tilde{k^*}} = 0$ and $\dot{\tilde{h^*}} = 0$, we can write the following expression

$$s_K \tilde{k^*}^{\alpha-1} \tilde{h^*}^{\beta} = s_H \tilde{k^*}^{\alpha} \tilde{h^*}^{\beta-1} = n+g+\delta \tag{3.37}$$

Rearranging equation (3.36) by employing the last expression yields

$$\dot{\tilde{y}}/\tilde{y} = -(1-\alpha-\beta)(n+g+\delta)[\alpha(log\tilde{k} - log\tilde{k^*}) + \beta(log\tilde{h} - log\tilde{h^*})] \tag{3.38}$$

This follows

$$\dot{\tilde{y}}/\tilde{y} = -\lambda^*(log\tilde{y} - log\tilde{y^*}) \tag{3.39}$$

where $\lambda^* = (1-\alpha-\beta)(n+g+\delta)$ is the convergence rate in the vicinity of steady-state.

Chapter 4

Augmented Neoclassical Growth Model: A Replication over the 1960-2000 Period

4.1 Introduction

This chapter empirically examines the augmented neoclassical growth model suggested by Mankiw, Romer and Weil (1992, MRW henceforth). We attempt to answer whether MRW provide an appropriate benchmark model in order to investigate the relationship between long run economic growth and openness (more generally any particular growth theory) for the 1960-2000 period. For this we replicate MRW using updated and revised data for several samples, and compare our findings with those obtained by MRW.

As noted in Chapter 3, the framework provided by MRW is the workhorse in the empirical cross-country growth literature and most of the studies in this literature are based on MRW. However, our replication is different from these studies in some aspects: First, most of the studies in the literature estimate MRW over the 1960-1990 or the 1970-1990 period. In this chapter, we estimate MRW over the period of 40 years, which should be sufficiently long to reflect long run growth dynamics; second, many previous studies employ a proxy variable for the initial level of human capital stock rather than the saving rate for human capital. In this chapter, we strictly follow MRW by employing the secondary school enrolment rate.

Our findings are consistent with the theory and support the results of MRW. Both our cross-country regression results and those obtained by MRW show that the investment rates of both physical and human capital significantly contribute to the growth rates of countries, while the rate of population growth has a negative effect on growth in the long run. In addition, we obtain more reasonable coefficient estimates on capital shares. We also check for geographical differences and for outlying countries. We conclude that the inclusion of continental dummy variables does not change the basic results and any outlier effects are very small.

This chapter is organised as follows: Section 2 firstly describes the basic framework of MRW and data and then reports and discusses basic findings. Section 3 seeks geographical differences. Section 3 deals with the outlier problem. Section 4 concludes.

4.2 Replication of Augmented Neoclassical Growth Model by MRW

In this section, we estimate the augmented neoclassical growth model developed by MRW by using updated data over the period 1960-2000 and compare our findings with those obtained by MRW. In other words, we set up this model for the period 1960-2000 since we specifically aim to answer whether augmented neoclassical growth model is an appropriate benchmark model in order to investigate the relationship between long run economic growth and openness. This means that the explanatory variable in our cross-country growth regressions is growth rate of output per worker between 1960 and 2000. Our data set typically covers 107 countries.[1] The sample of countries is listed in the Appendix.

4.2.1 Description of Benchmark Model

As explained and discussed in detail in Chapter 3, MRW produce the following equation for cross-country growth regression

$$\varrho_i = \pi_0 + \pi_1 log y_i(0) + \pi_2 log(n_i + g + \delta) + \pi_3 log s_{i,K} + \pi_4 log s_{i,H} + \upsilon_i \quad (4.1)$$

[1] In this point we follow the standard approach in the literature. More clearly we randomly select countries according to the criterion of data availability. At the first sight this approach seems reasonable. However, missing data, especially if the data of some particular countries are systematically missing (such as very poor countries or countries in transition) is a serious problem as noted by Durlauf et al. (2005).

where

$$\varrho_i = t^{-1}(logy_i(t) - logy_i(0))$$
$$\pi_0 = g + \eta a$$
$$\pi_1 = -\eta$$
$$\pi_2 = -\eta\frac{\alpha+\beta}{1-\alpha-\beta}$$
$$\pi_3 = \eta\frac{\alpha}{1-\alpha-\beta}$$
$$\pi_4 = \eta\frac{\beta}{1-\alpha-\beta}$$
$$\upsilon_i = \mu_i + \eta\varepsilon_i$$
$$\eta = t^{-1}(1 - e^{-\lambda^* t})$$

In equation (4.1), y_i and $(n_i+g+\delta)$ denote the level of GDP per worker and the sum of rates of population growth, technological progress and depreciation in country i, respectively. Similarly, the terms $s_{i,K}$ and $s_{i,H}$ represent the rates of accumulation of both physical and human capital for country i. Hence, one can see that growth rate of per worker output, ϱ_i in equation (4.1) is measured annually over the time period between 0 and t. However we prefer to construct the growth rate as the log difference from time 0 to time t in this chapter in order to compare our results with those of MRW directly and to make interpretation of results easier. As noted in Chapter 3, measuring the average growth rate over a particular time period as either annually or log difference is in essence the same and the results will be identical in the manner that one can easily convert and interpret results obtained from one approach to those obtained from another. That is why, we will use the following specification which is obtained from multiplication of equation (4.1) by time t.[2]

$$logy_i(t) - logy_i(0) = \gamma_0 + \gamma_1 logy_i(0) + \gamma_2 log(n_i + g + \delta) + \gamma_3 logs_{i,K} + \gamma_4 logs_{i,H} + \varepsilon_i \tag{4.2}$$

where

$$\begin{aligned}
\gamma_0 &= gt + \theta a \\
\gamma_1 &= -\theta \\
\gamma_2 &= -\theta \frac{\alpha + \beta}{1 - \alpha - \beta} \\
\gamma_3 &= \theta \frac{\alpha}{1 - \alpha - \beta} \\
\gamma_4 &= \theta \frac{\beta}{1 - \alpha - \beta} \\
\varepsilon_i &= \mu_i + \theta \varepsilon_i \\
\theta &= t\eta = (1 - e^{-\lambda^* t})
\end{aligned}$$

As can be seen in both equations (4.1) and (4.2), the augmented neoclassical growth model basically involves regressing growth rates on the log of initial income and a set of long-run equilibrium or steady-state level of income determinants. Put differently, growth rates of output per worker can vary across countries either because of differences in the variables determining their steady-state levels namely saving rates for physical and human capital, and rate of population growth respectively or because of differences in the initial level of output per worker, $logy_i(0)$.

Following MRW, we assume that the sum of rates of depreciation

[2]Moreover, it is a well-known fact that if the dependent variable is multiplied by a particular constant, then the OLS intercept and slope estimates are also multiplied by that constant

and technological progress is constant and equal to 0.05 across countries and estimate equation (4.2) over the period 1960-2000. For this purpose, we measured $s_{i,K}$ by the ratio of real investment to real GDP and $s_{i,H}$ by the secondary school gross enrolment rate. As mentioned in Chapter 3, using the school enrolment rate as a proxy for the saving rate of human capital is problematic and leads researchers to employ average years of schooling as more reliable variables for human capital. We, however, employ the secondary school enrolment rate in order to follow the theoretical framework more strictly as years of schooling are a stock rather than a flow variable for human capital. In addition, school enrolment rates are available for a larger sample of countries. Data are compiled from standard sources: GDP per capita and investment rates are taken from the Penn World Tables Version 6.1 (Heston, Summers and Aten, 2002); population, labour force and gross secondary school enrolment rates come from the World Bank World Development Indicators (2002; 2006). Using labour force as the total population between ages 15 and 64, per capita GDP is converted to per worker GDP. All of these variables are averaged over the period 1960-2000 except the initial level of income. The variables and their sources are detailed in the Appendix.

In summary, our baseline cross-country growth specification for each country i as follows

$$\begin{aligned} logy_{i,2000} - logy_{i,1960} = \gamma_0 + \gamma_1 logy_{i,1960} + \gamma_2 log(n_i + g + \delta) \\ + \gamma_3 log(Investment\ rate_i) \\ + \gamma_4 log(School\ enrolment_i) + \varepsilon_i \end{aligned} \tag{4.3}$$

4.2.2 Results

Before evaluating the regression results, we want to emphasise two points about the regressions. First, in each regression we check the normality assumption applying median and inter quartile range comparison suggested by Hamilton (1992) which is originally based on Hoaglin, Iglewicz and Tukey (1986) on regression residuals and conclude that residuals are normally distributed. Therefore, we may assume that actual errors are normally distributed (at least approximately).

Second, in each regression we also check the constant error variance assumption by employing the Breusch-Pagan test for heteroscedasticity. The common practice in the cross-country growth literature for dealing heteroscedasticity is reporting regression results with the heteroscedasticity consistent (White-robust) standard errors since they work well regardless of heteroscedasticity in the actual errors. However, these standard errors are consistent but not unbiased. More clearly they are justified only asymptotically. In small samples, heteroscedasticity consistent standard errors may have distributions that are not close to those of usual standard errors which means that they may be larger or smaller than the usual ones. As pointed out by Wooldridge (2003) heteroscedasticity consistent standard errors are generally found to be larger than the usual standard errors. This can affect the subsequent statistical inference such that one can conclude that a variable is statistically insignificant according to t-test based on the heteroscedasticity consistent standard errors even if that variable is significant (at least marginally) in the case of usual t-test. Therefore, there is no reason to use heteroscedasticity consistent standard errors as long as the homoscedastic error variance assumption holds and the errors are normally distributed. Hence, we carry out regression analysis employing t-statistics based on the usual standard errors unless we reject the homoscedasticity assumption. We report t-statistics based on the heteroscedasticity consistent standard errors only for the regressions in which the assumption of homoscedastic error variance is rejected.

Table 4.1 presents the OLS estimates of equation (4.3). In column 1, the model is estimated for a sample of 107 countries whose data are available over the 1960-2000 period. All variables have the expected signs and are found to be strongly significant.

In the literature, some studies exclude oil producing countries from cross-country samples since a substantial part of GDP in these countries depends on the usage of their oil resources rather than value added. However, omitting oil producing countries from sample may not be appropriate if the main objective of cross-country growth studies is to highlight the fundamental determinants of growth differences across countries. A comprehensive cross-country growth work should also explain the growth dynamics of these countries. As pointed out by Sachs and Warner (1997c) in the framework of recent growth theories emphasising the role of natural resources in the growth process, dropping oil countries from the sample may affect the regression results since oil producing countries are an important sub-group of natural resource intensive countries. Column 2 displays regression results after five oil producing countries are excluded from the full sample.[3] The estimation results of the non-oil sample are only slightly different from those of the full sample and hence we can conclude that five oil producing countries in the full sample are not changing the basic results. Therefore, we prefer to employ the full sample for our cross-country empirical investigation.

[3]These countries are, Algeria, Indonesia, Nigeria, Oman and Venezuela.

Table 4.1: Augmented Neoclassical Growth Model: OLS Estimates

Dependent Variable: Log Difference real GDP per worker over the 1960-2000 period

	Our Estimation Results: 1960-2000 period							Estimates of MRW[†] 1960-1985 Period		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sample	Full	NonOil	OECD[a]	NonOECD	High Income	Low Income	p-value[b]	NonOil	Intermediate	OECD
log GDP per worker 1960	-0.442	-0.423	-0.568	-0.448	-0.465	-0.393	0.68	-0.288	-0.366	-0.398
	(6.54)	(5.95)	(3.63)	(6.30)	(4.05)	(2.56)		(4.68)	(6.24)	(5.67)
$\log(n_i + g + \delta)$	-1.049	-0.906	-0.262	-1.023	-1.302	-0.735	0.73	-0.506	-0.545	-0.863
	(2.83)	(2.36)	(0.39)	(1.82)	(3.07)	(0.96)		(1.75)	(2.36)	(2.56)
log of Investment rate	0.411	0.410	0.588	0.390	0.581	0.389	0.55	0.524	0.538	0.332
	(4.47)	(4.43)	(1.63)	(3.07)	(3.05)	(3.24)		(6.03)	(3.98)	(1.91)
log of School enrolment	0.450	0.449	0.408	0.445	0.333	0.476	0.74	0.231	0.270	0.228
	(5.18)	(5.08)	(0.80)	(5.79)	(1.98)	(4.08)		(3.89)	(3.12)	(1.57)
Constant	2.782	3.014	6.492	2.834	2.522	3.225	0.70	1.874	2.498	4.155
	(2.56)	(2.72)	(2.31)	(1.76)	(1.63)	(1.32)		(2.22)	(3.15)	(4.16)
p-value for heteroscedasticity[c]	0.66	0.60	0.07	0.13	0.75	0.31		0.24	0.01	0.20
Number of observations	107	102	26	81	52	55		98	75	22
Adjusted R^2	0.61	0.61	0.60	0.56	0.61	0.58		0.46	0.43	0.65
Implied λ^*	0.0146	0.0137	0.0210	0.0149	0.0156	0.0125		0.0136	0.0182	0.0203

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported. All variables, except initial level of income are averaged over the 1960-2000 period. The variable, $(n_i + g + \delta)$ refers to sum of rates of population growth, technical progress and depreciation.

[†] Estimates of augmented neoclassical growth model in table V, page 426 of Mankiw, Romer and Weil (1992). Dependent variables for these regressions are log difference GDP per worker over the period 1960-1985.

[a] Czech Republic, Germany, Poland and Slovak Republic are excluded due to missing data.

[b] The p-value refers to the hypothesis that individual coefficients are the same for the low and high income samples.

[c] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

In columns 3 and 4, the full sample is divided according to the membership of the OECD. Estimation results for the 26 OECD countries and for remaining countries are given in columns 3 and 4, respectively. As can be seen, the results for the OECD sample are not very precise since, except for the initial level of income, all variables are found to be statistically insignificant. An important reason is that the sample size for this regression is small. Therefore, the regression result is very sensitive to including or excluding observations.[4] Another, and more important, reason is that the relatively high coefficient of initial income and high level of R^2 imply greater absolute convergence for the OECD countries.[5]

The results for the remaining non-OECD countries indicate that all variables are strongly significant with expected signs. In columns 5 and 6, we divide the full sample into low-income and high-income countries according to initial income level. For this, we calculated the median of the GDP per worker in 1960 and classified the countries with initial income above the sample median as high income, while those with initial income below the sample median as low income countries. As can be seen, almost half the sample consists of high income countries since the

[4]While estimating the augmented neoclassical growth model for the OECD sample, we consider all OECD members except Germany, Poland, Czech Republic and Slovakia. These countries are omitted due to the missing data. However, one can prefer to select the OECD sample which consists of only larger countries as in the case of MRW, or to employ an OECD sample including only members since the foundation of OECD or use the OECD sample based on only high-income members which means that low-income members such as Turkey and Mexico excluded as in the case of Barro and Sala-i-Martin (2005). We also check these possibilities and conclude that all variables are insignificant except initial level of income in each case. However, in some cases (for instance when we estimate the model for 22 high-income OECD countries) we find that the coefficient of school enrolment rate is negative. On the other hand in each case the remaining non-OECD samples yield the regression results which are very close to those reported in the Table 4.1

[5]Testing of absolute convergence hypothesis for the OECD sample yields the following cross-country growth regression (heteroscedastic-consistent t-statistics are in parentheses)

$$logy_{i,2000} - logy_{i,1960} = \underset{(3.94)}{5.247} - \underset{(3.21)}{0.451} logy_{i,1960} \quad \bar{R}^2 = 0.40$$

median is calculated for all countries. Another distinguishing feature of this separation is that a majority of countries located in East Asia and Pacific belong to the low income country sample since these countries start the sample period with a relatively low GDP per worker.[6] Estimation results for both groups are displayed in columns 5 and 6. All variables, except the intercept terms and population growth for the low income sample, have the expected sign and are strongly significant. However, the coefficients of the initial income, population growth and investment rate are higher in the high income sample than those in low income group while the opposite situation is true for the coefficient of secondary school enrolment rate. In order to check parameter stability for these two income groups, a joint test for null hypothesis of equality of all coefficients across two samples concludes that the null cannot be rejected with a high probability level.[7] In addition, the same test is carried out across pairs of coefficients. As can be seen from p values in column 7, test results show parameter stability for each individual coefficients between two income groups. Therefore, it is possible to conclude that parameters are stable across high income and low income countries.

In general, the regression results presented in Table 4.1 are consistent with the theory and support the results of MRW. In order to facilitate comparison of our results with those of MRW, we also present their regression results in the last three columns in Table 4.1.[8] Both

[6]According to our criteria we classified the following countries located in East Asia and Pacific as low income countries: China, Indonesia, Malaysia, Papua New Guinea, Philippines, Singapore, South Korea, and Thailand. Similarly, a majority of the countries located in Sub-Saharan Africa are defined as low income countries whereas the opposite situation is true for the many countries in Latin America and Caribbean. See the list of countries in the full sample depicted in Appendix for further information low and high income countries.

[7]The F-statistics and p value are for this joint test is $F(5, 97)=0.40$ and 0.85, respectively.

[8]Indeed we estimated the augmented neoclassical growth model by employing the orig-

our cross-country regression results and those obtained by MRW show that investment rates of both physical and human capital significantly contribute to the growth rates of countries while the rate of population growth has a negative effect on growth in the long run. The outstanding differences between our estimates and those by MRW are that our regression results show that the effects of investment in human capital are greater than those found by MRW, while the contribution of the investment rate in physical capital is found to be lower than MRW. In addition, we conclude a higher effect of population growth on long run growth. In the cross-country growth literature, researchers generally find a weak negative relation between population growth and long run growth. We expect a negative association between these two due to the simple reason that it is very difficult to keep a high level of capital per worker for a given saving rate while the number of workers is growing at a higher rate. However, it should be remembered that the negative effect of population growth on GDP growth may be larger due to the other factors, such as environmental factors and access to safe water as noted by Temple (1999a). In addition, especially in Western Europe the aging population strains the social security system, negatively affecting the public budget and labour force participation because of higher health care costs of elderly people and the growing number of retirees in population. In particular, the substantially larger and strongly significant coefficient of population growth in the high income sample support this claim since a considerable part of this sample consists of Western European countries. Therefore, we believe that our results related to population growth seem more plausible.

On the other hand, strong evidence is found in each regression for

inal data and samples of MRW over the 1960-1985 period and reported.

the hypothesis of conditional convergence in the manner that an economy with a lower initial value of output per worker tends to generate higher growth rate of output per worker when other determinants are controlled. For instance, according to the full sample, the logarithm of real GDP per worker in 1960 has a cross-country mean of 8.295 and a standard deviation of 0.854. Therefore, the regression result based on the full sample indicates that a one-unit standard deviation decrease in the logarithm of initial income would increase the subsequent growth rate by 0.377 points over the 1960-2000 period (-0.442*-0.854=0.377). This is equivalent to a rise in annual growth rate of 0.9 percentage point over the same period (0.377/40=0.009). Comparing to MRW, the implied convergence rates in all samples are found to be very close to those estimated by MRW. However, some authors such as, Barro (1991), Easterly and Levine (1997), and others point out that this convergence result is generally quadratic rather than linear. If this argument is true, the subsequent growth rates firstly rise and then decrease with the initial level of income. This implies that the conditional convergence effect will be weaker for very poor countries while stronger for middle-income countries. In order to check for a possible non-linear relationship between initial income and growth rate, we also include the square of logarithm of initial income in the cross-country growth regressions in Table 4.1 and reestimate. Table 4.2 presents regression results. As can be seen from Table 4.2, we could not find any statistically significant quadratic relationship between the initial level of income and subsequent growth. In each sample, except for the OECD and high income samples, the coefficients of both initial income and initial income squared have the wrong signs if the argument above is true. Therefore, we conclude that the conditional convergence hypoth-

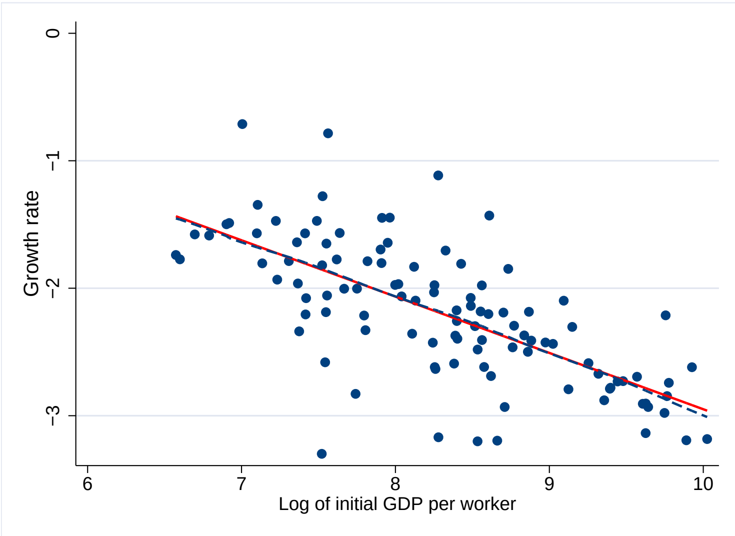


Figure 4.1: Growth Rate versus Initial Income: Partial Relation

esis is linear. The graphical visualization of partial association between growth rate and initial income shows a clear linearity (Figure 4.1).

For a further evaluation of the augmented neoclassical model, following MRW we imposed a restriction on equation (4.3) such that $\gamma_2 + \gamma_3 + \gamma_4 = 0$. As can be seen in equations (4.1) and (4.2), the sum of coefficients of $log(n_i + g + \delta)$, $logs_{i,K}$, and $logs_{i,H}$ should be equal to zero. Therefore, this restriction implies that equation (4.3) can be expressed as

$$\begin{aligned} logy_{i,2000} - logy_{i,1960} = \gamma_0 + \gamma_1 logy_{i,1960} \\ + \gamma_3[log(Investment\ rate_i) - log(n_i + g + \delta)] \\ + \gamma_4[log(School\ enrolmet_i) - log(n_i + g + \delta)] + \varepsilon_i \end{aligned} \tag{4.4}$$

The restricted regression results are presented in Table 4.3. Before estimating the restricted model, this restriction is tested for each sample and p-values for test of restriction are given in Table 4.3. As can be seen, this restriction is not rejected in all samples. The implied estimates of physical capital share (α), human capital share (β) and convergence rate (λ^*) are given in the last three rows of Table 4.3. Again we present restricted regression results of MRW through column 7 and column 9 of Table 4.3. The results show that estimation of the restricted model slightly improves the coefficients of investment rates for both physical and human capital. All variables are found to be highly significant with expected signs in each sample except the OECD sample.

Table 4.2: Quadratic Augmented Neo-classical Growth Model: OLS Estimates

Dependent Variable: Log Difference real GDP per worker over the 1960-2000 period

	Our Estimation Results: 1960-2000 period						Estimates of MRW[†] 1960-1985 Period		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sample	Full	NonOil	OECD[a]	NonOECD	High Income	Low Income	NonOil	Intermediate	OECD
log GDP per worker 1960	-0.086	-0.152	-2.424	0.494	1.747	-0.432	-0.340	-0.358	0.598
	(0.10)	(0.17)	(0.78)	(0.41)	(0.38)	(0.09)	(0.45)	(0.52)	(0.21)
Square of log GDP per worker 1960	-0.021	-0.016	0.102	-0.059	-0.121	0.003	0.003	-0.000	-0.058
	(0.41)	(0.31)	(0.58)	(0.78)	(0.48)	(0.01)	(0.07)	(0.01)	(0.35)
$\log(n_i + g + \delta)$	-1.086	-0.936	-0.427	-1.051	-1.268	-0.735	-0.500	-0.546	-0.795
	(2.84)	(2.35)	(0.53)	(1.84)	(2.93)	(0.95)	(1.65)	(2.41)	(2.00)
log of Investment rate	0.420	0.417	0.578	0.408	0.587	0.388	0.524	0.538	0.325
	(4.42)	(4.36)	(1.54)	(2.90)	(3.05)	(2.80)	(5.99)	(3.92)	(1.82)
log of School enrolment	0.441	0.442	0.369	0.432	0.319	0.476	0.233	0.270	0.209
	(4.88)	(4.84)	(0.67)	(5.43)	(1.86)	(3.80)	(3.61)	(2.54)	(1.32)
Constant	1.222	1.826	14.388	-0.958	-7.488	3.371	2.061	2.469	-0.139
	(0.31)	(0.45)	(1.15)	(0.18)	(0.36)	(0.19)	(0.73)	(0.86)	(0.01)
Number of observations	107	102	26	81	52	55	98	75	22
p- value for heteroscedasticity[b]	0.67	0.62	0.07	0.12	0.65	0.30	0.24	0.01	0.25
Adjusted R^2	0.61	0.61	0.59	0.55	0.60	0.57	0.46	0.43	0.63

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported. All variables, except initial level of income variables are averaged over the 1960-2000 period. The variable, $(n_i + g + \delta)$ refers to sum of rates of population growth, technical progress and depreciation.

[†] Estimation results based on the original data and samples of MRW.

[a] Czech Republic, Germany, Poland and Slovak Republic are excluded due to missing data.

[b] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

Table 4.3: Augmented Neo-classical Growth Model: Restricted OLS Estimates

Dependent Variable: Log Difference real GDP per worker over the 1960-2000 period

	Our Estimation Results: 1960-2000 period						Estimates of MRW† 1960-1985 Period		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sample	Full	NonOil	OECD[a]	NonOECD	High Income	Low Income	NonOil	Intermediate	OECD
log GDP per worker 1960	-0.438	-0.422	-0.539	-0.450	-0.467	-0.391	-0.298	-0.372	-0.402
	(6.55)	(6.03)	(5.53)	(5.00)	(4.09)	(2.58)	(4.93)	(6.38)	(5.81)
log of Investment rate - $\log(n_i + g + \delta)$	0.417	0.412	0.548	0.392	0.606	0.387	0.501	0.506	0.395
	(4.60)	(4.52)	(1.91)	(3.78)	(3.25)	(3.27)	(6.09)	(4.48)	(2.61)
log of School enrolment - $\log(n_i + g + \delta)$	0.465	0.452	0.218	0.457	0.391	0.469	0.235	0.266	0.241
	(5.75)	(5.47)	(0.92)	(4.96)	(2.65)	(4.34)	(3.98)	(3.08)	(1.69)
Constant	3.227	3.124	4.707	3.326	3.449	2.879	2.457	3.090	3.554
	(6.61)	(6.14)	(5.72)	(4.97)	(3.72)	(2.58)	(5.19)	(6.48)	(5.61)
Number of observations	107	102	26	81	52	55	98	75	22
p-value for heteroscedasticity[b]	0.74	0.62	0.48	0.15	0.62	0.29	0.32	0.02	0.23
Adjusted R^2	0.62	0.61	0.60	0.56	0.61	0.59	0.47	0.44	0.66
p-value for test of restriction	0.65	0.91	0.46	0.75	0.36	0.90	0.36	0.36	0.36
Implied α	0.32	0.32	0.42	0.30	0.41	0.31	0.48	0.44	0.38
Implied β	0.35	0.35	0.17	0.35	0.27	0.38	0.23	0.23	0.23
Implied λ^*	0.0144	0.0137	0.0194	0.0149	0.0157	0.0124	0.0142	0.0186	0.0206

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported. All variables, except initial level of income variables are averaged over the 1960-2000 period. The variable, $(n_i + g + \delta)$ refers to sum of rates of population growth, technical progress and depreciation.

† Estimates of restricted augmented neoclassical growth model in table VI, page 429 of Mankiw, Romer and Weil (1992). Dependent variables for these regressions are log difference GDP per worker over the period 1960-1985.

[a] Czech Republic, Germany, Poland and Slovak Republic are excluded due to missing data.

[b] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

However, Table 4.3 indicates that our results are different from those found by MRW in some respects. First, compared with the MRW results we find a stronger effect of investment in human capital and a weaker effect of investment in physical capital on economic growth. Second, we find that the effect of the accumulation of human capital is stronger than the contribution of investment in physical capital on economic growth. Third, the implied capital shares based on our regressions are substantially different from those estimated by MRW. As a natural result of first two findings we estimate a relatively larger share for human capital. However, conventionally capital shares are one-third (Mankiw (1995)); therefore, it is possible to conclude that our estimates of α and β are more reasonable. However, an exception to these findings are the regressions based on the high income and OECD samples. Our findings therefore imply two important conclusions for economic growth. First, accumulation of human capital is very important, especially in poor countries. Second, physical capital accumulation is more important in richer countries.

There can be several reasons for these results. First, as we note in Chapter 3, the secondary school enrolment rate is a crude proxy for accumulation of human capital and the strong relation between the school enrolment rate and economic growth in regressions in Table 4.1 and 4.3 may reflect other macroeconomic policies and factors which are excluded in the analysis. This is more likely in our regressions because, differently from MRW, we examine the effect of human capital on growth by using the secondary school enrolment rate over the schooling age population rather than over the economically active population. We check this possibility and find that the secondary school enrolment rates are highly correlated with the average inflation rate and some institutional quality measures such as rule of law, bureaucracy quality, corruption over the 1960-2000 period. However, even though this explanation is reasonable for our full sample results, it is not likely to explain the higher coefficient estimate of school enrolment rate in low income sample since these correlations are weaker for the low income countries.

Second, as noted by Caselli (2005), a considerable part of world's physical capital is produced in technologically advanced countries. This implies that, whilst the share of investment expenditures in GDP is a reasonable proxy in high income countries, the ratio of imported capital goods in GDP is a more plausible proxy for the physical capital saving rate in low income countries. More importantly, Caselli (2005) also emphasises the importance of technological progress embodied in capital goods. If physical capital in high income countries includes greater technological progress, then the effect of the investment rate on growth will be higher in these countries. Moreover, as pointed out by Mankiw (1995), physical and human capital are generally complementary inputs in the production process and so it is highly likely that this relation is stronger in high income countries due to the vintage physical capital. Therefore, the higher coefficient estimate of the investment rate in high income sample might be partly attributed to the accumulation of human capital.

Third, the strong association between the school enrolment rate and growth may be a result of a number of unrepresentative countries. In Section 4.4 we investigate the outlying countries, and highlight how Tanzania is an unrepresentative country. When we omit this country from the regression analysis, we conclude that the effect of the investment rate becomes stronger relative to the school enrolment rate.

Finally, the higher coefficient estimate on the school enrolment rate in the low income sample is a result of sub-Saharan Africa. As mentioned before, almost all countries in sub-Saharan Africa belong to the low income sample. Similarly, the majority of countries in East Asia and the Pacific are in this sample. Sub-Saharan Africa has a substantially lower school enrolment rate with an average value of 17 percent, than the sample mean which is equal to 48 percent over the 1960-2000 period. By contrast, the average school enrolment rate in East Asia and the Pacific is 68 percent. It is a well-known fact that sub-Saharan Africa experienced very poor growth performance over the 1960-2000 period while the countries of East Asia and the Pacific recorded very much faster growth rates during the same period. Thus, with the poor performing countries of sub-Saharan Africa with low school enrolment and the well performing countries of East Asia and the Pacific associated with greater schooling, the higher coefficient estimate is inevitably obtained.

Another distinguishing difference between our results and MRW estimates is that the R^2 is higher in our regressions, since the variation in the explanatory variables, especially the school enrolment rates are considerably higher over the 1985-2000 period than between 1960-1985.

It is obvious that the most important reasons for the differences between our results and those obtained by MRW are that we estimate the augmented neoclassical growth model employing the updated and revised data for different samples over a different time period. In addition, in order to make comparison concrete, we have also estimated the augmented neoclassical growth model using our data and the original data of MRW for the same samples of countries. The estimation results are given in the Appendix. However, selecting the same sample does not remove all of these differences. This implies that the differences between our estimations and those by MRW are partly the result of different time period and partly the result of different data. Yet, in spite of these differences it is possible to conclude that our results confirm the work of MRW and are consistent with the existing cross-country growth literature.

Before closing this chapter, we consider two further checks on our estimation, namely the effect of geographical differences across countries and investigating possible outlying observations.

4.3 Geographical Differences

In the cross-country growth literature, some studies (Barro (1991), De Long and Summers (1991), Levine and Renelt (1992), Barro and Lee (1994b), Easterly and Levine (1997), Barro and Sala-i-Martin (2004) *inter alia*) include dummy variables for sub-Saharan Africa, Latin America and the Caribbean and East Asia. The reason for employing these dummy variables is that estimated growth models are not adequate to explain different growth performances across these regions. Due to the poor growth performance in Africa and Latin America one can expect a significantly negative coefficient on dummy variables for these two regions whereas the opposite situation is true for East Asia and Pacific.

In order to investigate this claim, in particular for sub-Saharan Africa, we add to our baseline model three regional dummies. First column of Table 4.4 reports the results of this estimation. It can be seen that all dummy variables have the anticipated signs and jointly significant. This implies that these three regions exhibit different growth performances compared to the rest of the world.

In column 2, we omit the dummy variable for East Asia and Pacific. Notice that for this regression the reference countries now include the countries in East Asia and Pacific as well as others. The regression result shows that dummy variables for both sub-Saharan Africa and Latin America are individually and jointly significant with the negative signs. This finding clearly shows that both regions experienced a slower growth performance compared to other countries once the reference sample includes East Asia and Pacific. In column 3, we drop the Latin American dummy but keep the Asian dummy with African dummy and conclude that only dummy for East Asia and Pacific is significant. Finally, in column 4, we allow only dummy variable for sub-Saharan Africa and find that its coefficient estimate is not significant.

What can be inferred from these findings and should one employ regional dummies in the cross-country growth regressions? Undoubtedly, the cross-country growth regressions in Table 4.4 show clear evidence for different growth performances in these three regions. However, care must be taken with the reference group of countries. Yet, we think that the importance of sub-Saharan African dummy may have been exaggerated in the previous literature since we find a significant statistical relationship between growth and this dummy in only regression in Column 2. [9]

To investigate this further, we estimate the benchmark model for sub-Saharan Africa and rest of the world separately in columns 5 and 6 and carry out a parameter stability test across two samples. However, we could not reject the null hypothesis of equality of all coefficients between Africa and non-Africa samples (The F-statistics and p value for the parameter stability test are F(5,97)=0.95 and p=0.45, respec-

[9] Studies such as by Barro (1991), Barro and Lee (1994b), Easterly and Levine (1997) consistently conclude that the African dummy is significant and negative.

tively). Moreover, the same test for individual coefficients concludes parameter stability for each variable across two samples as it can be seen from p values in column 7. This implies that sub-Saharan Africa does not exhibit a different growth performance compared to the rest of the world on average.

More importantly, previous studies concluded strong and significant relation between regional dummy variables, especially dummies for Latin America and Africa, and growth may be attributable to the importance of model selection problem. Put differently, we believe that employing new growth theories in order to explain different growth performances of different geographical regions is more informative and useful than employing simple dummy variables.

Finally, in column 8, we include a landlocked country dummy that takes the value of 1 for countries that do not have access to international waters in order to check the growth performance of these countries compared with others. Landlocked countries may face higher costs for any kind of international activities, especially international trade. Therefore, this dummy variable has been extensively used in cross-country growth work. However, the regression in column 8 indicates that there is no significant difference in the growth performance of landlocked countries. In the last column of Table 4.4 we omit the landlocked countries in Europe such as Austria, Luxembourg, Switzerland and Hungary, from the dummy variable, since becoming landlocked for these countries may not create an important disadvantage. When we use this dummy variable, the regression result shows an improvement on both coefficient and t-statistics of landlocked dummy, but it is still insignificant.

Table 4.4: Augmented Neo-classical Growth Model and Geographical Dummy Variables

Dependent Variable: Log Difference real GDP per worker over the 1960-2000 period

	(1) Full	(2) Full	(3) Full	(4) Full	(5) Africa	(6) NonAfrica	(7) p-value[a]	(8) Full	(9) Full
log GDP per worker 1960	-0.414	-0.421	-0.431	-0.449	-0.406	-0.474	0.36	-0.441	-0.443
	(6.23)	(6.31)	(6.44)	(6.61)	(2.41)	(5.56)		(6.49)	(6.53)
$\log(n_i + g + \delta)$	-0.970	-0.863	-1.172	-1.076	-1.421	-1.104	0.32	-1.072	-1.059
	(2.61)	(2.35)	(3.20)	(2.90)	(1.02)	(2.52)		(2.84)	(2.85)
log of Investment rate	0.340	0.359	0.364	0.404	0.296	0.643	0.64	0.414	0.413
	(3.73)	(3.95)	(3.96)	(4.39)	(2.12)	(3.65)		(4.47)	(4.47)
log of School enrolment	0.382	0.375	0.402	0.398	0.455	0.265	0.31	0.440	0.436
	(3.90)	(3.81)	(4.06)	(3.94)	(3.10)	(1.91)		(4.75)	(4.75)
Sub-Saharan Africa	-0.228	-0.299	-0.079	-0.137	-	-	-	-	-
	(1.52)	(2.08)	(0.59)	(1.01)					
Latin America & Caribbean	-0.237	-0.294	-	-	-	-	-	-	-
	(2.11)	(2.75)							
East Asia & Pacific	0.198	-	0.290	-	-	-	-	-	-
	(1.51)		(2.31)						
Landlocked country dummy	-	-	-	-	-	-	-	-0.039	-
								(0.36)	
Landlocked country dummy [b]	-	-	-	-	-	-	-	-	-0.062
									(0.50)
Constant	2.648	3.079	2.211	2.747	1.229	3.231	0.31	2.715	2.765
	(2.43)	(2.90)	(2.03)	(2.53)	(0.35)	(2.15)		(2.45)	(2.53)
p-value for heteroscedasticity[c]	0.86	0.91	0.83	0.66	0.34	0.10	-	0.72	0.74
F-value[d]	3.68	4.32	3.19	-	-	-	-	-	-
Number of observations	107	107	107	107	34	73	-	107	107
Adjusted R^2	0.64	0.64	0.63	0.61	0.42	0.53	-	0.61	0.61

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported. All variables, except initial level of income variables are averaged over the 1960-2000 period. The variable, $(n_i + g + \delta)$ refers to sum of rates of population growth, technical progress and depreciation.

[a] The p-value refers to the hypothesis that individual coefficients are the same for Africa and non-Africa samples.

[b] The landlocked countries in Europe are dropped.

[c] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

[d] Test for joint significance of the regional dummies.

4.4 Outliers

An important concern related to the cross-country growth works is that results may be partly driven by outlying countries. Undoubtedly this concern is very important since cross-country growth studies are based on small samples. As Temple (1999a, 2000) points out we should make sure that our results reflect the tendencies of a majority of data not those of a minority of observations if we want to reach useful generalizations about growth.

Before proceeding for outlier checking, we want to make clear the terminology since the definition of outlier is sometimes unclear and confused. An outlier is simply an observation which is considerably different from the remaining observations in the sample (Hawkins (1980), Barnett and Lewis (1994)). This difference between outlying observation and others may occur either in the dependent variable or in the explanatory variable(s) or in the both. An outlier in the dependent variable yields a large residual and is some times referred to as outlier in the response variable (Chatterjee and Hadi (1988, 2006)) or outlier in y-direction or vertical outlier (Rousseeuw and Leroy (1987)). Hence, one can easily detect a single outlier in the response variable by simply checking residuals. Yet, an outlier may also arise in the explanatory variable(s) and take a place far from the bulk of data of observed explanatory variables in the sample. This kind of outlier is also known as the outlier in the predictors or design outlier. Since outlier in the predictors are far away from the bulk of data, they have high leverage values and are some times referred to as high leverage points in order to distinguish them from the outliers in the response variable. Therefore, detecting an outlying observation by checking residuals is often misleading. The reason is that a high leverage data point pulls the OLS regression line towards itself and yields small residuals. In addition, this data point causes the larger residuals for other observations.

On the other hand, an influential observation is the data point that has individually or collectively substantial influence on the regression results with respect to other observations in the sample (Belsley et al. (1980)). Thus, removing an influential observation from the sample changes the fitted regression equation considerably. Two points in this definition deserve special emphasis. First, an observation can be influential individually or together with a group of other observations. This implies that while removing a single observation from the sample does not change the regression result, dropping that observation with other observation(s) can substantially affect fitted regression equation. Second, the term of influence in the definition is partly subjective such that an influential observation can affect the coefficient estimates of variable(s) or their standard deviations, and hence t-statistics, R^2 and so on. This means that all influential observations do not have equal influence on the regression results as argued by Chatterjee and Hadi (1988). One can effect the magnitude and/or sign of coefficient estimates while the other can be influential on the statistical significance or goodness of fit. Therefore, one should particularly keep in mind how outliers affect the regression results in terms of the objective of empirical research.

Even though outliers are not necessarily influential observations, they are generally have influence on the regression results. Therefore, an important primary task of regression analysis is to detect influential outlying observations in the sample in order to conduct useful and reliable generalizations. However, identification of outliers in the multiple regression is not easy especially if the sample includes more than one outlier. As a starting point, checking residuals (especially studentized ones) and leverages after the regression is always suggested.

Many outlier identification methods have been suggested in statistics.[10] It is possible to classify these methods under the two main categories. The first and most common one is the regression diagnostics such as Cook's distance, DFITS statistics and Welsh distance. These diagnostics basically take into account the changes in the fitted regression equation after a single observation is removed and hence they directly measure the influence of each individual observation. Therefore, these diagnostics are some times referred as the direct outlier detecting methods (Rousseeuw and Leroy (1987)). Among these statistics, DFITS suggested by Belsley et al. (1980) is the most widely used in the regression analysis and shows the effect of each observation in the sample on the overall fitted regression analysis. In addition, Belsley et al. (1980) proposed a similar measure which is known as DFBETA statistics. Differently from DFITS, DFBETA reveals the influence of each observation on a particular explanatory variable and thus it is very useful when the primary interest of researcher is focused on a specific variable in the regression equation.

As a rule of thumb, observations having large values of these diagnostics are considered as influential outliers in the response variable and/or in the predictors. Moreover, several cutoff points for them are suggested in the literature. The choice of cutoff points depends on the sample size and number of explanatory variables. Generally, for small samples a high cutoff point is plausible (Bollen and Jackman (1990)). However, instead of using a particular cutoff level, it is better to examine these diagnostics graphically and identify observations with unusual

[10] Outlier detection methods from the Bayesian perspective are also suggested in the statistical literature. See, Guttman et al. (1978), Pettit (1992), Hoeting (1994)

patterns, as pointed out by Chatterjee and Hadi (1988).

Even though these diagnostic measures are useful, their efficiency substantially decreases if the sample includes more than one outlier. The reason is that all diagnostic measures mentioned above are based on the removing of single observation and they are no longer powerful in the case of multiple outliers due to the masking and swamping effects. When the sample includes more than one outlier, some outliers may be hidden by the others and this effect is known as masking effect. On the other hand, swamping effect arises due to the fact that outliers, especially those with high leverage values, make other observations lie far from the fitted regression equation by pulling the regression equation towards themselves. Therefore, the best solution of these problems is to calculate diagnostic measures based on the deletion of all subsets of observations. However, this is almost practically infeasible not only because deciding the number of subsets is difficult but also computation is immense due to the larger number of subsets. [11]

The second and in the case of multiple outliers, more efficient class of outlier detection methods is the robust regressions. These methods in essence suggest employing robust regression techniques which are resistant to outliers. On the contrary to the common view, robust regressions do not simply ignore outliers. Rather, one can identify outliers by comparing residuals obtained from a robust regression with those derived from the OLS. Therefore, regression diagnostics and robust regressions basically serve the same purpose only from the opposite side as argued by Rousseeuw and Leroy (1987). In statistics many robust regression techniques such as Least Median of Squares, Least Trimmed

[11]For instance, if the consideration of all subsets includes only 2 observations and the sample size is 107 as in the case of our full sample, there are 5671 possibilities. When we consider 3 out of 107 observations, the number of possibilities is 198485.

Squares are suggested (See, Rousseeuw and Leroy (1987), Rousseeuw and van Zomeren (1990), Atkinson (1994)). However, robust regression gives us an idea such that we can apply weighted least squares analysis based on the identification of the outliers. If this can be done, the results of weighted least squares will be less sensitive to the outlying observations and more plausible with respect to those obtained from usual least squares.

Hadi (1992b) suggests another measure in order to identify influential outliers in the data. This diagnostic which measures overall potential influence of the ith observation is defined as

$$H_i = \frac{k}{1-h_i}\frac{d_i^2}{1-d_i^2} + \frac{h_i}{1-h_i}, i = 1, ..., n \tag{4.5}$$

where k is the number of explanatory variables (including constant), $d_i = e_i/\sqrt{SSE}$ and h_i is the ith normalized residual and leverage, respectively. As can be seen, this diagnostic measure is the sum of two components. The first term on the right-hand side of the equation (4.5) is a function of the ith normalized residual weighted by the ith leverage value and measures outlyingness in the response variable. The second component is also known as the potential function and measure the outlyingness in the predictors.

The diagnostic measure proposed by Hadi (1992b) has several desirable properties compared to the traditional diagnostics. First, it measures overall potential influence of an observation. As can be seen, outlying observations in either response variable and/or predictors will have large values of Hadi's measures. Second, Hadi's measure identifies potentially influential observations on several regressions rather than the focusing on a single regression. Third, this measure is an additive function of both residual and leverage values.[12] Fourth, Hadi's measure is monotonically increasing function of both residuals and leverages.

Even though Hadi's measure is superior than the traditional measures, it is still designed for a single observations. In order to highlight multiple outliers in the data set, Hadi proposed two ways. Firstly, he suggests a simple graph which is based on the formula in equation (4.5). This graph which is also known as "potential-residual plot" is a more powerful tool in order to detect both single and multiple influential cases. Secondly and more importantly, he proposed a practical method to search multiple outliers (Hadi (1992a, 1994), Hadi and Simonoff (1993)).

In the light of these explanations, we apply the method suggested by Hadi (1992a,b;1994) for identification of outlying observations in our baseline cross-country growth regression. However, before applying Hadi methodology, we investigate outlying observations by employing diagnostic plots.

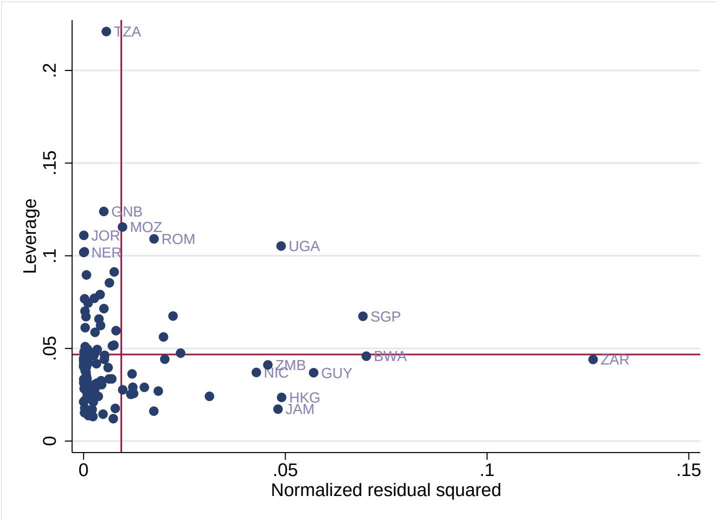
The diagnostic plot suggested by Gray (1986) is commonly used in statistical literature for a quick way of checking influential observations and shows leverage versus the residual squared. Figure 4.2(a) plots leverages against the normalised residual squared of baseline cross-country growth regression based on the full sample. In this figure two reference lines parallel to horizontal and vertical axes show the mean values of leverage and normalised residual squared respectively. Observations that are located far away from reference lines are of great concern for us. As can be easily seen Tanzania is the most influen-

[12] Traditional diagnostics such as Cook's distance and DFITS are the multiplicative function of residual and leverage values. Since observations with large values yields either large residuals or large leverages or both, multiplicative diagnostics would be small if one of these quantities (residuals and leverages) is small and thus could fail to detect influential outliers.

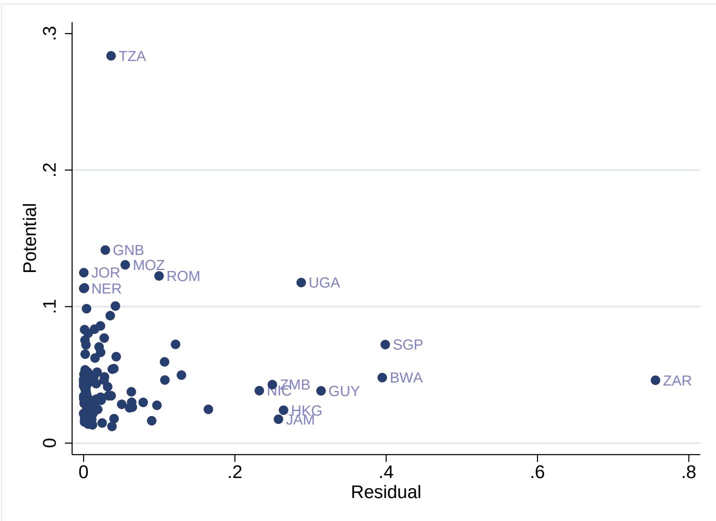
tial country with the highest leverage in our sample. The feature of this country is that it has the smallest school enrolment rate in our sample and hence it is an outlier in the saving rate for human capital. In addition, the countries Uganda, Romania, Mozambique, Guinea-Bissau, Jordan and Niger have moderately high level of leverages. Figure 4.2(a) also shows that Congo Democratic Republic (former Zaire) is the country with the highest residual. Congo Democratic Republic has the lowest growth performance in our sample and hence this country is clearly an outlier in the growth rate. Yet, the leverage value of this country is very close to the sample mean. Therefore, it is possible to conclude that Congo Democratic Republic is not influential in spite of its very high residual. In addition to this country, Figure 4.2(a) indicates the countries Guyana, Botswana, Jamaica, Zambia, Nicaragua, Uganda, Hong Kong and Singapore whose residuals are relatively higher. However, neither of them has a high leverage value. Therefore, graphical inspection indicates that only Tanzania may be a candidate as a potential influential outlier. Even though the leverage of Congo Democratic Republic is low, this country is of concern due to its high level of the residual. In addition to leverage versus plot we also present Hadi's potential-residual plot in figure 4.2(b). As can be seen, potential-residual plot exactly similar to leverage-residual plot and hence supports our findings from figure 4.2(a).

When we apply Hadi method on our data set, we conclude only Tanzania as a potential outlying country. As can be seen, Hadi measure confirms our findings from graphical inspection.

The most common approach for solving outlier problems is dropping these observations from the sample. Omitting Tanzania yields the following cross-country growth regression (t-statistics are in parentheses)



(a) Leverage versus Residual plot



(b) Potential-Residual Plot

Figure 4.2: Benchmark Growth Model: Diagnostic Plots for Outliers

$$
\begin{aligned}
logy_{i,2000} - logy_{i,1960} = & \underset{(2.55)}{2.779} - \underset{(6.55)}{0.443} logy_{i,1960} \\
& - \underset{(2.88)}{1.070} log(n_i + g + \delta) \\
& + \underset{(4.44)}{0.445} log(Investment\ rate_i) \\
& + \underset{(4.48)}{0.421} log(School\ enrolment_i), \quad \overline{R}^2 = 0.62
\end{aligned}
\tag{4.6}
$$

Compared to our previous regression presented the first column of Table 4.1, dropping Tanzania from the sample slightly changes the coefficient estimates of initial income and population growth. Therefore, there is not an important change for the implied convergence rate. Yet now, the effect of saving rate for physical capital is stronger than the saving rate for human capital. In addition, R^2 of the model increases by one percent.

However, removing outlying countries from the sample may not be a good solution in the cross-country growth regressions. The most important reason is that some countries can behave as outliers due to the fact that a relevant variable has been omitted from the specified model. This last point is closely related to model uncertainty problem and hence removing some observations may be considered another kind of data mining (Chatfield (1995)). Since the estimated cross-country growth regression is proposed as a benchmark model in order to investigate openness-growth connection, we prefer keeping Tanzania in our full sample. However, detecting outliers in the cross-country growth works is a noteworthy task. Temple (1999a, p.127) points out "[T]he identification of possible outliers will not only render generalizations more robust, but will also highlight countries with atypical growth experiences, ones that are particularly likely to reward further study." This is particularly very important when testing new growth theories and/or investigating the relationship between economic growth and a policy variable.

4.5 Conclusion

In this chapter, we replicate the augmented neoclassical growth model using an updated and revised data set over the period 1960-2000. Our results support findings of MRW, yet are different in some aspects: First, we find a stronger effect of investment in human capital and a weaker effect of investment in physical capital on economic growth compared to MRW; Second, the effect of accumulation of human capital is stronger than the contribution of investment in physical capital on economic growth. This finding is more obvious in the low income countries while results obtained from high income sample are more similar to MRW; Third, our coefficient estimates of physical and human capital shares are more reasonable than MRW. The regression results based on the largest sample indicates that the shares of physical and human capital are 32 and 35 percent, respectively. Comparing those obtained by MRW, our empirical results are more consistent with three factor Cobb-Douglas production function, $Y = K^{1/3}H^{1/3}L^{1/3}$.

We also check the effect of geography by employing three region dummy variables and conclude that inclusion of these dummies does not alter our main conclusions. In addition, our findings are not driven by outliers.

To conclude, the estimated growth model in this chapter appears appropriate for investigating the relation between growth and openness to international trade. Hence, in what follows we carry out our empirical investigation employing the augmented neoclassical growth model suggested by MRW as a benchmark model in the rest of this dissertation.

4.A Appendix: Descriptions and Sources of Variables used in Cross-Country Growth Regression Analysis

Real GDP per capita (RGDPCH) : 1996 international prices, chain series. **Source**: Global Development Network Growth Database (2005) which rely on Heston, Summers and Aten (2002)

Population (TP) : Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. **Source**: The World Bank World Development Indicators (2002, 2006).

Labour force (LF) : Labour force or economically active population defined as the total population between ages 15 and 64. **Source**: The World Bank World Development Indicators (2002, 2006).

Share of labour force (SLF): Share of labour force in total population. The exact calculation is LF/TP.

Real GDP per worker (PWGDP) : 1996 international prices, chain series. The exact calculation is $PWGDP = RGDPCH*(1/SLF)$.

Growth : Average growth rate of real GDP per worker over the 1960-2000 period. The exact calculation is $log(PWGDP2000/PWGDP1960)$, where PWGDP1960 and PWGDP2000 is the real GDP per worker in 1960 and 2000, respectively. Because of missing variables, for the countries Bahamas, Belize, Haiti, Hungary, Malta, Oman, Puerto Rico, Sierra Leone, Sudan and Tunisia, 1961 values are used instead of 1960 values.

Initial income (PWGDP1960) : Real GDP per worker in 1960. Because of missing variables, for the countries Bahamas, Belize, Haiti, Hungary, Malta, Oman, Puerto Rico, Sierra Leone, Sudan and Tunisia, 1961 values are used instead of 1960 values.

Population growth (n) : Average rate of population growth between 1960 and 2000. The exact calculation is $(1/40)*log(TP2000/TP1960)$, where TP1960 and TP2000 are total population in 1960 and 2000, respectively.

(g+δ) : Sum of exogenous rates of technological process and depreciation over the 1960-2000 period and assumed to be equal to 0.05.

(n+g+δ) : Sum of rates of population growth, technical process and depreciation over the 1960-2000 period.

Investment rate (INV) : Average of investment share in GDP at constant prices over the 1960-2000 period. The data are averages for Tunisia and Sierra-Leone over 1961-2000 period, for Hungary and Malta 1965-2000 period, for Namibia, Cyprus, Botswana, Mauritania, Haiti, Central African Republic, Guyana and Fiji, over 1960-1999 period instead of 1960-2000 period. **Source**: Heston, Summers and Aten (2002). In order to increase number of observations, data of seven countries are filled up by using gross capital formation data from the World Bank World Development Indicators (2002, 2006). These countries are Puerto Rico for 1986-1991 period, Hungary for 1965-69 period, Malta for 1965-1993 period and years 1999, 2000, Sierra Leon for years 1997, 1999 and

2000, Cyprus for 1997-99 period, Angola for 1997-2000 period, Congo Democratic Republic for 1998-2000 period.

School enrolment rate (SCH) : Average gross rate of secondary school enrolment over the 1960-2000 period. Gross secondary school enrollment ratio is defined as the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of secondary education. For countries Chad, Ethiopia, Portugal, Niger and Mauritania, the variable is calculated over the 1965-2000 period. **Source**: The World Bank World Development Indicators (2002, 2006).

Sub-Saharan Africa dummy (REG_SSA) : A dummy variable takes the value of 1 for the countries in sub-Saharan Africa. **Source**: Global Development Network Growth Database (2005).

Latin American dummy (REG_LAC) : A dummy variable takes the value of 1 for the countries in Latin America and Caribbean. **Source**: Global Development Network Growth Database (2005).

East Asian dummy (REG_EAP) : A dummy variable takes the value of 1 for the countries in East Asia and Pacific. **Source**: Global Development Network Growth Database (2005).

Landlocked Country (LANDLOCK) : A dummy variable for landlocked countries. **Source:** Gallup et al. (1999)

Landlocked Country without Europe (LANDLOCK_WE) : A dummy variable for landlocked countries, except those in Europe (Andorra, Austria, Belarus, Czech Republic, Hungary, Luxembourg, Liechtenstein, Moldova and Switzerland). **Source:** Gallup et al. (1999) and author's calculation.

Table 4.5: List of Countries in the Full Sample

Algeria*	Dominican Republic	Japan*	Peru*
Angola*	Ecuador	Jordan*	Philippines
Argentina*	Egypt	Kenya	Portugal*
Australia*	El Salvador*	Korea, Republic of	Romania
Austria*	Ethiopia	Lesotho	Rwanda
Bangladesh	Fiji*	Luxembourg*	Senegal
Barbados*	Finland*	Madagascar	Sierra Leone
Belgium*	France*	Malawi	Singapore
Benin	Gambia, The	Malaysia	Spain*
Bolivia*	Ghana	Mali	Sri Lanka
Botswana	Greece*	Malta	Sweden*
Brazil*	Guatemala*	Mauritania	Switzerland*
Burkina Faso	Guinea*	Mauritius*	Syria
Burundi	Guinea-Bissau	Mexico*	Tanzania
Cameroon	Guyana	Morocco	Thailand
Canada*	Haiti	Mozambique	Togo
Central African Rep.	Honduras	Nepal	Trinidad &Tobago*
Chad	Hong Kong*	Netherlands*	Tunisia
Chile*	Hungary*	New Zealand*	Turkey*
China	Iceland*	Nicaragua*	Uganda
Colombia*	India	Niger	United Kingdom*
Congo, Dem. Rep.	Indonesia	Nigeria	United States*
Congo, Republic of	Iran*	Norway*	Uruguay*
Costa Rica*	Ireland*	Pakistan	Venezuela*
Cote d'Ivoire	Israel*	Panama*	Zambia
Cyprus*	Italy*	Papua New Guinea	Zimbabwe
Denmark*	Jamaica*	Paraguay*	

Note: Countries with asterisk are the high income countries according to the median of real GDP per worker in 1960.

Table 4.6: Summary Statistics

Variable	♯ of Obs.	Mean	Std. Dev.	Min	Max
Growth	118	0.6728	0.6639	-1.3525	2.3247
log PWGDP1960	118	8.3153	0.8390	6.5737	10.0252
$(n+g+\delta)$	191	0.0696	0.0120	0.0465	0.1396
INV	116	0.1568	0.0777	0.0207	0.4120
SCH	125	0.4841	0.3120	0.0444	1.1460
REG_SSA	207	0.2367	0.4261	0	1
REG_LAC	207	0.1884	0.3920	0	1
REG_EAP	207	0.1691	0.3757	0	1
LANDLOCK	208	0.1923	0.3951	0	1
LANDLOCK_WE	208	0.1394	0.3472	0	1

Table 4.7: Augmented Neo-classical Growth Model: OLS Estimates

Dependent Variable: Log Difference real GDP per worker over the 1960-2000 period

Sample	Full		NonOil		Intermediate		High Income		Low Income	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Our	MRW†	Our	MRW†	Our	MRW†	Our	MRW†	Our	MRW†
log GDP per worker 1960	-0.503	-0.312	-0.483	-0.289	-0.612	-0.384	-0.541	-0.347	-0.382	-0.344
	(6.41)	(5.09)	(5.70)	(4.33)	(6.52)	(5.76)	(4.09)	(3.87)	(2.36)	(2.05)
$\log(n_i + g + \delta)$	-1.214	-0.414	-1.056	-0.345	-0.928	-0.584	-1.228	-0.522	-1.817	0.073
	(2.91)	(1.70)	(2.41)	(1.31)	(2.13)	(2.38)	(2.51)	(1.62)	(1.59)	(0.14)
log of Investment rate	0.429	0.572	0.425	0.560	0.445	0.529	0.471	0.661	0.441	0.534
	(4.46)	(5.11)	(4.38)	(4.94)	(3.90)	(3.85)	(2.22)	(4.30)	(3.57)	(3.60)
log of School enrolment	0.469	0.214	0.467	0.201	0.644	0.288	0.463	0.101	0.455	0.218
	(5.03)	(2.99)	(4.91)	(2.74)	(4.84)	(2.98)	(2.05)	(0.67)	(3.84)	(2.34)
Constant	2.914	1.794	3.169	1.529	4.775	2.710	3.268	2.257	0.449	1.112
	(2.58)	(2.02)	(2.75)	(1.59)	(3.51)	(3.03)	(1.93)	(1.94)	(0.14)	(0.76)
p-value for heteroscedasticity[a]	0.79	0.08	0.90	0.07	0.31	0.01	0.91	0.33	0.98	0.07
Number of observations	94	94	89	89	72	72	45	45	49	49
Adjusted R^2	0.62	0.48	0.61	0.46	0.59	0.43	0.59	0.50	0.59	0.43
Implied λ^*	0.0175	0.0150	0.0165	0.0136	0.0237	0.0194	0.0195	0.0170	0.0120	0.0169

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported. All variables, except initial level of income are averaged over the 1960-2000 period. The variable, $(n_i + g + \delta)$ refers to sum of rates of population growth, technical progress and depreciation.

† Estimates of augmented neoclassical growth model using the original data of Mankiw, Romer and Weil (1992) over the 1960-1985 period. Dependent variables for these regressions are log difference GDP per worker over the period 1960-1985.

[a] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

Chapter 5

Openness and Economic Growth: A Cross-Country Empirical Investigation

5.1 Introduction

The objective of this chapter is to empirically investigate the long-run relationship between economic growth and openness using a cross-country growth regression based on the augmented neoclassical growth model. In this chapter, we employ a large number of openness measures suggested in the literature to provide a wider picture in order to evaluate both existing openness variables and the openness-growth connection. We also carry out the empirical investigation over the 1960-2000 period and check whether our findings are driven by outlying countries. Finally, we carry out a sensitivity analysis.

The cross-country empirical investigation in this chapter indicates that many openness variables are positively and significantly correlated with economic growth. However, in many cases, this result depends on the presence of a few outlying countries. More importantly, the significance of openness variables disappears once other growth determinants, such as macroeconomic stability, institutions, and geography are accounted for.

The structure of this chapter is as follows. Section 2 provides the basic framework for the empirical cross-country investigation of the openness-growth connection. Section 3 presents OLS estimates based on the cross-country growth regressions for the 1960-2000 period. Section 4 examines how robust our findings are to model specification. For this, we carry out a sensitivity analysis accounting for other growth theories. Finally, Section 5 summarises our results.

5.2 Economic Growth and Openness to International Trade: Baseline Model

In this section we investigate the relationship between economic growth and openness to international trade in the framework of the augmented neo-classical growth model over the period 1960-2000. In other words, we extend this model by adding a proxy variable for openness as follows

$$\begin{aligned} logy_{i,2000} - logy_{i,1960} = \gamma_0 + \gamma_1 logy_{i,1960} + \gamma_2 log(n_i + g + \delta) \\ + \gamma_3 log(Investment\ rate_i) \\ + \gamma_4 log(School\ enrolmet_i) \\ + \gamma_5 Openness_i + \varepsilon_i \end{aligned} \tag{5.1}$$

Once we specify the cross-country growth regression expressed in equation (5.1), an important problem arises immediately: the endogeneity of the openness variable. It is highly likely that countries implementing open trade policies may also follow more liberal domestic policies and adopt sound and stable fiscal and monetary polices. In addition, countries having better institutions and geographical advantages can enjoy much more international trade and hence adapt open trade policies. Since these factors are also important determinants of economic growth, it is likely that the openness variable in equation (5.1) is correlated with the error term, ε_i. In this case, the coefficient estimate of openness variable, γ_5 will not reflect the true impact of openness on economic growth. Put differently the OLS estimate of γ_5 will be biased and the direction of causality between growth and openness will remain unclear.

The best way in order to overcome endogeneity problem is finding or constructing an instrumental variable (IV) which is correlated with the openness variable but uncorrelated with the error term. In other words, IV must affect economic growth only through the openness variable. If one can find a valid IV and estimate the cross-country growth regression in equation (5.1) by two stage least squares (2SLS), then the IV estimate of γ_5 will reflect the true effect of openness on growth. However, finding a valid IV is almost impossible in the cross-country growth works due to the open-endedness of growth theories.[1] More importantly, if IV is not valid, the coefficient estimate will be again biased and in this case the OLS estimate would be more preferable as argued by Durlauf et al. (2005).

Therefore, it may be possible to conclude that the cross-country growth regressions can never reveal the direction of causality. Despite

[1] Mankiw (1995, p.303) points out "[W]hen looking for instruments, it is easy to fall prey to temptation." Durlauf, Johnson and Temple (2005, p.) argue that "[t]he belief that it is easy to identify valid instrumental variables in the growth context is deeply mistaken." In some studies the lagged values of endogenous variables are used as instruments. However, predetermined variables do not guarantee that they are directly uncorrelated with growth and hence they are proper instruments. More importantly, even if they are valid instruments, whether the instrumental estimate shows the effect of endogenous variable or of lagged value of that variable on economic growth remain unanswered. According to Mankiw (1995) the answer is generally neither.

this fact, the cross-country works still provide useful information between growth and a variable of interest. Even if we can not establish the casuality between growth and openness, a statistically significant partial association can be used to reject alternative hypotheses which fail to provide statistically significant correlation and one can provide plausible causal statement (Mankiw (1995), Wacziarg (2002)). For instance, if we conclude that OLS estimate of γ_5 is positive and statistically significant and fail to conclude the statistically significant negative association between openness and growth, then it is not reasonable to reach an inference such that openness is harmful for economic growth.[2]

5.3 Empirical Results

As mentioned before, a large number of openness measures have been suggested in the literature. That is why, we carry out our empirical investigation classifying the openness measures under four categories: trade volumes; direct trade policy measures; deviation measures; and subjective indexes.

5.3.1 Trade Volumes

We start our estimations with the ratio of trade volume in GDP. We obtain two measures for this variable: one is from the World Bank and

[2] For instance, Warner (2003) argues that it is very difficult to attribute a positive coefficient estimate on openness variable to reverse casuality from growth to trade polices. The reason is that there are no specific cases in which countries opened to international trade, grew slowly and then closed again because of poor economic performance. However, Rodrik (2005) questions this kind of reasoning since the policy endogeneity in growth regressions is not only an econometric nuisance but also problematic conceptually when government policies are used systematically to achieve certain economic and social objectives. Rodrik (2005, p.3) points out that "[a] government that cares about social welfare (and nothing else) will increase its policy intervention in response to larger market failures, but not so much as to completely insulate economic performance from their adverse consequence."

the other is from Penn World Tables (Version 6.1). One advantage of the World Bank measure is that the data are published in terms of exports and imports. Thus, this allows us to investigate the export-growth connection and import-growth connection separately. On the other hand the trade ratio of the Penn World Tables is published only as a sum of exports and imports at current prices. This data have the advantage that they are available for a larger number of countries. This is a very common proxy in the cross-country growth literature and some times referred to as "current openness". The simple correlation between these two trade ratios is almost one (Table 5.1).

Table 5.1: Economic Growth and Trade Volumes: Pairwise Correlations

1960-2000 averages

	Average growth	GDP per worker in 1960	Exports ratio	Imports ratio	Trade Ratio	Current open.	Real open.	Trade ratio with OECD
Average growth	1.000							
GDP per worker in 1960	0.137	1.000						
Exports ratio of WB	0.359	0.231	1.000					
Imports ratio of WB	0.288	0.004	0.840	1.000				
Trade ratio of WB	0.335	0.120	0.958	0.960	1.000			
Current openness of PW	0.344	0.152	0.958	0.962	0.996	1.000		
Real openness by A&C	0.426	0.381	0.846	0.721	0.812	0.868	1.000	
Trade ratio with OECD	0.280	0.184	0.851	0.850	0.876	0.909	0.815	1.000
Trade ratio with NonOECD	0.276	0.036	0.672	0.661	0.687	0.880	0.759	0.687

Table 5.2 provides the estimation results. Columns 1 and 2 show the regression results using the ratio of exports and the ratio of imports, respectively. Column 3 includes the trade ratio as a sum of the ratio of exports and the ratio of imports. In each regression the coefficient of the openness variable is to be found positive but not significant. Therefore, a significant association between growth and openness is not established using the World Bank data. However, we find that coefficient estimate of openness is positive and highly significant when employing current openness of the Penn World in column 4. The regression results indicate a 10 percent increase in trade ratio would raise the growth by 2.73 percent over the 1960-2000 period. This is equivalent to 0.07 percent increase in annual growth rate over the same period (2.73/40=0.07). In column 5 we estimate our baseline model with the variable of real openness suggested by Alcalá and Ciccone (2004) and conclude positive and strongly significant coefficient estimate. As can be seen, the estimated coefficient of real openness is higher compared to that of current openness and implies that a 10 percent increase would raise the growth rate 3.99 percentage points over the period 1960-2000 (which is equal to 0.10 percent increase in annual growth rate for the same period). In columns 6 and 7 we estimate our benchmark model adding trade ratio with OECD and trade ratio with non-OECD countries. The rationale is straightforward as Yanikkaya (2003) points out. In the light of recent endogenous growth theories countries, particularly the developing ones, can benefit more from trade with technologically advanced countries in order to stimulate growth. If this argument is true then one would expect a higher coefficient estimate of trade ratio with the OECD with respect to that of the trade ratio with non-OECD countries. However, the regression results in columns 6 and 7 show that the coefficient of the trade ratio with OECD is not only less than the coefficient of trade ratio with non-OECD but also is statistically insignificant. These results confirm the findings of Yanikkaya (2003) and imply that technology spillover effects of international trade on economic growth are not very important compared to the effects of scale economies and comparative advantage.

In summary, the regression results in Table 5.2 show a positive association between economic growth and international trade and confirm the findings of previous work (Vamwakidis (2002), Irwin and Terviö (2002), Dollar and Kraay (2003a), Yanikkaya (2003), Alcalá and Ciccone (2004) are a few recent examples). However, it is puzzling that we could not find any statistically significant relation between trade ratios of the World Bank and growth despite the very high correlations between these measures and current openness.[3] The reason is that regressions including trade ratios of World Bank have smaller samples than those including current openness and real openness. More clearly, some countries are dropped from the regressions when we use the World Bank data and hence this implies that the positive and statistically significant relation between growth and trade ratios of Penn World data may be driven by outlying countries.

When we look at the data of current openness, we highlight that Singapore has the highest trade ratio with a value of 323 percent. This country not only has the highest trade ratio but also records the highest growth rate over the 1960-2000 period. However, Singapore is missing in the trade ratios of World Bank since data for this country are available only over the 1974-2000 period. When we add Singapore

[3]For a comparison see Table 5.1. As can be easily seen, the correlation between current openness and real openness is smaller than the correlations between current openness and trade ratios of the World Bank.

Table 5.2: Economic Growth and Trade Volumes: OLS Estimates

Dependent Variable: Log Difference real GDP per worker over the 1960-2000 period

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log GDP per worker 1960	-0.471	-0.456	-0.462	-0.429	-0.464	-0.454	-0.434
	(6.46)	(6.16)	(6.31)	(6.46)	(6.97)	(5.81)	(5.66)
$\log(n_i + g + \delta)$	-1.108	-1.063	-1.080	-1.100	-1.021	-1.153	-1.286
	(2.66)	(2.52)	(2.58)	(2.93)	(2.77)	(2.97)	(3.38)
log of Investment rate	0.410	0.400	0.403	0.360	0.338	0.507	0.468
	(3.80)	(3.66)	(3.72)	(3.98)	(3.74)	(4.68)	(4.38)
log of School enrolment	0.436	0.453	0.445	0.430	0.438	0.391	0.390
	(4.28)	(4.46)	(4.38)	(5.11)	(5.28)	(3.89)	(4.00)
Exports ratio of WB	0.388	-	-	-	-	-	-
	(1.58)						
Imports ratio of WB	-	0.316	-	-	-	-	-
		(1.37)					
Trade ratio of WB	-	-	0.185	-	-	-	-
			(1.51)				
Current Openness of PW	-	-	-	0.273	-	-	-
				(2.85)			
Real Openness by A&C	-	-	-	-	0.399	-	-
					(3.29)		
Trade ratio with OECD	-	-	-	-	-	0.358	-
						(1.74)	
Trade ratio with NonOECD	-	-	-	-	-	-	0.787
							(2.80)
Constant	2.730	2.734	2.725	2.244	2.731	2.603	2.018
	(2.23)	(2.22)	(2.22)	(2.08)	(2.60)	(2.20)	(1.71)
Number of observations	93	93	93	105	105	89	89
p-value for heteroscedasticity[a]	0.95	0.94	0.95	0.64	0.81	0.43	0.69
Adjusted R^2	0.60	0.60	0.60	0.63	0.64	0.64	0.66

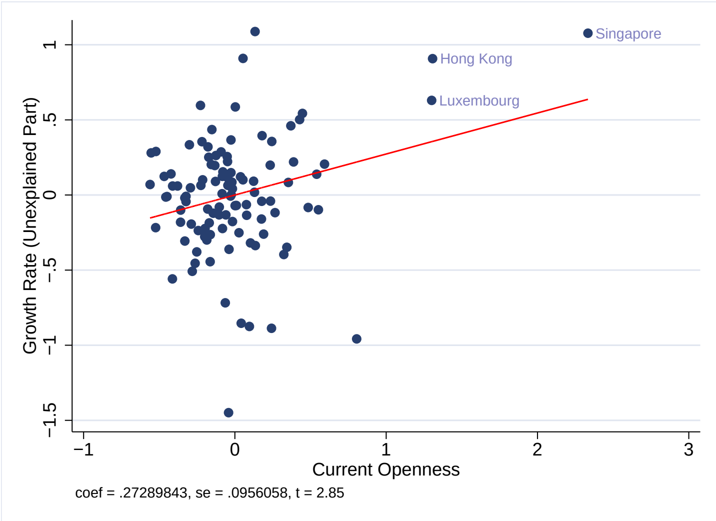
Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported.

[a]Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

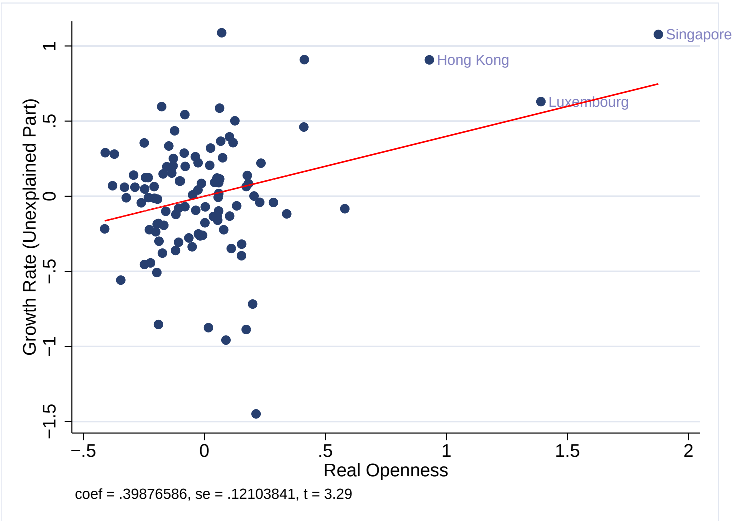
to the regressions based on the trade ratios of the World Bank using the average values over the 1974-2000 period instead of the 1960-2000 period, we find a positive and statistically significant relationship between growth and all three trade ratios of World Bank. This finding clearly indicates that Singapore is a highly influential country in the cross-country regressions in Table 5.2.

In order to check possible outliers we apply the Hadi measure on each data set subject to cross-country growth regressions in Table 5.2. We identify four countries namely Singapore, Hong Kong, Luxembourg and Tanzania as outliers in the regressions including current openness and real openness. Recall that we have already determined Tanzania as an outlying country in Chapter 4. Thus, Hong Kong, Luxembourg and Singapore are clearly outliers in current openness and/or real openness (See figures 5.1(a) and 5.1(b) for a graphical inspection). The outstanding characteristics of these countries is that they have the highest trade ratios with an average value of 244 percent according to the current openness and experience very high growth performances. In addition, we also identify Hong Kong and Luxembourg as outliers for the data set including trade ratios of the World Bank. A sample of countries based on the trade ratios with the OECD and non-OECD concludes that only Singapore for the data set including trade ratio with the OECD and five countries namely Congo Democratic Republic, Hong Kong, Singapore, Malaysia and Hungary for the data set including trade ratio with non-OECD as outlying observations.

When we drop all outlying countries from our regressions, we find that all openness variables except trade ratios with the OECD and non-OECD are negative but statistically insignificant (Table 5.3). Therefore, our findings such that both current openness and real openness are



(a) Current Openness: Exports plus Imports as a ratio of GDP in current prices



(b) Real Openness: Exports plus Imports as a ratio of GDP in PPP

Figure 5.1: Partial Associations between Growth Rate and Trade Shares

significantly and positively correlated with growth may not be robust. As can be seen from Table 5.3 after dropping outliers we conclude very similar findings to our first result for the trade ratio with the OECD such that this variable is still positive but not significant. Contrary to our first findings, we find a significantly negative coefficient estimate of the trade ratio with non-OECD which implies that trading with non-OECD countries, and hence technologically less advanced countries, is not beneficial for economic growth.

However, as discussed in the previous chapter, omitting outliers may not be a good solution for cross-country growth analysis. Instead of dropping these countries an alternative and better way is to carry out the analysis by employing weighted least squares (WLS). Indeed, omitting some observations from OLS regression is another kind of WLS estimation such that we assign each observation a weight of 1 if it is included in the regression or a weight of 0 if omitted. In contrast to these extreme weights, WLS gives each observation a weight between 1 and 0 such that outlying cases are down-weighted gradually. Therefore, we estimate the cross-country growth regressions in Table 5.2 employing Iteratively Reweighted Least Squares (IRLS). IRLS is based on iterative computation of case weights obtained from the residuals. Weight functions for the observations are first Huber weights and second the Tukey bisquare weights.[4] However, the most important shortcoming of IRLS is that it is not robust to high leverage data points. Therefore, if one can identify and drop the observations with the high leverage value and then estimate the sample of remaining observations by IRLS, estimation results will be more robust. Hence, before applying IRLS, we firstly highlight high leverage countries in each data set. For this, following Huber (1981) we determine the countries as risky whose leverage values are greater than 0.2. In the second step, we delete these risky countries from each sample and estimate the cross-country growth regressions by IRLS. Table 5.4 provides IRLS regression results. The first

[4] See Hamilton (1992) for more information about the IRLS.

Table 5.3: Economic Growth and Trade Volumes: OLS Estimates without Outlying Countries

Dependent Variable: Log Difference real GDP per worker over the 1960-2000 period

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log GDP per worker 1960	-0.495	-0.496	-0.496	-0.444	-0.441	-0.458	-0.526
	(6.83)	(6.67)	(6.76)	(6.81)	(6.64)	(5.97)	(7.72)
$\log(n_i + g + \delta)$	-1.170	-1.175	-1.174	-1.159	-1.167	-1.269	-1.429
	(2.86)	(2.84)	(2.86)	(3.16)	(3.17)	(3.30)	(4.20)
log of Investment rate	0.384	0.385	0.385	0.357	0.355	0.465	0.333
	(3.62)	(3.62)	(3.63)	(3.70)	(3.66)	(4.30)	(3.53)
log of School enrolment	0.478	0.474	0.476	0.444	0.441	0.411	0.497
	(4.71)	(4.76)	(4.75)	(5.00)	(4.95)	(4.15)	(5.77)
Exports ratio of WB	-0.073	-	-	-	-	-	-
	(0.24)						
Imports ratio of WB	-	-0.044	-	-	-	-	-
		(0.17)					
Trade ratio of WB	-	-	-0.031	-	-	-	-
			(0.21)				
Current Openness of PW	-	-	-	-0.071	-	-	-
				(0.49)			
Real Openness by A&C	-	-	-	-	-0.024	-	-
					(0.12)		
Trade ratio with OECD	-	-	-	-	-	0.132	
						(0.58)	
Trade ratio with NonOECD	-	-	-	-	-	-	-1.299
							(2.09)
Constant	2.862	2.855	2.860	2.406	2.318	2.327	2.467
	(2.36)	(2.35)	(2.36)	(2.25)	(2.19)	(2.00)	(2.34)
Number of observations	91	91	91	101	101	88	84
p-value for heteroscedasticity[a]	0.58	0.60	0.59	0.76	0.84	0.74	0.47
Adjusted R^2	0.61	0.61	0.61	0.62	0.62	0.63	0.69

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported.

[a]Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

four columns of Table 5.4 shows that both trade ratios of the World Bank and current openness are significantly and positively associated with economic growth. However, we could not conclude the same thing for the real openness. As can be seen in column 5 of Table 5.4, the coefficient estimate of real openness is positive but not statistically significant. In columns of 6 and 7, we report regressions including the trade ratios with OECD and non-OECD, respectively and conclude that both are positive. Yet, trade ratios with OECD is not found to be statistically significant.

Table 5.4: Economic Growth and Trade Volumes: IRLS Estimations

Dependent Variable: Log Difference real GDP per worker over the 1960-2000 period

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log GDP per worker 1960	-0.492	-0.468	-0.477	-0.442	-0.464	-0.503	-0.487
	(7.99)	(7.31)	(7.60)	(7.79)	(7.97)	(7.64)	(7.24)
$\log(n_i + g + \delta)$	-1.157	-1.115	-1.124	-1.302	-1.215	-1.280	-1.307
	(3.28)	(3.07)	(3.14)	(4.05)	(3.77)	(3.87)	(3.95)
log of Investment rate	0.394	0.375	0.379	0.331	0.305	0.403	0.425
	(4.33)	(3.98)	(4.08)	(3.90)	(3.57)	(4.34)	(4.55)
log of School enrolment	0.442	0.466	0.457	0.427	0.441	0.452	0.434
	(5.13)	(5.32)	(5.26)	(5.53)	(5.65)	(5.30)	(5.07)
Exports ratio of WB	0.564	-	-	-	-	-	-
	(2.72)						
Imports ratio of WB	-	0.385	-	-	-	-	-
		(1.93)					
Trade ratio of WB	-	-	0.247	-	-	-	-
			(2.36)				
Current Openness of PW	-	-	-	0.231	-	-	-
				(2.27)			
Real Openness by A&C	-	-	-		0.209	-	-
					(1.29)		
Trade ratio with OECD	-	-	-	-	-	0.279	-
						(1.42)	
Trade ratio with NonOECD	-	-	-	-	-	-	0.771
							(2.07)
Constant	2.741	2.668	2.693	1.805	2.234	2.592	2.423
	(2.64)	(2.51)	(2.56)	(1.95)	(2.41)	(2.59)	(2.35)
Number of observations	93	93	93	103	102	88	88
Adjusted R^2	0.69	0.67	0.68	0.69	0.67	0.70	0.70

Note: t-statistics are in parentheses.

However, the ratio of trade volume in GDP is an idiosyncratic measure of openness as noted by Birdsall and Hamoudi (2002).[5] First, some large countries may appear closed economy by this measure. For instance, according to the current openness the United States and Japan are the fourth and seventh most closed economies in our sample. Second, the volume of international trade is affected not only by trade policies but also by other factors such as transportation costs, world demand, geography, natural resource dependence and so on. Hence, it is likely that a positive association between trade to GDP ratio and growth rate implies the impact of international trade rather than the effect of trade polices on economic growth.

5.3.2 Direct Trade Policy Measures

In the second step we investigate the openness-growth connection by employing direct trade policy measures namely tariff rates, non-tariff barriers on imports and black market premium. It is obvious that the first two measures directly affect a country's trade volume and reducing or removing them clearly indicates a more open trade regime. Yet, the use of the black market premium as a measure of trade barriers is debated in the literature. Authors such as Sachs and Warner (1995) and Warner (2003) argue that a high black market premium causes increases in the price of imports relative to domestic prices and thus plays the same role with tariff and non-tariff barriers. Others, such as Rodrik and Rodríguez (2000), claim that a high black market premium

[5]The ratio of trade volume in GDP is defined as follows:

$$openness = \frac{X + M}{A + X - M}$$

where X is exports, M is imports and A is domestic absorbtion (sum of consumption and investment). Assume that the world economy consists of two identical countries. In this setting the country running trade deficit will be more open than the other country.

generally shows macroeconomic imbalances rather than trade barriers.

Undoubtedly, both tariff rates and non-tariff barriers are ideal measures in order to capture a country's degree of openness to international trade. Yet, unfortunately we do not have good data for these measures across countries and over time. The most common data for these measures in the literature come from the data set by Barro and Lee (1994a). In this data set, tariff rate and non-tariff coverage ratios are weighted averages by the product shares in a country's overall imports. However, both variables cover the only imports of intermediate inputs and capital goods over the 1983-1985 period. In addition, they have a problem of downward bias since both measures are weighted by their own-import value. Finally, it is not likely that all non-tariff barriers can be measured and they accurately reflect the intensity of non-tariff barriers.

Employing these two measures as an openness variable, we estimate our baseline model. The estimation results are reported in Table 5.5. In columns 1 and 2 of Table 5.5, we only include tariff rate and non-tariff barriers, respectively. Both measures enter the regressions with negative but insignificant coefficient estimates. In column 3, we allow both tariff rate and non-tariff barriers together. As can be seen, tariff rate and non-tariff barriers are neither individually nor jointly significant. In the fourth column, we replace tariff rate with the collected import duties as a ratio of imports over the 1970-1998 period and find a positive but insignificant coefficient estimate. It is well known fact that the ratio of collective import duties in a country's overall imports is a problematic measure in order to reflect a country's tariff structure due to the fact that a country with very high tariff rates may appear open by this measure. In column 5, we include unweighted average tariff rate over the 1990-2000 period that is provided by Wacziarg and Welch (2003). The difference between this measure and tariff rate of Barro and Lee (1994a) is that the former is simply averages of ad valorem tariff rates across commodities subjected to imports. The estimated coefficient of unweighed tariff rates is negative but again statistically insignificant. We include average black market premium over the 1960-2000 period in column 7 and find that the black market premium is negatively and significantly associated with economic growth. In columns 8 and 9, we replace average black market premium with two dummy variables, respectively. The first dummy variable takes the value of 1 if the average black market premium exceeds 20 percent in the 1960s or the 1970s or the 1980s or the 1990s while the second one is equal to 1 if the average black market premium is higher than 20 percent over the 1960-2000 period. Our aim in constructing for these dummies is to check the relation between growth and a larger level of black market premium. Following Sachs and Warner (1995), we assume 20 percent as a threshold level. As can be seen, in each case the dummy variables are negatively correlated with growth and strongly significant. In column 10, we include tariff rate, non-tariff barriers and average black market premium jointly. The result is essentially same. Both tariff rates and non-tariff measures are not significant but black market premium is. In the last column, the regression is exactly the same as the regression in column 10, the only difference is that we replace average black market premium with the dummy variable for black market premium. As can be seen, the result is unchanged.

Table 5.5: Economic Growth and Direct Trade Measures: OLS Estimates[†]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
log GDP per worker 1960	-0.485	-0.476	-0.497	-0.446	-0.479	-0.484	-0.499	-0.506	-0.493	-0.505
	(5.82)	(5.74)	(5.78)	(5.29)	(6.14)	(7.30)	(7.24)	(7.59)	(6.88)	(7.46)
$\log(n_i + g + \delta)$	-1.291	-1.274	-1.229	-1.109	-1.061	-1.092	-0.996	-1.043	-1.269	-1.194
	(2.85)	(2.77)	(2.65)	(2.60)	(2.80)	(3.09)	(2.74)	(2.98)	(3.54)	(3.39)
log of Investment rate	0.428	0.433	0.420	0.443	0.400	0.327	0.323	0.329	0.319	0.336
	(4.20)	(4.24)	(4.07)	(4.02)	(4.14)	(3.53)	(3.42)	(3.61)	(2.49)	(2.77)
log of School enrolment	0.423	0.426	0.440	0.445	0.448	0.475	0.495	0.483	0.441	0.436
	(4.08)	(4.12)	(4.21)	(4.14)	(4.79)	(5.57)	(5.63)	(5.71)	(4.85)	(5.06)
owti[a]	-0.327	-	-0.290	-	-	-	-	-	-0.309	-0.096
	(1.12)		(0.93)						(1.07)	(0.33)
owqi[b]	-	-0.116	-0.050	-	-	-	-	-	0.088	0.019
		(0.60)	(0.24)						(0.48)	(0.10)
Import Duties[c]	-	-	-	0.377	-	-	-	-	-	-
				(0.44)						
uwti[d]	-	-	-	-	-0.477	-	-	-	-	-
					(0.90)					

Continued on Next Page...

Table 5.5 – *Continued*

log (1+BMP)[e]	-	-	-	-	-	-0.233	-	-	-0.224	-
						(2.84)			(2.26)	
BMP dummy[f]	-	-	-	-	-	-	-0.199	-	-	-
							(2.32)			
BMP dummy[g]	-	-	-	-	-	-	-	-0.263	-	-0.275
								(3.22)		(3.01)
Constant	2.556	2.495	2.821	2.654	3.109	2.937	3.357	3.301	2.523	2.874
	(1.96)	(1.91)	(2.08)	(1.88)	(2.56)	(2.78)	(3.00)	(3.11)	(2.14)	(2.51)
Number of observations	87	85	85	93	101	101	101	101	83	83
p-value for heteroscedasticity[h]	0.82	0.70	0.83	0.59	0.81	0.30	0.47	0.39	0.12	0.11
F-value[i]	-	-	0.61	-	-	-	-	-	2.09	3.51
Adjusted R^2	0.60	0.60	0.60	0.56	0.61	0.64	0.64	0.65	0.62	0.63

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported.

[†] Dependent Variable is the log difference real GDP per worker over the 1960-2000 period

[a] Own-import weighted tariff rates on intermediate inputs and capital goods.

[b] Own-import weighted non-tariff frequency on intermediate inputs and capital goods.

[c] Collected import duties as ratio of imports over 1970-1998 period.

[d] Unweighted average tariff rate over the 1990-99 period.

[e] Logarithm of one plus average value of black market premium over the 1960-1999 period.

[f] Dummy variable is equal to 1 if the average black market premium exceeds 20 % in either the 1960s or the 1970s or the 1980s or the 1990s.

[g] Dummy variable is equal to 1 if the average black market premium exceeds 20 % over the 1960-2000 period.

[h]Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

[i] Test for joint significance of openness variables.

As a result, our empirical investigation between growth and direct trade policy measures indicates that the significant association with economic growth is established only for the black market premium. However, Warner (2003) points out that the time period should be 1970-1990 for testing the impact of trade protection through tariff rates. The reason is that the majority of developing countries have liberalised their trade regime during the late 1980s and early 1990s. In other words, the large cross-country variation in tariff rates in the earlier period was eliminated after the 1980s. In addition, he indicates that India is a clear outlying observation. Therefore, according to Warner (2003), one can find a negative and significant correlation between growth and tariff rate if he omits India from the sample and estimates the growth regression over the 1970-1990 period.

In order to test Warner's claim we estimate our baseline model over the period 1970-1990 for the same sample without India. The regression result is given in the first column of Table 5.6 and shows a negative but statistically insignificant coefficient on the tariff rate. In addition to India, we identify three more countries namely Burkina Faso, Guyana, and Tanzania as outliers applying the Hadi methodology on the data set over the 1970-1990 period. In the second column of Table 5.6, we drop these countries as well as India from the regression and conclude that tariff rate is again negative but not significant. Therefore, our findings indicate that Warner's claim is not valid over the 1970-1990 period. However, it may be more reasonable to investigate growth-tariff connection over the period 1960-1990, the reason is that most of the developing countries followed protectionist trade polices not only during the 1970s but also during 1960s and it is more likely that their trade policy measures did not change substantially over the 1960-1980 period. In addition, most of them experienced relatively higher growth performance during the 1960s. Therefore the time period suggested by Warner (2003) might be biased since it does not include the growth information of 1960s. In columns 3 and 4, we estimate our baseline specification with the tariff rate over the 1960-1990 period. In column 3, we omit India from the regressions and conclude that tariff rate is negative but insignificant. In column 4, the other outlier country, Tanzania, is omitted and the coefficient estimate of tariff rate is again found to be negative but insignificant. Indeed, we think that the time period 1960-2000 is more plausible in order to investigate the relationship between tariff rate and economic growth. First, the period 1960-2000 is sufficiently long in order to reflect long run growth dynamics. Second, the period 1970-1990, especially the period 1975-1985 can be considered as a transition period from protectionist trade policies to more liberal trade regimes for the majority of developing countries. Therefore, even though the tariff rate of the Barro-Lee data set is measured for only the 1983-1985 period, it is likely that this tariff rate reflects the average tariff rate across countries over the period 1960-2000. Therefore, in column 5, we estimate our baseline growth model with the tariff rate whilst dropping India and conclude that coefficient of tariff rate is negative and significant at the 11 percent significance level. In addition if we also omit Tanzania from the regression in column 6, we find that tariff rate is negative and significant at 9 percent significance level. Therefore, it is possible to conclude that tariff rate is negatively associated with economic growth over the 1960-2000 period at the marginally significant level once we take into account outlying countries.

In summary, our cross-country empirical investigation indicates that

Table 5.6: Economic Growth and Tariffs: OLS Estimates under Different Time Period and without Outliers

Dependent Variable: Log Difference real GDP per worker

	1970-1990		1960-1990		1960-2000	
	(1)	(2)	(3)	(4)	(5)	(6)
log of Initial GDP per worker	-0.289	-0.357	-0.392	-0.401	-0.488	-0.494
	(4.64)	(6.33)	(5.37)	(5.49)	(5.87)	(5.95)
$\log(n_i + g + \delta)$	-0.494	-0.818	-0.658	-0.705	-1.151	-1.209
	(1.57)	(2.69)	(1.85)	(2.08)	(2.47)	(2.59)
log of Investment rate	0.302	0.364	0.368	0.432	0.424	0.493
	(4.57)	(5.40)	(4.32)	(4.93)	(4.17)	(4.30)
log of School enrolment	0.193	0.174	0.271	0.216	0.420	0.355
	(2.92)	(2.51)	(3.42)	(2.82)	(4.07)	(3.10)
owti	-0.360	-0.444	-0.582	-0.637	-0.725	-0.762
	(1.12)	(1.48)	(1.39)	(1.53)	(1.64)	(1.73)
Constant	2.280	2.140	3.236	3.258	3.006	2.990
	(2.45)	(2.46)	(3.16)	(3.34)	(2.22)	(2.21)
Number of observations	86	83	86	85	86	85
p-value for heteroscedasticity[b]	0.36	0.21	0.08	0.09	0.86	0.80
Adjusted R^2	0.41	0.54	0.56	0.58	0.6	0.61

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported.

[a] Own-import weighted tariff rates on intermediate inputs and capital goods.

[b] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

among the direct trade policy measures only tariff rate and black market premium are negatively correlated with economic growth. However, we conclude that this correlation is marginally significant in the tariff case while strongly significant for the black market premium.

Black Market Premium: A Proxy for Trade Policy or Macroeconomic Imbalances?

As mentioned above, whether the significant association between black market premium and economic growth reflects the relationship between growth and restrictive trade policies or the connection between growth and other poor macroeconomic polices rather than trade polices is debatable. Now, we consider this point further.

Our data for black market premium come from Global Development Network (2005). Unfortunately, we lack data on the black market premium for several countries in the 1960s. In addition, for many countries data are missing during the mid 1990s. In order to increase the number of observations, we take the averages of black market premium for the 18 countries over the 1970-2000 period instead of 1960-2000 period. Of course, this approach implicitly assumes that for these countries the black market premium in the 1970s reflects the black market premium in the 1960s. Indeed, this assumption is not very realistic since we do not observe a certain pattern on the black market premium during the 1960s and the 1970s for the countries whose data are available in both decades. Among the 103 countries we identify, 43 of them experience a higher level of black market premium in the 1970s compared to the 1960s. Most of these countries are located in Africa and Latin America. On the other hand only 39 countries mostly located in the Middle East, North Africa, East Europe, Asia and Pacific have a lower level of black market premium in the 1970s with respect to the 1960s. 21 developed countries have zero black market premium in both decades.

Table 5.7 provides summary statistics of black market premium for each decade. As can be seen, for the first and largest sample in Table 5.7, both the mean and standard deviation of black market premium is higher in the 1960s compared to the 1970s. In order to provide a better comparison we also report the summary statistics of black market premium for 103 countries whose data are available in each decade (the second largest sample). Again both the mean and standard deviation of the black market premium is higher in the 1960s compared to the 1970s. Therefore, it is likely that we underestimate average black mar-

Table 5.7: Black Market Premium (%): Summary Statistics

	Number of Observations	Mean value	Standard Deviation	Minimum value	Maximum value
The Largest Sample					
BMP 1960-2000	121	259.701	2114.377	-0.442	23235.250
BMP in 1960s	103	48.685	228.780	-0.090	2276.400
BMP in 1970s	121	36.319	72.469	-6.960	451.790
BMP in 1980s	121	129.106	600.604	-1.410	6406.610
BMP in 1990s	121	1205.328	12627.680	-0.350	138935.900
The 2^{nd} Largest Sample					
BMP 1960-2000	103	297.5641	2291.072	-0.442	23235.250
BMP in 1960s	103	48.68505	228.7795	-0.090	2276.400
BMP in 1970s	103	39.39447	77.2462	-1.290	451.790
BMP in 1980s	103	139.4033	648.8455	-1.410	6406.610
BMP in 1990s	103	1411.573	13686.08	-0.350	138935.900
The Regression Sample					
BMP 1960-2000	101	66.520	199.778	-0.442	1796.679
BMP in 1960s	90	47.521	241.983	-0.090	2276.400
BMP in 1970s	101	32.399	64.711	-6.960	451.790
BMP in 1980s	101	137.674	654.984	-1.410	6406.610
BMP in 1990s	101	30.501	124.572	-0.350	1199.310
The Smallest Sample					
BMP 1960-2000	90	67.668	209.826	-0.442	1796.679
BMP in 1960s	90	47.521	241.983	-0.090	2276.400
BMP in 1970s	90	33.895	67.323	-0.870	451.790
BMP in 1980s	90	142.192	692.166	-1.410	6406.610
BMP in 1990s	90	32.662	131.741	-0.350	1199.310

ket premium over the 1960-2000 period by using the 1970-2000 averages for the countries whose data are missing during the 1960s. However, since we conclude that a negative and highly significant association between black market premium and economic growth over the 1960-2000 period, this bias in the data makes our result stronger.

The other important point is that the mean of the black market premium is substantially higher in the 1990s compared to the other decades in the largest sample. At the first sight, this might be thought to be surprising because most of the developing countries have liberalised their capital accounts since the late 1980s and one would expect very low black market premium for these countries during the 1990s. However, this is mainly a result of a small number of countries with the extreme values of black market premium in this decade such as Iran, Iraq, Afghanistan, Liberia, Syria and Libya. As can be seen, not only is the mean value of black market premium substantial but also its standard deviation is high during the 1990s. Of course, from our point summary statistics of regression sample are of great concern rather than those of the largest samples. When we consider only the regression sample, both mean and standard deviation of black market premium in the 1980s are considerably higher than other decades. In addition, the statistics of black market premium based on the smallest sample consisting of the countries whose data are available in each decade support this fact. This implies that the negative and statistically significant association between black market premium and economic growth over the 1960-2000 period may be as a result of both the high level and variation of the black market premium during the 1980s.

Therefore, in Table 5.8 we estimate our baseline model with the averages of black market premium in each decade. In column 1, we allow average black market premium in each decade to vary continuously and conclude that none of them are statistically significant despite a negative sign. In addition, they are jointly insignificant. However, the t-statistics of black market premium in the 1980s is relatively higher. In columns 2-5, we insert average black market premium in each decade separately and find that the only average black market premium in the 1980s is negatively and significantly correlated with growth. Therefore, it is possible to conclude that the significant and negative correlation between black market premium and economic growth over the 1960-2000 period mainly depends on the high level and high variation in the black market premium during the 1980s in which many developing

Table 5.8: Economic Growth and Black Market Premium: OLS Estimates

Dependent Variable: Log Difference real GDP per worker over the 1960-2000 period

	(1)	(2)	(3)	(4)	(5)
log GDP per worker 1960	-0.514	-0.507	-0.483	-0.456	-0.475
	(7.14)	(6.39)	(8.00)	(6.99)	(6.92)
$\log(n_i + g + \delta)$	-1.032	-1.180	-1.222	-1.008	-1.070
	(2.94)	(3.05)	(3.64)	(2.85)	(2.91)
log of Investment rate	0.294	0.324	0.341	0.336	0.362
	(2.69)	(3.17)	(3.14)	(3.68)	(3.84)
log of School enrolment	0.511	0.506	0.452	0.453	0.470
	(5.93)	(5.11)	(6.05)	(5.36)	(5.34)
log (1+BMP) in 1960s	-0.113	-0.132	-	-	-
	(0.76)	(1.16)			
log (1+BMP) in 1970s	-0.068	-	-0.244	-	-
	(0.26)		(1.16)		
log (1+BMP) in 1980s	-0.130	-	-	-0.186	-
	(1.35)			(3.07)	
log(1+BMP) in 19990s	-0.034	-	-	-	-0.181
	(0.28)				(1.52)
Constant	3.318	2.855	2.560	2.925	2.941
	(2.84)	(2.53)	(2.50)	(2.79)	(2.64)
Number of observations	90	90	101	101	101
p-value for heteroscedasticity[a]	0.08	0.53	0.11	0.21	0.91
F-value[b]	1.81	-	-	-	-
Adjusted R^2	0.62	0.61	0.63	0.65	0.62

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported.
[a] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.
[b] Test for joint significance of log of average black market premium in the decades.

countries launched the liberalisation programs after the debt crises in the late 1970s and the early 1980s. Hence, it is more likely that negative and significant connection between black market premium and economic growth over the period 1960-2000 reflects the adverse rela-

Table 5.9: Economic Growth and Black Market Premium Dummy: OLS Estimates

Dependent Variable: Log Difference real GDP per worker over the 1960-2000 period

	(1)	(2)	(3)	(4)	(5)
log GDP per worker 1960	-0.560	-0.511	-0.517	-0.476	-0.545
	(6.24)	(6.43)	(7.63)	(8.46)	(7.96)
$\log(n_i + g + \delta)$	-1.117	-1.139	-1.181	-1.001	-1.266
	(3.64)	(2.97)	(3.39)	(3.18)	(3.67)
log of Investment rate	0.321	0.318	0.340	0.334	0.380
	(2.70)	(3.10)	(3.75)	(3.21)	(4.25)
log of School enrolment	0.488	0.520	0.476	0.452	0.445
	(5.32)	(5.11)	(5.64)	(5.97)	(5.36)
BMP dummy in 1960s[a]	-0.026	-0.137	-	-	-
	(0.21)	(1.26)			
BMP dummy in 1970s[a]	-0.150	-	-0.261	-	-
	(1.34)		(3.17)		
BMP dummy in 1980s[a]	-0.103	-	-	-0.275	-
	(0.85)			(3.38)	
BMP dummy in 1990s[a]	-0.173	-	-	-	-0.385
	(1.01)				(3.65)
Constant	3.555	3.007	3.022	3.138	3.052
	(3.11)	(2.62)	(2.88)	(3.06)	(2.96)
Number of observations	90	90	101	101	101
p-value for heteroscedasticity[b]	0.09	0.58	0.18	0.12	0.50
F-value[c]	3.09	-	-	-	-
Adjusted R^2	0.65	0.61	0.65	0.66	0.66

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported.
[a] Dummy variable is equal to 1 if the average black market premium exceeds 20 %.
[b] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.
[c] Test for joint significance of the black market premium dummies.

tion between macroeconomic imbalances and growth. In Table 5.9 we exactly replicate the cross country growth regressions in Table 5.8. The only difference is that in Table 5.9 we use a dummy variable which takes the value of 1 if the average value of black market premium exceeds 20 percent. As can be seen, the dummy variables are continuously and separately negative and significant, except the dummy in the 1960s. This implies that a higher level of black market premium is particularly harmful for economic growth.

In conclusion, our findings about the relationship between economic growth and direct trade policy measures are not in favour of more liberal trade policies. We find evidence for the adverse growth-tariff connection, but the tariff rate is only marginally significant. On the other hand our finding concerning the statistically significant association between black market premium and economic growth may indicate the negative relation between growth and macroeconomic imbalances rather than the trade restrictive effect of black market premium.

5.3.3 Deviation Measures

Cross-country growth regressions including only single trade policy measures have low-power for testing openness-growth connection as argued by Warner (2003). The reason is that each trade policy measure takes into account only one aspect of trade policy and hence tells only part of story (Leamer (1988)). Therefore, we need a single general measure encompassing all aspects of trade policy for testing the protectionism in general. As noted by Warner (2003, p.4) "The right regression for testing the impact of protectionism would seem to entail some aggregation of the policy instruments."

One way in order to overcome this is employing deviation measures. These measures basically show the difference between predicted and actual trade and hence can be used as an indicator of the overall level of trade protectionism. Deviation measures are essentially based on the following rationale. According to the traditional small country model, international trade is determined by the factor endowments, international prices, technology, preferences, natural trade barriers and trade policy instruments (Leamer (1988)). Therefore, differences among the countries in the level of trade can be considered as trade policy barriers if the countries are substantially identical in terms of factor endowment, technology, preferences, and natural barriers or their effects are controlled. This implies that if one constructs a model which sufficiently explains trade flows across countries, then residuals obtained from that model can be considered as an overall measure of trade barriers subject to only trade policy. Of course this approach implicitly assumes that trade policy barriers are the only important omitted variables and they are uncorrelated with the other determinants of trade.[6]

In the literature many deviation measures as an indicator of openness to international trade have been suggested. In this respect as noted in Chapter 3, outward orientation index by Syrquin and Chenery (1989), openness and distortion indexes by Leamer (1988) and the recent predicted trade shares by Frankel and Romer (1999) are the most well-known measures. In addition to these, we also construct a very simple model as

$$\begin{aligned}((X+M)/GDP_i) = \alpha_0 + \alpha_1 log(Initial\ per\ worker\ GDP_i)\\ + \alpha_2 log(area_i) + \alpha_3 log(Average\ labour\ force_i) + \varepsilon_i\end{aligned} \tag{5.2}$$

The model in (5.2) includes the dependent variable which is the exports plus imports as a share of GDP and hence already takes into account the size of country. We employ the real GDP per worker as a

[6]Both assumptions are not realistic as pointed out by Leamer (1988) and Wacziarg (2001).

proxy for factor endowments of country. In order to avoid the possible endogeneity problem we use the 1960 value of per worker GDP. The other explanatory variables are the land area and average labour force. Both variables are expressed in logarithms and represent the country size. As pointed out by Frankel and Romer (1999) country size is an important determinant of international trade due to the fact that there are more opportunities for within country trade in the larger countries.

The specification in (5.2) is of course very simple in many aspects. First, the dependent variable is the average total trade as a ratio of GDP rather than the sum of bilateral trades across countries. Obviously estimating total trade as a sum of bilateral trades by employing a model including some gravity variables such as distance between two countries, common border dummy as well as other determinants would be better. However, unfortunately we lack data on bilateral trades across countries over the period 1960-2000. Second, this specification assumes that the only important omitted variables are trade policy barriers. A better specification therefore would be to include trade policy barriers such as tariffs and non-tariff barriers on imports (we will consider this point later). Finally we assume that preferences and technology are constant among countries. Even though these are important shortcomings for the model in (5.2), we think that the estimated residuals from this model can be used as a more reliable indicator for openness compared to simple actual trade ratios. Obviously, a large value of residual implies that the country is more open to international trade once the initial factor endowments and country's size are controlled.

Employing the current openness as a dependent variable we estimate this model by OLS over the 1960-2000 period. Column 1 of

Table 5.10: Exports plus Imports as a Share of GDP: OLS Estimates

Dependent variable	Current Openness		Real Openness	
	(1)	(2)	(3)	(4)
log GDP per worker 1960	0.061	0.050	0.150	0.150
	(2.08)	(1.59)	(5.23)	(4.70)
log Area	-0.110	-0.106	-0.094	-0.094
	(2.57)	(2.40)	(2.62)	(2.54)
log Average Labour Force	-0.049	-0.054	0.003	0.003
	(1.52)	(1.56)	(0.11)	(0.09)
Landlocked country dummy[a]	-	-0.072	-	-0.005
		(0.91)		(0.09)
Constant	2.218	2.354	0.222	0.231
	(5.73)	(5.59)	(0.72)	(0.67)
Number of observations	111	111	111	111
p-value for heteroscedasticity[b]	0.00	0.00	0.00	0.00
Adjusted R^2	0.45	0.45	0.40	0.40

Note: t-statistics based on heteroscedastic-consistent (White-robust) standard errors are in parenthesis.
[a] The landlocked countries in Europe are dropped.
[b] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

Table 5.10 presents the resulting OLS estimate. In column 2, we also include a dummy variable for landlocked countries in order to control for natural trade barriers. However, inserting the landlocked country dummy neither changes the basic results nor improves the fit of the model. Therefore, we prefer to employ residuals which come from the first regression as an openness variable and label it as *RESID_Current Openness*. In columns 3 and 4, we replicate the regressions in the first two columns. The only difference is that in columns 3 and 4 we use the real openness as the dependent variable. As can be seen, the regression results in columns 3 and 4 are different from those in columns 1 and 2 in some aspects: First, when the dependent variable is real openness the coefficient estimate of initial income is considerably larger and highly significant. Second, average labour force is not only significant but also very close to zero. Third, the R^2 values of the regressions in columns 3 and 4 is smaller and hence it is possible to conclude that these regressions are less precise. On the other hand, as in the case of current openness, including a landlocked country dummy does not improve the goodness of fit of the regression in column 3. Therefore, we again use the estimated residuals in column 3 as an openness measure and label it as *RESID_Real Openness*.

Table 5.11 reports the estimation results by employing deviation measures in the framework of our baseline cross-country growth model. In column 1 we include the outward orientation index by Syrquin and Chenery (1989) and conclude that its coefficient estimate is negative but insignificant. However, it is more plausible to estimate this index over the period 1960-1985 since the index covers 1965-1980 period. Therefore, in column 2 we setup our benchmark model over the 1960-1985 period and estimate it with the outward orientation index. Now, coefficient estimate of index is positive but again insignificant. In columns 3 and 4 we insert the openness and distortion indexes constructed by Leamer (1988), and find that both are positive and statistically significant at the 1 percent level. The results are obviously inconsistent due to the fact that the coefficient estimate of distortion index should be negative if openness is positively correlated with economic growth. Notice that these two regressions are estimated over the 1960-1985 period since both openness and distortion indexes are calculated for only 1982. In column 5 and 6 we include *RESID_Current Openness* and *RESID_Real Openness* and conclude that both variables are positively and significantly associated with growth. Notice that this association is stronger for the *RESID_Real Openness*, with the

RESID_Current Openness being only marginally significant. The regression in column 7 includes the Frankel-Romer predicted trade shares from a gravity model. Since this variable is predicted for only 1985 the cross-country growth regression covers 1960-1985 period. Estimation results show that the Frankel-Romer predicted trade share is positive and statistically significant. Since this variable predicts trade shares from a gravity model based on the geographical characteristics of the countries, this result can be only seen as an indication of a positive impact of international trade on economic growth if one assumes that geography influences growth only through international trade. In column 8, we estimate our benchmark model with the Frankel-Romer predicted trade shares over the 1960-2000 period. For this regression we employ the predicted trade shares provided by Dollar and Kraay (2003a). This variable is different from the original Frankel-Romer predicted trade shares in two aspects: First it is based on the data on bilateral trade in 1995; Second, it expresses the bilateral trade as a fraction of GDP at PPP rather than current prices. Therefore, this variable is identical to real openness once the geographical characteristics of the countries are controlled. The regression results imply that the predicted trade share has a positive and significant effect on economic growth. As can be seen, this effect is substantially stronger than in the previous regression.

In conclusion, our cross-country empirical investigation indicates that adjusted trade ratios and the Frankel-Romer predicted trade shares are significantly and positively correlated with growth. We, however, conclude an insignificant association between growth and outward orientation index by Syrquin and Chenery (1989) and inconsistent results for Leamer's (1988) openness and distortion indexes.

Table 5.11: Economic Growth and Deviation Measures: OLS Estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log GDP per worker 1960	-0.480	-0.331	-0.363	-0.343	-0.415	-0.418	-0.340	-0.406
	(6.39)	(5.87)	(5.25)	(5.11)	(6.09)	(6.16)	(6.71)	(6.22)
$\log(n_i + g + \delta)$	-1.199	-0.339	-0.639	-0.777	-1.198	-1.118	-0.191	-0.817
	(3.00)	(1.26)	(2.08)	(2.58)	(3.03)	(2.91)	(0.74)	(2.27)
log of Investment rate	0.415	0.296	0.483	0.475	0.359	0.349	0.302	0.397
	(4.42)	(5.16)	(5.30)	(5.42)	(3.80)	(3.66)	(5.41)	(4.52)
log of School enrolment	0.471	0.266	0.110	0.083	0.429	0.446	0.279	0.405
	(5.11)	(4.75)	(0.97)	(0.75)	(4.99)	(5.22)	(5.29)	(4.82)
Outward orientation by S&C	-0.036	0.082	-	-	-	-	-	-
	(0.42)	(1.29)						
Openness index by Leamer	-	-	0.523	-	-	-	-	-
			(2.53)					
Distortion index by Leamer	-	-	-	0.685	-	-	-	-
				(3.23)				
RESID_Current Openness	-	-	-	-	0.268	-	-	-
					(1.91)			
RESID_Real Openness	-	-	-	-	-	0.323	-	-
						(2.07)		
log F&R predicted trade 1985	-	-	-	-	-	-	0.091	-
							(2.39)	
log F&R predicted trade 1995	-	-	-	-	-	-	-	0.209
								(3.35)
Constant	2.745	3.283	2.988	2.216	2.038	2.268	3.544	3.672
	(2.39)	(4.05)	(2.83)	(2.08)	(1.76)	(2.04)	(4.65)	(3.43)
Number of observations	103	103	50	50	105	105	107	107
p-value for heteroscedasticity[a]	0.73	0.35	0.20	0.26	0.69	0.71	0.21	0.93
Adjusted R^2	0.61	0.53	0.63	0.66	0.61	0.62	0.57	0.65

Note: t-statistics are in parenthesis. [a] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

5.3.4 Subjective Measures

In the fourth and last step, we consider some subjective measures for openness. These measures are in some sense similar to the deviation measures such that both try to capture all aspects of trade policy. The main difference is that they are partly or completely based on the subjective judgment.

We start with a trade orientation index based on the the World Bank World Development Report 1987 (WBWDR87 hereafter). As noted in Chapter 2, the report classifies 41 developing countries according to their trade orientation as strongly outward, moderately outward, moderately inward and strongly inward over the periods 1963-1972 and 1975-1985. In order to quantify the classification of WBWDR as a single variable, we assign the value of 1 if the country is either strongly or moderately outward oriented and then simply takes the averages of two sub periods. Therefore our openness measure based on WBWDR varies between 0 and 1 and reflects the outward orientation of the countries over the 1963-1985 period. Column 1 of Table 5.12 reports the estimation result of our benchmark specification including this openness measure over the 1960-1985 period. As can be seen, the coefficient estimate on this variable considerably large (0.639) and highly significant. This implies that an increase in the WBWDR openness index by one standard deviation (which is equal to 0.387 over the 1963-1985 period) would raise the growth rate on impact by 0.247(=0.639x0.387). However, it is difficult to attribute this to evidence of a positive correlation between growth and outward orientation in the light of problems of WBWDR classification which are detailed in Chapter 2. In column 2 we employ the real exchange rate distortion index suggested by Dollar (1992) as an openness variable. Our data on this variable come from

Global Development Network (2005) and cover the 1970-2000 period. As noted in Chapter 3, this measure compares the domestic prices of tradable goods across countries. Assuming that the law of one price always holds, a higher level of distortion index indicates a more distorted trade regime. Our estimation results show that the distortion index is significantly and negatively associated with growth. However, the coefficient estimate of the index is very small (-0.003!) which implies that the distortion index does not have any influence on growth. In column 3, we include the variability index which is simply a coefficient of variation of the real exchange rate distortion index over the 1970-2000 period and conclude that the variability is negative and significant with a substantially larger coefficient estimate. However, in a difference to Dollar (1992), we find an insignificant coefficient estimate of the distortion index when both distortion and variability indexes are included in the regression together. As can be seen from column 4, the regression result shows that the distortion index is not only insignificant but also is very close to zero (-0.001).[7]

In column 5, we include the dummy variable for openness suggested by Sachs and Warner (1995, SW henceforth). As pointed out in Chapter 2, the SW dummy variable is a single openness measure covering all major kinds of trade restrictions. However, different from SW, we extend the openness dummy over the period 1960-2000 rather than 1970-1989 period. This means that we consider only 26 countries as

[7]A similar result is obtained by Rodrik and Rodríguez (2000). One important criticism of Rodrik and Rodríguez (2000) concerning the real exchange rate distortion index is that Dollar (1992) estimated a very simple growth regression model in which per capita GDP growth is a function of his real exchange rate distortion and variability indices as well as investment share. In replicating analysis of Dollar (1992) paper, Rodrik and Rodríguez (2000) conduct alternative specifications such as considering regional dummies, initial income and initial schooling. They conclude that only variability of real exchange rate is robust to these alternative specifications while distortion index is not. They attribute these findings to evidence to show the importance of macroeconomic stability rather than the liberal trade polices for better growth performance.

always open during the 1960-2000 period while SW define 33 open countries between 1970 and 1989. More clearly we define the countries Taiwan, Jordan, Ireland, South Korea, Indonesia, Japan and Australia as closed over the 1960-2000 period since these countries opened their trade regimes during the 1960s according to the SW criteria. Notice that in our regressions Germany and Taiwan are always omitted because of missing data on these countries over the 1960-2000 period. In spite of this difference, we conclude that the SW dummy variable is statistically significant and positive. Regression result in column 5 implies that in the long run GDP per worker in an open economy would have 2.6 times that in a closed economy once the other determinants are controlled.[8] [9] In addition, in column 6 we employ the SW dummy over the period 1970-2000 period which is exactly identical to the original SW dummy variable. Now the coefficient estimate of the dummy is larger and indicates that GDP per worker in an open economy would be equal to 3.2 times the GDP per worker in a closed economy in the long run. However, the SW dummy variable is heavily criticized by Harrison and Hanson (1999) and Rodrik and Rodríguez (2000). The most important criticism is that the strength of the dummy is mainly the result of the criteria related to state monopolies on exports and the

[8]The effect of openness dummy on the long run income level can be calculated as $\exp(-\gamma_5/\gamma_0)$ where γ_5 is the coefficient of openness dummy and γ_0 is the coefficient of the initial level of income. According to the regression result in Column 5, $\gamma_5 = 0.463$ and $\gamma_0 = -0.483$, hence the long run level of GDP per worker in an open country would be $2.6 = exp(-0.463/-0.483)$ times the GDP per worker in a closed economy.

[9]Moreover, we test the absolute convergence hypothesis for open economies over the 1960-2000 period. In order to facilitate comparison with SW, we employ annual growth rate and initial income according to GDP per capita rather than GDP per worker and conclude the following cross-country growth regression for 24 countries which are always open during the 1960-2000 period (robust t-statistics are in parentheses).

$$[logy_{i,2000} - logy_{i,1960}]/40 = \underset{(6.14)}{15.349} - \underset{(5.00)}{1.397} logy_{i,1960} \quad \bar{R}^2 = 0.68$$

where y_i is the real GDP per capita. As can be seen, the coefficient estimate of initial income is very close to that estimated by SW (They report the coefficient estimate of initial GDP per capita as minus 1.368 in column 3 of Table 11 p. 48).

black market premium. According to Rodrik and Rodríguez (2000), the export monopolies component of the SW dummy acts like a sub-Saharan Africa dummy while the black market premium component reflects poor macroeconomic conditions and imbalances rather than restrictive trade polices. That is why, in column 7 we insert a sub-Saharan Africa dummy to the regression. The regression result indicates that the coefficient estimate of the SW dummy is now higher and highly significant. In column 8, we substitute the sub-Saharan African dummy with a composite regional dummy for both sub-Saharan Africa and Latin America. Now, the coefficient estimate of SW dummy is relatively smaller, but still statistically significant. In column 9, we introduce the black market premium dummy which takes the value of 1 if the average black market premium exceeds 20 % in any of the 1960s, 1970s, 1980s or 1990s as well as the composite regional dummy variable. The regression result shows that the coefficient estimate of SW dummy is not only smaller but also marginally significant at the 7 % level. In column 10, we substitute the black market premium dummy with logarithm of average black market premium and conclude the same result. Therefore, it is possible to conclude that the SW dummy is sensitive to the black market premium. In column 11, we employ the fraction of open years according to SW liberalisation dates over the 1960-2000 period.[10] This variable is more reasonable with respect to the SW dummy

[10] For the period 1990-2000, we employ the liberalisation dates provided by Wacziarg and Welch (2003) that updates the SW dummy and liberalsation status. In their systematic review, Wacziarg and Welch (2003) disagree with SW on the liberalization status or dates in the case of several countries. Some countries such as Panama and Cape Verde which were not included in SW are classified in the study by Wacziarg and Welch (2003). There are five countries namely, Ivory Coast, the Dominican Republic, Mauritania, Niger and Trinidad and Tobago for which Wacziarg and Welch (2003) disagree with SW assignment of liberalization dates and four countries which remains closed as of 2001 according to Wacziarg and Welch (2003) while SW classifies them as open in the early 1990s. These countries are Belarus, Croatia, Estonia, and India. In this study, we follow the Wacziarg and Welch (2003) for the disagreement cases. See Sachs and Warner (1995) and Wacziarg and Welch (2003) and appendices therein for more information about SW liberalisation

since SW liberalisation dates are based on the intensive survey of the country cases as pointed out by Wacziarg (2001). The regression result indicates that the fraction of open years is strongly and significantly correlated with economic growth over the period 1960-2000.

dates.

Table 5.12: Economic Growth and Subjective Measures: OLS Estimates[†]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
log GDP per worker 1960	-0.271	-0.498	-0.520	-0.515	-0.483	-0.478	-0.500	-0.454	-0.469	-0.472	-0.496
	(3.46)	(6.91)	(7.63)	(7.42)	(7.10)	(7.44)	(7.37)	(6.72)	(6.57)	(7.81)	(7.43)
$\log(n_i + g + \delta)$	-0.086	-1.245	-1.042	-1.041	-0.315	-0.310	-0.294	-0.258	-0.483	-0.506	-0.524
	(0.16)	(3.29)	(2.83)	(2.81)	(0.79)	(0.84)	(0.75)	(0.66)	(1.21)	(1.39)	(1.44)
log of Investment rate	0.263	0.536	0.526	0.524	0.335	0.316	0.313	0.302	0.278	0.261	0.317
	(3.24)	(5.49)	(5.65)	(5.58)	(3.71)	(3.65)	(3.48)	(3.38)	(2.98)	(2.36)	(3.57)
log of School enrolment	0.103	0.421	0.466	0.460	0.471	0.426	0.383	0.409	0.424	0.421	0.397
	(1.32)	(4.36)	(5.05)	(4.92)	(5.65)	(5.35)	(4.04)	(4.76)	(4.70)	(4.95)	(4.84)
Openness measure of WBWDR87[a]	0.639	-	-	-	-	-	-	-	-	-	-
	(5.64)										
Distortion Index by Dollar (1992)[b]	-	-0.003	-	-0.001	-	-	-	-	-	-	-
		(2.47)		(0.46)							
Variability Index by Dollar (1992)[c]	-	-	-0.468	-0.428	-	-	-	-	-	-	-
			(3.81)	(2.83)							
Openness Dummy (1960-2000)[d]	-	-	-	-	0.463	-	0.510	0.397	0.269	0.244	-
					(3.69)		(4.03)	(3.15)	(1.86)	(1.89)	

Continued on Next Page…

Table 5.12 – *Continued*

Openness Dummy (1970-2000)[d]	-	-	-	-	-	0.549	-	-	-	-	-
						(4.88)					
Sub-saharan Africa	-	-	-	-	-	-	-0.242	-	-	-	-
							(1.85)				
Latin America and Africa[e]	-	-	-	-	-	-	-	-0.234	-0.210	-0.234	-
								(2.30)	(2.06)	(2.44)	
BMP dummy[f]	-	-	-	-	-	-	-	-	-0.072	-	-
									(0.73)		
log (1+BMP)[g]	-	-	-	-	-	-	-	-	-	-0.195	-
										(2.42)	
Fraction of open years[h]	-	-	-	-	-	-	-	-	-	-	0.645
											(4.31)
Constant	2.918	3.240	3.828	3.831	4.839	4.675	4.971	4.765	4.302	4.269	4.097
	(1.91)	(2.94)	(3.57)	(3.56)	(4.18)	(4.43)	(4.34)	(4.21)	(3.66)	(3.51)	(3.90)
Number of observations	39	87	87	87	102	102	102	102	98	98	102
p-value for heteroscedasticity[i]	0.43	0.68	0.82	0.72	0.77	0.37	0.68	0.55	0.26	0.15	0.91
Adjusted R^2	0.70	0.67	0.70	0.70	0.65	0.68	0.66	0.67	0.65	0.67	0.67

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported.

[†] Dependent Variable is the log difference real GDP per worker over the 1960-2000 period except the regression in Column 1.

[a] Openness measure based on the classification of the World Bank World Development Report 1987.

[b] Real exchange rate distortion index. 1970-2000 averages.

[c] Coefficient variation of real exchange rate distortion index over the 1970-2000 period.

[d] Dummy variable for open countries according to Sachs and Warner (1995) criteria.

[e] Composite regional dummy variable for Latin America and Sub-saharan Africa.

[f] Dummy variable is equal to 1 if the average black market premium exceeds 20 % in either the1960s or the 1970s or the 1980s or the 1990s.

[g] Logarithm of one plus average value of black market premium over the 1960-1999 period.

[h] Fraction of open years according to librealization dates in Sachs and Warner (1995) and Wacziarg and Welch (2003)

[i]Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

Table 5.13: International Trade and Trade Policy Indexes: OLS Estimates

Dependent variable	Current Openness		Real Openness	
	(1)	(2)	(3)	(4)
log GDP per worker 1960	0.019	0.041	0.091	0.100
	(0.47)	(1.25)	(2.61)	(3.29)
log Area	-0.124	-0.072	-0.103	-0.055
	(2.24)	(1.89)	(2.28)	(1.87)
log Average Labour Force	-0.021	-0.055	0.034	0.003
	(0.46)	(1.46)	(0.98)	(0.09)
owti[a]	-0.140	-0.063	-0.236	-0.193
	(0.72)	(0.42)	(1.19)	(1.20)
owqi[b]	-0.237	-0.162	-0.196	-0.115
	(2.06)	(1.75)	(2.01)	(1.49)
log (1+BMP)[c]	-	0.016	-	-0.038
		(0.36)		(1.11)
Constant	2.369	2.014	0.403	0.205
	(4.10)	(4.71)	(0.83)	(0.52)
Number of observations	85	83	85	83
p-value for heteroscedasticity[d]	0.00	0.00	0.00	0.00
F-value[e]	2.19	1.11	2.60	1.76
Adjusted R^2	0.43	0.43	0.40	0.40

Note: t-statistics based on heteroscedastic-consistent (White-robust) standard errors are in parenthesis.
[a] Own-import weighted tariff rates on intermediate inputs and capital goods.
[b] Own-import weighted non-tariff frequency on intermediate inputs and capital goods.
[c] Logarithm of one plus average value of black market premium over the 1960-1999 period.
[d] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.
[e] Test for joint significance of owti, owqi and log(1+BMP)

Finally, following Wacziarg (2001) we construct a simple subjective openness measure.[11] Recall that our simple model for international trade expressed in equation (5.2). As mentioned above, one of the weaknesses of this model is the assumption that the only important omitted variable is trade policy barriers. Now we relax this assumption. For this, we introduce three trade policy instruments namely tariffs, non-tariff barriers and the black market premium. Our aim is

[11] A similar approach is taken by Lee (1993)

to obtain approximate weights for these trade policy instruments in order to construct a composite trade policy indicator. Estimation results are given in Table 5.13. Regression results are not very precise compared to our previous estimations in Table 5.10. First, introducing trade policy instruments does not improve the goodness of fit. Second, except for non-tariff barriers, all trade policy instruments are found to be statistically insignificant. One reason for the less precise results is that our data on tariffs and non-tariff barriers are not very satisfactory. Multicollinearity among the policy instruments may be another reason. However, in spite of the lack of precision, our results indicate that all trade policy instruments have the expected sign. The only exception is the regression in column 2 in which the sign of the black market premium is positive. Hence, except this regression, the coefficient estimates of trade policy instruments can be used as approximate weights. In the light of the regressions in Table 5.13, we define the following three trade policy indicators;

$$Trade\ policy\ 1 = -0.14(owti) - 0.24(owqi)$$
$$Trade\ policy\ 2 = -0.24(owti) - 0.20(owqi)$$
$$Trade\ policy\ 3 = -0.19(owti) - 0.12(owqi) - 0.04log(1 + BMP)$$

where BMP is the average black market premium and owti and owqi denote the own-import weighted tariff rates and non-tariff frequency on intermediate inputs and capital goods, respectively. Notice that the higher level of trade policy index implies a more open country since weights are negative numbers. Thus, one would expect a positive coefficient estimate of the indexes if openness is positively correlated with economic growth. Employing these indexes we estimate our baseline model and conclude them all of them have the positive but insignificant coefficient estimates (Table 5.14).

Table 5.14: Economic Growth and Composite Trade Policy Measures: OLS Estimates

	(1)	(2)	(3)
log GDP per worker 1960	-0.484	-0.489	-0.489
	(5.78)	(5.81)	(5.97)
log(n+g+d)	-1.237	-1.221	-1.298
	(2.68)	(2.65)	(2.87)
log of Investment rate	0.431	0.428	0.363
	(4.24)	(4.22)	(3.65)
log of School enrolment	0.432	0.436	0.439
	(4.17)	(4.20)	(4.35)
Trade policy 1	0.574	-	-
	(0.86)		
Trade policy 2	-	0.643	-
		(0.99)	
Trade policy 3	-	-	1.188
			(1.40)
Constant	2.682	2.783	2.464
	(2.01)	(2.06)	(1.83)
Number of observations	85	85	83
p-value for heteroscedasticity[a]	0.73	0.77	0.37
Adjusted R^2	0.60	0.60	0.60

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported.

[a] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

5.4 Sensitivity Analysis

In this section, we investigate the sensitivity of our findings concerning the relationship between openness and economic growth in the previous section. As we note in Chapter 3, most of the studies in the empirical cross-country growth literature include a small set of explanatory variables. However, the main problem in these studies is that their results are very sensitive to changes in the list of explanatory variables. The empirical literature on openness and growth is particularly subject to this problem because many studies in this literature employ simple growth models and it is likely that many of the results of these works arise from model misspecification (Rodrik and Rodríguez (2000)). Therefore, the estimating framework requires a reasonably comprehensive set of explanatory variables. For this purpose, we redefine our cross-country growth regression expressed in equation (5.1) as:

$$\begin{aligned} logy_{i,2000} - logy_{i,1960} = {} & \gamma_0 + \gamma_1 logy_{i,1960} + \gamma_2 log(n_i + g + \delta) \\ & + \gamma_3 log(Investment\ rate_i) \\ & + \gamma_4 log(School\ enrolment_i) \\ & + \gamma_5 Openness_i + \gamma_6 Z_i + \varepsilon_i \end{aligned} \tag{5.3}$$

where Z is a vector of other explanatory variables. We determine Z as follows: First, we include two variables related to macroeconomic policy, namely inflation rate and government consumption expenditures. Inclusion of these variables is particularly important since an important criticism on the openness-growth literature is that openness measures are proxy for other macroeconomic policies rather than trade policy per se. Second, we employ two variables in order to consider the effect of institutions and geography. For this, following Keefer and Knack (1997), Sachs and Warner (1997a) and Hall and Jones (1999), we measure institutional quality by using a composite index based on the data set of *International Country Risk Guide* (ICRG) published by a private international consulting company *Political Risk Services.*

This index consists of equally weighting an average of four ICRG components for the years 1984-2000: i) investment profile as a average of three subcomponents namely, contract viability, profits repatriation and payment delays; ii) law and order; iii) corruption; and iv) bureaucratic quality. We use the share of population in geographical tropics in order to capture the effect of geography (Sachs (2001)). Finally, we include ethnolinguistic fragmentation index (ELF). This index shows the probability that two randomly selected persons of a given country will belong to the same ethnolinguistic group and has become a standard variable in the cross-country growth literature since the important studies by Mauro (1995) and Easterly and Levine (1997).

Before carrying out our sensitivity analysis, we estimate an augmented neoclassical growth model with the only Z variables. Table 5.15 reports the estimation results. As it can be seen from the first column, all Z variables are found to be statistically significant with the anticipated signs. Moreover, this regression has substantially high explanatory power such that it explains 76 percent of variation in growth of per worker GDP over the period 1960-2000. However, applying the Hadi method we identify six countries (namely Brazil, Bolivia, Argentina, Peru, Nicaragua and Congo Democratic Republic) as outliers. In the second column we present the regression results without these six outlying countries and conclude that, except for the inflation rate, all Z variables are statistically significant. In column 3, instead of dropping these countries, we estimate the same model by IRLS. Notice that in this regression we exclude two risky countries, Congo Democratic Republic and Nicaragua, because of their high leverage values. We again conclude that all Z variables are statistically significant with the expected signs, except the inflation rate. Therefore, in column 4 we

Table 5.15: Other Determinants of Growth

	(1)	(2)	(3)	(4)
log GDP per worker 1960	-0.617	-0.624	-0.620	-0.650
	(8.54)	(7.25)	(9.01)	(8.69)
log(n+g+δ)	-0.208	-0.233	-0.246	-0.281
	(0.57)	(0.55)	(0.71)	(0.73)
log of Investment rate	0.344	0.318	0.393	0.242
	(3.46)	(2.84)	(4.11)	(2.01)
log of School enrolment	0.383	0.385	0.330	0.370
	(3.93)	(4.26)	(3.59)	(4.52)
Inflation Rate	-0.099	-0.245	-0.005	-
	(3.71)	(0.68)	(0.09)	
Government Consumption/GDP	-1.855	-1.761	-1.917	-1.725
	(2.17)	(1.71)	(2.36)	(1.81)
Institutional Quality Index	0.219	0.215	0.238	0.255
	(3.54)	(2.44)	(4.03)	(3.42)
Population in Tropics	-0.244	-0.272	-0.308	-0.279
	(2.36)	(2.90)	(3.11)	(3.22)
Ethnolinguistic Fragmentation	-0.340	-0.321	-0.253	-0.301
	(2.45)	(1.97)	(1.90)	(1.85)
Constant	6.013	5.972	5.852	5.706
	(5.54)	(4.87)	(5.69)	(5.03)
Number of observations	80	74	78	80
p-value for heteroscedasticity[a]	0.17	0.06	-	0.05
Adjusted R^2	0.76	0.71	0.75	0.71

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported.

[a] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

omit the inflation rate and estimate the augmented neoclassical growth model with the remaining control variables. The regression results show that government consumption, institutions, having population living in tropics and ELF are significantly associated with growth. This regression does not include any outliers and hence can be considered as a reasonable model for sensitivity analysis. In this regard, we set up the following cross-country growth regression

$$\begin{aligned} logy_{i,2000} - logy_{i,1960} = \gamma_0 + \gamma_1 logy_{i,1960} + \gamma_2 log(n_i + g + \delta) \\ + \gamma_3 log(Investment\ rate_i) \\ + \gamma_4 log(School\ enrolment_i) \\ + \gamma_5 (Government\ Consumption_i) \\ + \gamma_6 (Institutional\ Quality_i) \\ + \gamma_7 (Population\ in\ Tropics_i) \\ + \gamma_8 ELF_i + \gamma_9 Openness_i + \varepsilon_i \end{aligned} \tag{5.4}$$

We carry out our sensitivity analysis under four categorizations: trade volumes, direct trade policy measures, deviation measures and subjective indexes. However, we focus only on openness variables found to be significant in the previous section.

We start our sensitivity analysis with trade volumes, with Table 5.16 reporting our estimation results. All openness variables are found to be positive but not statistically significant. Table 5.17 then presents the results of sensitivity analysis for direct trade policy measures. As can be seen from column 1-3, the tariff rate and non-tariff barriers are neither individually nor jointly significant, albeit they have anticipated negative signs. In columns 4 and 5, we include the average black market

Table 5.16: Economic Growth and Trade Volumes: Sensitivity Analysis

	(1)	(2)	(3)	(4)	(5)
log GDP per worker 1960	-0.638	-0.630	-0.634	-0.644	-0.652
	(8.39)	(8.28)	(8.35)	(8.52)	(8.67)
log(n+g+d)	-0.036	-0.020	-0.028	-0.264	-0.266
	(0.09)	(0.05)	(0.07)	(0.67)	(0.68)
log of Investment rate	0.226	0.224	0.225	0.241	0.243
	(1.70)	(1.69)	(1.70)	(1.98)	(2.02)
log of School enrolment	0.372	0.377	0.374	0.362	0.368
	(4.63)	(4.70)	(4.67)	(4.46)	(4.47)
Government Consumption /GDP	-1.820	-1.976	-1.901	-2.009	-1.860
	(1.82)	(1.95)	(1.89)	(1.93)	(1.85)
Institutional Quality Index	0.246	0.249	0.247	0.249	0.244
	(3.17)	(3.22)	(3.20)	(3.30)	(3.10)
Population in Tropics	-0.326	-0.327	-0.327	-0.308	-0.290
	(3.62)	(3.55)	(3.60)	(3.64)	(3.31)
Ethnolinguistic Fragmentation	-0.344	-0.331	-0.338	-0.297	-0.297
	(1.89)	(1.81)	(1.85)	(1.80)	(1.81)
Exports ratio of WB	0.256	-	-	-	-
	(1.18)				
Imports ratio of WB	-	0.295	-	-	-
		(1.40)			
Trade ratio of WB	-	-	0.140	-	-
			(1.31)		
Current Openness of PW	-	-	-	0.100	-
				(0.92)	
Real Openness by A&C	-	-	-	-	0.094
					(0.71)
Constant	6.256	6.214	6.237	5.713	5.797
	(5.18)	(5.15)	(5.17)	(4.93)	(5.06)
Number of observations	75	75	75	80	80
p-value for heteroscedasticity[a]	0.02	0.02	0.02	0.04	0.04
Adjusted R^2	0.70	0.70	0.70	0.71	0.71

Note: t-statistics based on heteroscedastic-consistent (White-robust) standard errors are in parenthesis.

[a] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

Table 5.17: Economic Growth and Direct Trade Policy Measures: Sensitivity Analysis

	(1)	(2)	(3)	(4)	(5)
log GDP per worker 1960	-0.641	-0.605	-0.635	-0.657	-0.659
	(8.89)	(7.68)	(8.61)	(8.93)	(8.85)
log(n+g+d)	-0.428	-0.561	-0.460	-0.293	-0.230
	(1.14)	(1.34)	(1.14)	(0.76)	(0.57)
log of Investment rate	0.255	0.237	0.228	0.236	0.233
	(2.05)	(1.80)	(1.80)	(1.95)	(1.96)
log of School enrolment	0.343	0.346	0.368	0.395	0.405
	(3.04)	(3.17)	(3.18)	(4.73)	(4.96)
Government Consumption /GDP	-3.174	-2.441	-2.896	-1.559	-1.646
	(2.66)	(2.27)	(2.39)	(1.62)	(1.66)
Institutional Quality Index	0.226	0.221	0.217	0.229	0.219
	(3.03)	(2.66)	(2.77)	(2.73)	(2.54)
Population in Tropics	-0.324	-0.286	-0.317	-0.287	-0.285
	(3.26)	(3.03)	(3.21)	(3.23)	(3.22)
Ethnolinguistic Fragmentation	-0.194	-0.256	-0.174	-0.271	-0.314
	(1.10)	(1.45)	(0.99)	(1.71)	(1.92)
owti	-0.493		-0.524		
	(1.95)		(2.09)		
owqi		0.028	0.122		
		(0.19)	(0.80)		
log (1+BMP)				-0.057	
				(0.47)	
BMP dummy					-0.079
					(0.82)
Constant	5.622	4.753	5.422	5.823	6.105
	(4.72)	(3.71)	(4.26)	(5.05)	(5.00)
Number of observations	69	67	67	78	78
p-value for heteroscedasticity[a]	0.00	0.00	0.01	0.06	0.04
F-value[b]			0.09		
Adjusted R^2	0.71	0.69	0.71	0.71	0.71

Note: t-statistics based on heteroscedastic-consistent (White-robust) standard errors are in parenthesis. The variables *owti* and *owqi* refers to own-import weighted tariff rates and own-import weighted non-tariff frequency on intermediate inputs and capital gods, respectively. The term *log (1+BMP)* denotes the logarithm of one plus average value of black market premium over the 1960-2000. The variable *BMP dummy* is a dummy variable which is equal to 1 if the average black market premium exceed 20 % in either the 1960s or the 1970s or the 1980s or the 1990s.

[a] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

[b] Test for joint significance of owti and owqi.

premium and a dummy variable for the black market premium, respectively. Both variables enter the regression with negative but insignificant coefficient estimates. This may be attributed as another evidence in favour of black market market premium as a proxy for macroeconomic imbalances rather than trade policy. In table 5.18, we estimate deviation measures for openness. In the first and second columns, we include adjusted trade ratios for current openness and real openness respectively, and conclude that both variables are insignificant. In column 3, we check the sensitivity of the Frankel-Romer predicted trade shares and find that the coefficient estimate on this variable is positive but statistically insignificant (Note that this regression is run over the 1960-1985 period because the Frankel-Romer predicted trade share is calculated for only 1985). In column 4, we enter the Frankel-Romer predicted trade shares at PPP in 1995. We again find that this variable is not statistically significant at conventional levels.

Finally, sensitivity analysis on subjective openness indexes is provided in Table 5.19. In column 1, we include the fraction of open years according to SW liberalization dates and conclude that this variable is significant at the 10 percent significance level. In columns 2-4 we include three composite trade policy indexes with only the third index being statistically significant at the 9 percent level. The first two indexes are weighted averages of tariff and non-tariff barriers, the third index includes the black market premium as well. Hence, it is more likely that the marginal significance of this variable is a result of inclusion of black market premium rather than tariff rates and non-tariff barriers.

In summary, all openness measures are very sensitive to inclusion of other growth variables and are typically statistically insignificant.

Table 5.18: Economic Growth and Deviation Measures: Sensitivity Analysis

	(1)	(2)	(3)	(4)
log GDP per worker 1960	-0.646	-0.647	-0.454	-0.633
	(8.77)	(8.76)	(6.29)	(7.59)
log(n+g+d)	-0.300	-0.289	0.361	-0.220
	(0.77)	(0.74)	(1.35)	(0.55)
log of Investment rate	0.235	0.239	0.202	0.256
	(1.88)	(1.92)	(2.82)	(2.07)
log of School enrolment	0.366	0.370	0.206	0.355
	(4.42)	(4.50)	(2.96)	(4.20)
Government Consumption /GDP	-1.803	-1.756	-0.427	-1.936
	(1.71)	(1.76)	(0.56)	(1.86)
Institutional Quality Index	0.253	0.251	0.172	0.252
	(3.43)	(3.39)	(2.99)	(3.35)
Population in Tropics	-0.284	-0.279	-0.226	-0.272
	(3.31)	(3.19)	(2.76)	(3.14)
Ehnolingustic Fragmentation	-0.315	-0.307	-0.086	-0.282
	(1.80)	(1.83)	(0.66)	(1.70)
RESID_Current Openness	0.057	-	-	-
	(0.27)			
RESID_Real Openness	-	0.040	-	-
		(0.20)		
log F&R predicted trade 1985	-	-	0.024	-
			(0.62)	
log F&R predicted trade 1995	-	-	-	0.055
				(0.90)
Constant	5.633	5.674	5.416	5.941
	(4.96)	(4.93)	(6.14)	(5.06)
Number of observations	80	80	80	80
p-value for heteroscedasticity[a]	0.04	0.04	0.18	0.04
Adjusted R^2	0.71	0.71	0.59	0.71

Note: t-statistics are in parenthesis. In the regressions where the heteroscedasticity test is failed to pass at 15 % level t-statistics based on heteroscedastic-consistent (White-robust) standard errors are reported.

[a] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

Therefore, it is possible to conclude that our cross-country empirical analysis does not support that openness is significantly associated with economic growth in the long run.

Table 5.19: Economic Growth and Subjective Measures: Sensitivity Analysis

	(1)	(2)	(3)	(4)
log GDP per worker 1960	-0.638	-0.611	-0.618	-0.625
	(8.98)	(7.71)	(7.90)	(8.20)
log(n+g+d)	-0.138	-0.502	-0.458	-0.432
	(0.30)	(1.21)	(1.12)	(1.08)
log of Investment rate	0.231	0.249	0.255	0.254
	(2.01)	(1.91)	(1.98)	(1.98)
log of School enrolment	0.333	0.342	0.343	0.352
	(3.98)	(3.17)	(3.17)	(3.26)
Government Consumption /GDP	-1.519	-2.577	-2.707	-2.751
	(1.52)	(2.38)	(2.45)	(2.48)
Institutional Quality Index	0.200	0.221	0.221	0.212
	(2.51)	(2.69)	(2.72)	(2.68)
Population in Tropics	-0.306	-0.296	-0.306	-0.318
	(3.20)	(3.13)	(3.19)	(3.31)
Ethnolinguistic Fragmentation	-0.299	-0.246	-0.230	-0.200
	(1.85)	(1.37)	(1.28)	(1.11)
Fraction of Open Years	0.278	-	-	-
	(1.66)			
Trade policy 1	-	0.257	-	-
		(0.53)		
Trade policy 2	-	-	0.498	-
			(1.19)	
Trade policy 3	-	-	-	0.967
				(1.71)
Constant	6.003	5.026	5.258	5.451
	(4.55)	(3.91)	(4.15)	(4.45)
Number of observations	79	67	67	67
p-value for heteroscedasticity[a]	0.06	0.00	0.00	0.00
Adjusted R^2	0.72	0.69	0.70	0.70

Note: t-statistics based on heteroscedastic-consistent (White-robust) standard errors are in parenthesis.

[a] Breusch-Pagan test for heteroscedasticity in which the null refers to the homoscedastic errors.

5.5 Summary and Concluding Remarks

In this chapter, we investigate the openness-growth connection. For this, we employ a large number of openness measures and classify them under four categories. We briefly summarise our main findings as follows:

- We conclude that ratio of trade volume in GDP is positively and significantly associated with economic growth over the period 1960-2000. However, their significance in OLS estimate is mainly driven by a few outlying countries. When we repeat the analysis using weighted least squares, giving relatively lower weight to outlying countries, we find a significant and positive correlation between growth and trade ratios at current prices. We could not conclude the same result for the real openness which measures the ratio of trade volume in GDP at PPP.

- Our findings relating to direct trade policy measures indicate only weak evidence for the adverse growth-tariff connection such that the tariff rate is only marginally significant. We could not find any statistically significant relation between non-tariff barriers and economic growth while the black market premium is negatively and significantly associated with growth. However, our empirical investigation concerning the relation between black market premium and economic growth implies the negative relation between growth and macroeconomic imbalances rather than the trade restrictive effect of black market premiums.

- We find that adjusted trade ratios and Frankel-Romer predicted trade shares are significantly and positively correlated with growth. Our findings, however, show an insignificant association between growth and outward orientation index by Syrquin and Chenery (1989) and inconsistent results for Leamer's (1988) openness and distortion indexes.

- Both the Sachs-Warner openness dummy and the fraction of open years on the basis of Sachs and Warner (1995) and Wacziarg and Welsh (2003) liberalization dates are positively and significantly correlated with economic growth over the period 1960-2000. We could not find any significant relation between growth and our composite trade policy indexes consisting of weighted averages of tariff rates, non-tariff barriers and the black market premium.

We also check the sensitivity of these results to model specification. For this we expand our baseline model by adding government consumption, economic institutions, geography, and ethnolinguistic fragmentation. Once we consider this model, the openness measures which are previously found to be significant become insignificant. Hence, we conclude that our cross-country empirical investigation does not support the proposition that openness is associated with economic growth.

Although our model specification for sensitivity analysis is comprehensive, it is still subject to the model uncertainty problem and one could reach different results by employing different growth variables and hence models. One promising solution to this problem is to integrate model uncertainty into subsequent statistical inference employing model averaging techniques. In the following chapter, we employ Bayesian model averaging technique to take into account model uncertainty issues regarding model specification.

5.A Appendix: Descriptions and Sources of Variables used in Cross-Country Growth Regression Analysis

Augmented Neo-classical Growth Model

Real GDP per capita (RGDPCH) : 1996 international prices, chain series. **Source**: Global Development Network Growth Database (2005) which rely on Penn World Tables Version 6.1 (Heston, Summers and Aten (2002)).

Population (TP) : Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. **Source**: The World Bank World Development Indicators (2006).

Labour force (LF) : Labour force or economically active population defined as the total population between ages 15 and 64. **Source**: The World Bank World Development Indicators (2006)

Share of labour force (SLF): Share of labour force in total population. The exact calculation is LF/TP.

Real GDP per worker (PWGDP) : 1996 international prices, chain series. The exact calculation is $PWGDP = RGDPCH*(1/SLF)$.

Growth : Average growth rate of real GDP per worker over the 1960-2000 period. The exact calculation is $log(PWGDP2000/PWGDP1960)$, where PWGDP1960 and PWGDP2000 is the real GDP per worker in 1960 and 2000, respectively.

Initial income (PWGDP1960) : Real GDP per worker in 1960.

Population growth (n) : Average rate of population growth between 1960 and 2000. The exact calculation is $(1/40)*log(TP2000/TP1960)$, where TP1960 and TP2000 are total population in 1960 and 2000, respectively.

(g+δ) : Sum of exogenous rates of technological process and depreciation over the 1960-2000 period and assumed to be equal to 0.05.

(n+g+δ) : Sum of rates of population growth, technical process and depreciation over the 1960-2000 period.

Investment rate (INV) : Average of Investment share in GDP at constant prices over the 1960-2000 period. **Source**: Penn World Tables Version 6.1 (Heston, Summers and Aten (2002)) and the World Bank World Development Indicators (2002, 2006).

School enrolment rate (SCH) : Average gross rate of secondary school enrolment over the 1960-2000 period. Gross secondary school enrollment ratio is defined as the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of secondary education. **Source**: The World Bank World Development Indicators (2002, 2006).

Trade Policy

Imports share by the World Bank (MGDP_WB) : Average share of imports of goods and services in GDP over the 1960-2000 period. The variable is calculated for the countries Bhutan, Hungary, Sao Tome and Principe over the period 1970-2000, for Turkey over the 1968-2000 period, for the countries Oman, Pakistan and Mali over the period 1967-2000, for Gambia over the 1966-2000 period, for Cameroon and Nepal over the period 1965-2000, for Sierra Leon over the period 1964-2000, for Kuwait over the period 1963-2000, for Tunisia and Papa New Guinea over the period 1961-2000. **Source:** The World Bank World Development Indicators (2002, 2006).

Exports share by the World Bank (XGDP_WB) : Average share of exports of goods and services in GDP over the 1960-2000 period. The variable is calculated for the countries Bhutan, Hungary, Sao Tome and Principe over the period 1970-2000, for Turkey over the 1968-2000 period, for the countries Oman, Pakistan and Mali over the period 1967-2000, for Gambia over the 1966-2000 period, for Cameroon and Nepal over the period 1965-2000, for Sierra Leon over the period 1964-2000, for Kuwait over the period 1963-2000, for Tunisia and Papa New Guinea over the period 1961-2000. **Source:** The World Bank World Development Indicators (2002, 2006).

Trade ratio by World Bank (XMGDP_WB) : Average share of exports plus imports of goods and services in GDP over the 1960-2000 period. The exact calculation is $XMGDPWB = XGDPWB + MGDPWB$. **Source:** The World Bank World Development Indicators (2002, 2006).

Current Openness of Penn World (COPEN) : Average share of exports plus imports of goods and services in GDP in current prices over the 1960-2000 period. **Source**: Penn World Tables Version 6.1 (Heston, Summers and Aten (2002)).

Real Openness of Penn World (ROPEN) : Average share of imports plus exports in US dollar to GDP in PPP US dollar over the

1960-2000 period. The Exact calculation is $ROPEN = (PGDP/100) * COPEN$, where $PGDP$ is the Penn World variable of price level of GDP, unit: US dollar=100 in current prices, and $COPEN$ is the current openness variable of Penn World. **Source**: Penn World Tables Version 6.1 (Heston, Summers and Aten (2002)).

Trade ratio with OECD (XM_OECD) : Trade with OECD members over the 1960-1998 period (Exports plus Imports as a ratio of GDP). **Source:** Global Development Network Growth Database (2005).

Trade ratio with NonOECD (XM_NonOECD) : Trade with Non-OECD countries over the 1960-1998 period (Exports plus Imports as a ratio of GDP). **Source:** Global Development Network Growth Database (2005).

Tariff rate (OWTI) : Own-import weighted tariff rates on intermediate inputs and capital goods over the 1983-1985 period. **Source:** Barro and Lee (1994a),

Non-tariff Barriers (OWQI) : Own-import weighted non-tariff frequency on intermediate inputs and capital goods over the 1983-1985 period. **Source:** Barro and Lee (1994a).

Import Duties (M_DUTY : Collected import duties as ratio of imports over the 1970-1998 period. **Source:** World Bank World Development Indicators (2002).

Tariff rate (UWTI) : Unweighted average tariff rates on all commodities over the period 1990-1999 period. **Source:** Wacziarg and Welch (2003)

Black Market Premium (BMP) Average of black market premium over the period 1960-1999. The black market premium is calculated as $(Parallel\ Exchange\ rate/Official\ Exchange\ rate) - 1$. **Source:** Global Development Network Growth Database (2005).

log (1+BMP) : Logarithm of one plus average of black market premium over the period 1960-1999.

Black Market Premium Dummy 1 (BMP_Dummy1) : The dummy variable is equal to 1 if the average black market premium exceeds 20 percent in the 1960s or the 1970s or the 1980s or the 1990s.

Black Market Premium Dummy 2 (BMP_Dummy2) : The dummy variable is equal to 1 if the average black market premium exceeds 20 percent over the 1960-2000 period.

Outward Orientation Index by Syrquin and Chenery (SCOUT) : Dummy variable for outward orientation based on Syrquin and Chenery (1989). **Source:** Levine and Renelt (1992)

Openness index by Leamer (LEAMER_Open) : Measure of overall trade openness index based on Leamer (1988) in 1982. **Source:** Levine and Renelt (1992)

Intervention Index by Leamer (LEAMER_Inter.) : Measure of overall trade intervention index based on Leamer (1988) in 1982. **Source:** Levine and Renelt (1992)

log F&R predicted trade 1985 (F&R85) : Logarithm of the Frankel-Romer predicted trade shares from gravity model in 1985. **Source:** Frankel and Romer (1999).

log F&R predicted trade 1995 (F&R95) : Logarithm of the Frankel-Romer predicted trade shares from gravity model as a fraction of

GDP in PPP in 1995. **Source:** Dollar and Kraay (2003a).

Outward Orientation Index by World Bank (WBWDR87) : Dummy variable for outward orientation over the period 1963-1985 based on the World Bank World Development Report (1987). **Source:** The World Bank World Development Report (1987).

Exchange rate distortion index (RERD) : The real exchange rate distortion index over the period 1970-2000. **Source:** Dollar (1992) and Global Development Network Growth Database (2005).

Exchange rate variability index (RERV) : Coefficient of variation of the real exchange rate distortion index over the 1970-2000 period.

Sachs-Warner openness dummy (SW-Dummy) : The Sachs-Warner openness dummy over the period 1960-2000. **Source:** Sachs and Warner (1995) and Wacziarg and Welch (2003).

Sachs-Warner Open Years(SW-Years) : Fraction of open years on the basis of Sachs-Warner and Wacziarg-Welch liberalisation dates over the 1960-2000 period. **Source:** Sachs and Warner (1995) and Wacziarg and Welch (2003).

Table 5.20: Summary Statistics of Openness Measures

	♯ of Obs.	Mean	Std. Dev.	Min	Max
Trade Volumes					
MGDP_WB	107	0.3377	0.1887	0.0723	1.0051
XGDP_WB	107	0.2958	0.1848	0.0656	1.0270
XMGDP_WB	107	0.6335	0.3583	0.1453	2.0320
COPEN	114	0.6432	0.4165	0.1477	3.2260
ROPEN	114	0.3734	0.3526	0.0436	2.4601
XM_OECD	106	0.3912	0.2627	0.0655	1.7622
XM_NonOECD	106	0.1409	0.1636	0.0156	1.2300
Direct Trade					
Policy Measures					
OWTI	104	0.1688	0.1630	0	1.319
OWQI	102	0.1858	0.2372	0	0.888
M_DUTY	117	0.1229	0.0888	0	0.4645416
UWTI	121	0.1496	0.0932	0.003	0.547
log (1+BMP)	121	0.3776	0.6716	-0.004	5.453
BMP_Dummy1	121	0.5455	0.5000	0	1
BMP_Dummy2	121	0.4463	0.4992	0	1
Deviation Measures					
SCOUT	119	0.3445	0.4772	0	1
LEAMER_Open	52	0.0310	0.1476	-0.21	0.51
LEAMER_Inter.	52	0.2917	0.1393	0.11	0.8
F&R85	148	2.9882	0.7905	0.833	5.639
F&R95	195	-2.8315	0.6409	-4.4070	-0.6378
WBWDR87	41	0.2927	0.3869	0	1
RESID_COPEN	111	0.0000	0.3071	-0.5700	1.9100
RESID_ROPEN	111	0.0000	0.2706	-0.5495	1.5548
Subjective Measures					
RERD	94	114.6070	39.2534	59.2693	358.0221
RERV	94	0.2917	0.3220	0	2.7937
SW-Dummy	114	0.2281	0.4214	0	1

Table 5.20 – *Continued*

SW-Years	114	0.4322	0.3832	0	1
POLICY1	102	-0.0684	0.0695	-0.3978	-0.0002
POLICY2	102	-0.0780	0.0729	-0.4942	-0.0002
POLICY3	92	-0.0724	0.0617	-0.3666	0.0001

Chapter 6

Openness and Economic Growth: Bayesian Model Averaging Estimate of Cross-Country Growth Regressions

6.1 Introduction

The link between openness and growth is one of the oldest issues in economic theory and has been extensively investigated by empirical researches. However, the results of this analysis are very sensitive to model specification. Although some studies address the problem of model uncertainty, their approaches are neither systematic nor complete. This will have serious policy implications.

The purpose of this chapter is to examine the relationship between growth and openness accounting for model uncertainty. For this purpose, a number of existing openness measures as well as various growth variables are used in the framework of augmented neo-classical growth model developed by Mankiw et al. (1992).

The main contributions of this chapter are firstly, differently from previous cross-country empirical work, this chapter tackles model uncertainty problem by employing Bayesian model averaging technique instead of estimating and reporting a small number of cross-country growth regressions. Secondly, this chapter addresses the issue of proxy uncertainty to compare alternative proxy variables for openness.

The results obtained from our Bayesian model averaging do not support the contention that openness is a long run growth determinant. However, we find substantial evidence in favour of economic institutions and macroeconomic stability.

The organization of this chapter is as follows: Section 2 describes the methodology. Section 3 provides a cross-country growth model for our Bayesain model averaging application. Section 4 deals with some difficulties related to implementation of Bayesian model averaging. Our findings are reported and discussed in Section 5. Finally, Section 6 concludes.

6.2 Methodology

We start this section with a brief summary of Bayesian statistics since Bayesian model averaging (BMA henceforth) is a direct application of the Bayesian paradigm. Then we show how BMA is used to solve the model uncertainty in the context of linear regression model.

6.2.1 Bayesian Statistical Inference

Bayesian statistical inference about a population parameter is based on probability models. The main feature of the Bayesian approach is that probability is used as the fundamental measure of uncertainty. Generally speaking, in classical statistics we try to make inferences about the true, but unknown population parameter within a repeated sampling process since probability is defined in terms of the limits of a relative frequency of the event and inference is carried out by techniques with a high probability of giving the correct results.[1]

However, differently from the classical framework, in the Bayesian context the definition of probability is subjective such that different persons can assign different probabilities to the same event. In other words, probability is defined in terms of degree of belief and this belief does not necessarily depend on the relative frequency of the event. An important result of subjective definition of probability, in the Bayesian context an unknown population parameter is considered as a random variable such that an unknown population parameter is assigned with a subjective probability distribution which summarises our knowledge about that parameter.[2] This distribution, which shows the individual's prior beliefs or information about the parameter before or prior to observing data, is called as *prior probability.* After observing data, we combine our prior probability distribution of the population parameter with the sample information with presented data. In other words, we calculate the conditional probability distribution on observed value of population parameter. This probability conditional on data is called *posterior probability distribution* of that parameter. For this purpose, assume that data for a random variable Y are generated from the fol-

[1] It is a well known fact that in the classical framework an unbiased (and also efficient) estimator is favourable since average value of the sample estimates within the repeated samples approaches the value of the unknown population parameter.

[2] This property is another departure from the classical context since in the classical framework the unknown population parameter is treated as constant and hence a probability distribution can not assign to that parameter.

lowing model:

$$M = \{p(\theta, y);\ \theta \in \Omega\} \tag{6.1}$$

where θ is a vector of unknown population parameters in some parameter space Ω, y is a vector of sample observations for Y and $p(\theta, y)$ is the joint density function for θ given y. We can write the joint probability function for θ and y, given the model described above, as

$$p(\theta, y) = p(y|\theta)p(\theta) = p(\theta|y)p(y) \tag{6.2}$$

which leads to

$$p(\theta|y) = \frac{p(y|\theta)p(\theta)}{p(y)} \tag{6.3}$$

This last expression is known as Bayes' theorem. In this expression $p(\theta|y)$ is the posterior probability distribution for θ and characterises all information about θ after the data is observed; $p(\theta)$ is the prior probability for θ and indicates the non-sample information about θ; $p(y|\theta)$ is the conditional probability function for y given θ. As can be seen, $p(y|\theta)$ is algebraically identical to the likelihood function for θ given y and contains all sample information about θ. Hence, $p(y|\theta)$ can be expressed as the likelihood function $\ell(\theta|y)$.[3] Finally the denominator of Bayes' theorem $p(y)$ is the marginal or individual distribution of y and, before the data y are observed, the distribution of the unknown but observable y is $p(y) = \int p(\theta)p(y|\theta)d\theta$ (or $p(y) = \sum_\theta p(\theta)p(y|\theta)$ if θ is discrete).[4] After observing data, $p(y)$ is considered fixed with respect to θ ($p(y)$ does not depend on θ), and equation (6.3) can be expressed

[3] As an example suppose that the model $M \sim$ i.i.d. $N(\mu, \sigma^2)$ so that $\theta=(\mu, \sigma)$, and $\ell(\theta|y) = (\sigma\sqrt{2\pi})^{-1}exp\{-(1/2)(y-\mu)^2/\sigma^2\}$. If y consists of n observations, then the likelihood function is defined by $\ell(\theta|y) = \prod_{i=1}^{n}(\sigma\sqrt{2\pi})^{-1}exp\{-(1/2)(y_i-\mu)^2/\sigma^2\}$.

[4] As pointed out by Gelman et al. (2004), the more informative name of $p(y)$ is the *prior predictive distribution.*

as follows

$$p(\theta|y) \propto \ell(\theta|y)p(\theta) \tag{6.4}$$

where the symbol $\propto$ means "proportional to". In plain English, the posterior probability distribution of an unknown population parameter is proportional to likelihood function for that parameter weighted by the prior probability distribution for that parameter.

The Bayes' theorem expresses in (6.4) shows that how we combine our prior information about θ, expressed in terms of prior distribution $p(\theta)$ with the sample information expressed in terms of likelihood function $\ell(\theta|y)$ in order to obtain posterior information about θ expressed in terms of posterior density function $p(\theta|y)$. For instance a point estimate of θ is obtained by the posterior mean of θ such that $\bar{\theta} = E(\theta|y) = \int \theta p(\theta|y)d\theta$.

As can be seen, incorporation of prior information to statistical inference is one of the most important differences of the Bayesian approach from classical inference in which there is no formal mechanism for incorporation of prior beliefs. However, an immediate point arising in the Bayesian context is that one needs to specify priors before observing data. In some cases, one has certain knowledge about θ and can define definite priors. In such cases, priors are known as *informative* or *proper* priors. Yet, in many circumstances there is very little knowledge about θ, and hence priors do not contain information. These priors are known as *noninformative* or *improper* priors.[5] Moreover, even if substantial prior information is available, one may prefer to employ noninformative priors in order to obtain a more objective posterior distribution. As a result, noninformative priors lead to a

[5]Noninformative priors are some times referred to as *vague* or *diffuse* priors as our knowledge about θ is vague or diffuse.

posterior distribution that is substantially dominated by the sample information. However, as noted by Judge et al. (1988, p.126) "[t]here are many statisticians who believe the Bayesian approach to inference is superior to the classical approach, irrespective of whether or not substantial prior information is incorporated."

Finally, one can calculate posterior odds in order to compare alternative hypotheses. In the Bayesian context, posterior odds are defined as the ratio of posterior densities evaluated at points θ_1 and θ_2 under a given model

$$\frac{p(\theta_1|y)}{p(\theta_2|y)} = \frac{p(\theta_1)\ell(\theta_1|y)/p(y)}{p(\theta_2)\ell(\theta_2|y)/p(y)} = \frac{p(\theta_1)\ell(\theta_1|y)}{p(\theta_2)\ell(\theta_2|y)} \tag{6.5}$$

The verbal explanation of expression (6.5) is that posterior odds, $(p(\theta_1|y)/p(\theta_2|y))$ are equal to prior odds, $(p(\theta_1)/p(\theta_2))$ multiplied by the likelihood ratio, $(\ell(\theta_1|y)/\ell(\theta_2|y))$. Likelihood ratio is also known as Bayes factor.

These expressions are the technical core of Bayesian statistical inference. Therefore, the primary objective of any specific application is to develop a model $p(\theta|y)$ and perform the necessary computations to summarise $p(\theta|y)$ in an appropriate way.

So far our analysis for Bayesian inference is based on the assumption that we have only one model (or true data generated process for the random variable Y is known). However, as detailed in Chapter 3, one does not have certain information about whether or not the selected model is true. In other words, model uncertainty is an important problem in most statistical applications. The Bayesian solution to this problem is to incorporate the model uncertainty into inference by averaging all possible models. We will now discuss this approach, which is known as Bayeasian model averaging.

6.2.2 Bayesian Model Averaging

As mentioned above BMA is a technique used to take into account model uncertainty. Suppose that the data are generated by a particular model in the model space which encompasses all possible models. That is, assume that there are k possible different models and model space can be defined such that $\mathcal{M} = \{M_1, \ldots, M_k\}$, where $\mathcal{M}$ denotes the model space and M_j is one of its typical element as follows

$$M_j = \{p(\theta_j, y);\ \theta_j \in \Omega_j\} \tag{6.6}$$

where θ_j is the vector of unknown population parameters and $p(\theta_j, y)$ is the joint density function for θ given y in j^{th} model, M_j. In this context, the likelihood function for model M_j is expressed by $\ell_j(\theta_j|y, M_j)$

In this setting, as pointed out by Wasserman (2000), model selection refers to problem of using the data to choose one of the possible models considered in the model space while model averaging refers to the procedure of estimating the quantity of interest under each possible model and then averaging those estimates according to the probabilities assigned to each model. Therefore, model averaging takes into account all possible models instead of focusing on a selected one. That is, BMA accounts for model uncertainty by integrating the posterior probabilities of every possible model given the data such that:

$$p(\theta|y) = \sum_{j=1}^{k} p(\theta_j|y, M_j)p(M_j|y) \tag{6.7}$$

where $p(M_j|y)$ is the posterior probability of model M_j conditional on the data.

As it can be seen, the BMA estimate of parameter vector θ is the weighted average of all possible posterior probabilities of θ conditional on data and each possible model, with weights equal to posterior probabilities of each possible model. The obvious feature of BMA expressed in equation (6.7) is that model uncertainty is incorporated into subsequent inference by considering the model as a random variable as well as θ and y. This implies that, in order to obtain a BMA estimate of θ, we first need to specify prior probabilities $p(M_j)$ for each model indicating how likely it is the true model given the model space, and then for each model we need to assign priors to the parameters in that model, $p(\theta_j|M_j)$. In the light of these explanations, using the Bayes's rule, the posterior probability of model M_j can be expressed as

$$p(M_j|y) = \frac{p(y|M_j)p(M_j)}{\sum_{h=1}^{k} p(y|M_h)p(M_h)} \tag{6.8}$$

where

$$P(y|M_j) = \int \ell_j(\theta_j|y, M_j)p(\theta_j|M_j)d\theta_j \tag{6.9}$$

is the integrated likelihood of model M_j. This shows how the observed data supports the assigned prior probability that M_j is the true model while assuming that one model in the model space is true. Using the equations (6.8) and (6.9) one can obtain Bayes factor for model M_j against the model M_h as:

$$B_{jh} = \frac{p(M_j|y)p(M_h)}{p(M_h|y)p(M_j)} = \frac{\int \ell_j(\theta_j|y, M_j)p(\theta_j|M_j)d\theta_j}{\int \ell_h(\theta_h|y, M_h)p(\theta_h|M_h)d\theta_h} \tag{6.10}$$

The Bayes factor for model M_j versus model M_h shows the probability that model M_j is true vis-a-vis model M_h. For instance if $B_{jh} = 5$, then model M_j is five times likely than model M_h, given the data. Therefore, we can compare the possible models using the Bayes factors for these models. However the main objective of BMA is to provide a better average value of parameters of interest, not to provide the "best" model.

Even though BMA is a coherent way in order to tackle model uncertainty, implementation of this procedure in the context of linear regression is not easy. There are three important difficulties which a researcher must overcome.[6] First, one needs to assign appropriate priors to models and their parameters, namely coefficients of regressors and variances for error term and specifying plausible priors over the models is challenging. Second, the calculation of integrals expressed in (6.9) can be extremely difficult. Third, when the potential regressors and so the number of possible models are enormous (as in the case of cross-country growth regression), then computation of posterior probabilities of parameters of interest is very difficult, and in some cases practically infeasible. However, recent Markov chain Monte Carlo techniques can be used to perform the computations necessary for model averaging.

6.3 Model

Recall the generic presentation of cross-country growth regression model discussed in Chapter 3

$$\varrho_i = \gamma + \pi X_i + \psi Z_i + \upsilon_i \tag{6.11}$$

where ϱ_i is average real growth rate per capita over a particular time period, γ is intercept, X_i is a set of explanatory variables suggested by the augmented neo-classical growth model[7], Z_i is a set of addi-

[6] Indeed, these difficulties are the main reasons for why BMA was not popular until recently.

[7] These are initial level of income, rates of population growth, technological change and depreciation, physical and human capital savings rates. See Chapter 3 for transformations

tional control variables suggested by new growth theories and υ_i is error term. As noted previously, while X variables are generally fixed in the cross-country growth studies, there is no consensus about the Z variables. This is the result of theory and proxy uncertainties relating to model selection which casues model uncertainty producing many different models in cross-country growth work. As Brock et al. (2003) point out, uncertainty concerning functional forms and heterogeneity about growth process across countries are other important aspects of model uncertainty. However, in this chapter we deal with only model uncertainty in terms of theory and proxy uncertainties. Our BMA application on cross-country growth regression follows closely that of Fernández, Ley and Steel (2001a; 2001b; FLS henceforth). We also substantially benefit from the study by Brock, Durlauf and West (2003, BDW hereafter), especially in assigning prior probabilities to models over the model space.

We assume T different growth theories and k different proxy variables capturing these theories such that $k = \sum_t^T k^t$, where k^t is the number of proxies measuring t^{th} theory. Dealing with theory and proxy uncertainty, in every model we includes X variables and the intercept γ. This means that only different proxies capturing different theories generate different models. Since additional theories are reflected by k different proxies, our model space consists of 2^k different models including the null model (with only X variables as a baseline model) and full model (with all variables: X variables plus k proxies). The rationale for the model space as defined here is straightforward: Firstly, there is a complete consensus about the X variables since they are proximate determinants of growth. Secondly, and more importantly,

of these variables in the augmented neo-classical model allowing proximate determinants of growth in every model reveals the impact of other variables on growth through the productivity channel.

Assuming that the average growth rate for n countries is regressed on an intercept γ and a set of s fixed regressors X with a number of additional explanatory variables chosen from a set of k different variables Z, we can rewrite the generic presentation of cross-country growth regression model for all variables as follows (for simplicity country subscript i is dropped)

$$\varrho = \gamma\iota_n + \pi X + \psi Z + \sigma\upsilon \tag{6.12}$$

where π is a full s-dimensional vector grouping coefficients of s different fixed regressors, ψ is a full k-dimensional vector including regression coefficients of k additional explanatory variables, ι_n is a n-dimensional vector of 1's and $\sigma \in \Re_+$ is a scale parameter.

As pointed out by FLS, the exclusion of an additional variable from the regression expressed by equation (6.12) means that the corresponding element of ψ is zero. Therefore, a possible model over the model space $M_j,\ j = 1...2^k$ includes $k_j \quad (0 \leq k_j \leq k)$ additional regressors and can be expressed as

$$\varrho = \gamma\iota_n + \pi X + \psi_j Z_j + \sigma\upsilon \tag{6.13}$$

where Z_j is the $n \times k_j$ submatrix of Z and ψ_j is the a k_j-dimensional coefficient vector of corresponding additional variables. Thus we can group the zero component of ψ under the model M_j in a vector $\psi_{\sim j} \in \Re^{k-k_j}$. Prior distribution for the parameters of the model M_i can be written as

$$p(\gamma, \psi_j, \sigma | M_j) \tag{6.14}$$

This obviously requires that priors are assigned to models over the model space as follows

$$p(M_j) = p_j,\ j = 1...2^k,\ p_j \geq 0\ \ and\ \sum_{j=1}^{2^k} p_j = 1 \tag{6.15}$$

In order to obtain posterior distribution of parameters in model M_j we need to calculate its posterior probability which can be expressed by

$$p(M_j|\varrho) = \frac{\ell(M_j)p_j}{\sum_h^{2^k} \ell(M_h)p_h} \tag{6.16}$$

where p_j is the prior probability of model M_j and $\ell(M_j)$ is the integrated marginal likelihood of (M_j) which is explicitly defined as

$$\ell(M_j) = \int p(\varrho|\gamma, \psi_j, \sigma, M_j)p(\gamma, \psi_j, \sigma|M_j)d\gamma d\psi_j d\sigma \tag{6.17}$$

where $p(\varrho|\gamma, \psi_j, \sigma, M_j)$ is the likelihood function and $p(\gamma, \psi_j, \sigma|M_j)$ is the prior distribution of parameters in model M_i. As can be seen, the expressions in (6.16) and (6.17) are algebraically identical to those in (6.8) and (6.9), respectively.

6.4 Implementation

As noted before, implementation of BMA is difficult because i) specifying priors over the models and their parameters is challenging, ii) computation of integrals expressed by equation (6.17) is very hard, and iii) when the number of regressors and hence models are enormous, exact calculation of posterior quantities of interest is infeasible. In this section, we deal with these difficulties.

6.4.1 Specifying Prior Probabilities

Priors over the Models

We start by specifying prior probabilities over the model space. The most common approach in the model averaging literature in which model uncertainty mostly considered as variable uncertainty is assigning uniform prior to each possible model. More clearly, in the case of linear regression, model uncertainty arises from the presence of k different regressors and hence a prior probability of 2^{-k} is assigned to each of 2^k models in the model space. Therefore, this prior structure over the model space implies that the prior probability that a given variable appears in the true model is 0.5 and the probability that a particular variable appears in the true model is independent from the presence or absence of other variables in that model.

This approach is however problematic in the context of cross-country growth regression even though assigning equal priors to models seems reasonable. The first problem is that uniform priors over the models implies the higher weights for larger models (Sala-i-Martin et al. (2004)). Yet there is no *a priori* reason to believe that the larger models are more likely than smaller models. The second problem is that it is very difficult to assume that the probability that one regressor appears in a growth model is independent from the absence or presence of other regressors, as indicated by BDW. The reason is that some regressors, such as alternative proxies for a particular growth theory (e.g., different openness measures) are quite similar, while some regressors are quite disparate-such as proxy variables belonging to different growth theories (e.g., ethnolinguistic fragmentation index that measures population heterogeneity and absolute latitude which measures geographical location).[8] Therefore, it is obvious that models including variables which represent the same theory takes higher weights if one assigns equal priors to the possible models. For instance, consider a case in which a particular growth theory is measured by n different proxies. Hence, $2^n - 1$ different combinations of these proxies give models including only proxies of that theory. Obviously, in this case, that theory has a prior probability which is $2^n - 1$ times prior probability of another growth theory which captured by only one proxy if we specify uniform priors over the models.

In order to overcome these difficulties, BDW suggest a tree structure according to different aspect of model uncertainty in growth regression.[9] First they identify alternative class of models according to different growth theories suggested in the literature. Hence, in the first step they deal theory uncertainty. Second, they highlight proxy uncertainty for each theory class. Third, for each specification of theories and associated proxies, BDW specify models with and without sub-Saharan Africa dummy for accounting heterogeneity uncertainty. This means that their model space generated by theory and proxy uncertainties is doubled by allowing heterogeneity uncertainty. Once this tree structure is established, they assign a prior probability for each level of uncertainty as follows. Assuming that prior probabilities with respect to theory inclusion are equal and independent of presence or absence of other theories, BDW assigns a prior probability of 0.5 to each theory and this prior is unaffected by inclusion or exclusion of other theories. It is obvious that specifying uniform priors over the

[8]This problem is very similar to red bus/blue bus problem in discrete choice theory while determining the probability of an individual's choice of a red bus over the taxi. Undoubtedly, this probability is affected by the possibility of choosing a blue bus since blue bus is a quite substitute for red bus. See BDW for a detailed discussion.

[9]The priors structure over the model space suggested by BDW is indeed motivated by Sala-i-Martin et al. (2004).

alternative growth theories is reasonable and also consistent with the open-ended nature of growth theories since the probability that each growth theory is included in the true model is equally likely. That is, for a given growth theory, it is either included or excluded in the true model and the probability that theory is included (or excluded) in the true model is equal to 0.5. In the second step, identifying a small number of proxies capturing each theory, BDW define a uniform prior on the proxies under the consideration of each theory class. In other words, BDW assign equal priors to each of the proxy variables of a theory. In the third stage, for each pair of corresponding model with and without sub-Saharan Africa dummy, BDW assign a prior of q to heterogenous model and of 1-q to homogenous model.

The prior structure suggested by BDW seems plausible. It allows us to distinguish the uncertainty over theories from the uncertainty concerning proxy variables. The important point about this prior structure is that one should avoid employing empirical proxies which represent more than one theory. In the light of this discussion, we highlight nine growth theories (including openness) and 29 proxy variables measuring these theories in what follows.

Categorization of Growth Theories

i) Institutions: The role of institutions on economic growth and development has been an important issue in economics since Adam Smith. In particular, differences in institutions and property rights among the countries have received substantial interest in explaining cross-country growth differences in recent years.

According to North (1990, p.3) "[I]nstitutions are the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction. In consequence they structure incentives in human exchange, whether political, social, or economic." The literature on institutions and economic growth points out that countries with better institutions not only invest more in physical and human capital but also employ production factors efficiently (see North (1981, 1990), Schleifer and Wishny (1993), Landes (1999), Hall and Jones (1999), Acemoglu et al. (2001, 2002)). The reason is that countries with good-quality institutions provide incentives for individuals that encourage investment, the accumulation of skills and innovative activities. As a result, better institutions lead to higher economic growth. In addition Keefer and Knack (2002) provide theoretical argument and empirical evidence that public investments are dramatically higher in the countries with insecure property rights. This increases rent-seeking and reduces the incentive for government to use tax revenues for productive purposes.

These views have been affirmed by numerous recent works in the cross-country growth literature.[10] For instance, Mauro (1995) concludes that corruption (measured as an average of Business International indexes on corruption, red tape and inefficient judiciary over the period 1980-1983) has a negative impact on investment and hence economic growth. Employing various indicators of institutional quality (such as rule of law, corruption, risk of expropriation and contract repudiation) Keefer and Knack (1997) indicate that convergence is slow in the absence of good institutions. Hall and Jones (1999) find that differences in capital accumulation, productivity and hence output per worker are substantially driven by differences in economic institutions (measured an average of indexes of law and order, bureaucratic qual-

[10] Knack and Keefer (1995), Mauro (1995), Hall and Jones (1999), Rodrik (1999b), Aron (2000), Keefer and Knack (1997, 2002), Acemoglu et al. (2001, 2002), Dollar and Kraay (2003a), Rodrik et al. (2004) are few examples among others.

ity, corruption, risk of expropriation and government repudiation of contracts.) Similarly, Barro (1996, 1997) provides empirical evidence for the positive relation between the rule of law index and economic growth. Acemoglu et al. (2001) document the substantial positive effects of secure property rights on per capita income.[11] Therefore, economic institutions and the protection of property rights, generally measured by the rule of law and risk of expropriation, are considered as the fundamental or deeper determinants of economic growth in the literature (Rodrik (2003), Acemoglu et al. (2005)).

The recent literature has also emphasised the role of political institutions on economic growth (La Porta et al. (1999), Acemoglu et al. (2005)). According to Acemoglu et al. (2005), the basic mechanism works as follows: the political institutions and the distribution of resources shape the form of political power and then the political power determines the economic institutions. The political institutions which create incentives and impose constraints on the political actors are the key for economic success. In this regard, it is likely that the extent of democracy influences economic growth positively because economic institutions providing protection of property rights and equal opportunity for the individuals in the society are difficult to sustain in an autocratic regime or a dictatorship as noted by Acemoglu et al. (2005). The recent studies such as Roll and Talbot (2003), Feng (2003), Krieckhaus (2004), Giavazzi and Tabellini (2005), Rodrik and Wacziarg (2005), Rigobon

[11]The casuality between economic institutions and growth is an important problem in these studies since it is likely that a country with a good macroeconomic performance may choose or afford better institutions. Acemoglu et al. (2001) employing settler mortality rate in the countries colonized by Europeans as an IV for the present institutions, estimate large effects of institutions on per capita income. In addition, they point out that their results are not driven by outliers and are robust to controlling a number of other growth determinants. However, Glaeser et al. (2004) question settler mortality rate as a valid IV for current institutions and show that this variable is highly correlated with human capital. They argue that it is more likely that causality runs from economic outcomes to institutional quality.

and Rodrik (2005), Persson and Tabellini (2006; 2007), Papaioannou and Siourounis (2006), conclude a positive and statistically significant association between growth and democracy. Moreover, Rodrik (1999a) points out a robust and significant association between democracy and the level of manufacturing wages.

On the other hand some scholars argue that the relationship between democracy and growth could reflect a reverse causality and/or there is no significant relation between these two at all. For instance, as indicated by Przeworski and Limongi (1993), the idea that democracy protects property rights is questionable due to the fact that property rights may be threatened by private actors such as trade unions or landless peasants as well as the political power. Thus, democracy may undermine property rights by equalizing the right to influence the allocation of resources and providing a means to expropriate the riches. In addition, under democratic regimes, the distribution of state-owned resources is subject to pressures from different interest groups and hence democracy may lead to an expansion of consumption at the cost of investment and of economic growth. Using the successful economic performances of East Asian countries (in particular South Korea, Taiwan and China) under the autocratic state regimes and poor economic experiences during the democratization period of Latin America as examples, another line of literature argues that democracy hinders economic growth and autonomous state regime may be more beneficial for development, especially in developing countries (see Sirowy and Inkeles (1990), and Przeworski and Limongi (1993) for overall reviews and an assessment of the literature on the relationship between economic growth and political institutions). There are empirical cross-country studies finding a negative association or concluding insignificant relation between growth and democracy.[12] For instance, Barro (1996) finds that the effect of democracy on growth is weakly negative once the initial level of income, rule of law, free markets, government consumption and level of human capital are controlled for. In addition, Barro (1996, 1997) suggests a non-linear relationship between growth and democracy, such that democracy stimulates growth at low levels of political freedom and depresses it at the moderate levels of political freedom. Barro (1996, 1997) concludes that democracy is not a key factor in economic growth.

Finally, Engerman and Sokoloff (2002) and Djankov et al. (2003) emphasise the role of factor endowments, cultural heritage, and ecological and geographical environment on determining the economic and political institutions, rather than the influence of political institutions on economic institutions. La Porta et al. (1999) and Glaeser et al. (2004) provide empirical evidence in favour of this view.

In this regard, we consider both economic and political institutions as possibly important growth determinants and measure them by using two composite indexes. The first one represents the economic institutions and comes from a subjective database by "*the International Country Risk Guide* (ICRG)", published by a private international consulting company *Political Risk Services*. Following Keefer and Knack (1997), Sachs and Warner (1997a) and Hall and Jones (1999), the index is calculated as the average of four ICRG components: i) Investment profile as a average of three subcomponents namely, contract viability, profits repatriation and payment delays; ii) Law and order; iii) Corrup-

[12]Especially results of early studies are not favour of democracy. See Kurzman et al. (2002) for a summary of these studies. Krieckhaus (2004) points out that choosing time period strongly influences the empirical result. His findings indicate that democracy is negatively associated with economic growth in the 1960s while positively correlated in the 1990s. He concludes that there is no statistically significant relation during 1970s and 1980s.

tion; and iv) Bureaucratic quality. The index is calculated as the equal weighting average of these four categories for the years 1984-2000. The higher value of index indicates the greater institutional quality. The second index measures the level of democracy over the period 1960-2000 and comes from *Polity IV Project* (Marshall et al. (2005)).

ii) Geography : Another fundamental determinant of economic growth is geography. This theory points out that differences in the economic performance across countries are a result of differences in their geographical, climate and ecological characteristics. However, in spite of this fact, the role of geography was neglected in the empirical cross-country growth literature until very recently. Interest for geography has mainly raised from the contribution by Sachs and Warner (1997a), Bloom et al. (1998) and Gallup et al. (1999) and two recent books by ecologist Diamond (1998) and Landes (1999) which emphasise the role of geography in economic and social development.

Geography directly influences economic growth since temperature, soil quality, rainfall, water resources and topography are mainly determined by it. Especially, geography considerably affects productivity in agriculture and variety of plant crops. For instance Bloom et al. (1998, p.227) argue that "[t]ropical agriculture, especially food production, is faced with chronic problems of low yields and fragility due to low photosynthetic potential, high evapotranspiration, low and variable rainfall, highly weathered soils, veterinary diseases, and plant and animal pests." Masters and McMillan (2001) and Sachs (2001) provide empirical evidence regarding how climate and other geographical factors (such as burden of pest, parasites, disease vector and so on) matter for agricultural and hence economic performance. According to these authors, the absence of winter frost is a key factor in the growth of pests, parasites and diseases which are an important obstacle for improvement of agricultural productivity as well as public health. Secondly, geography may stimulate technological progress. According to Diamond (1998) cold climates require more innovatory activities since people need to build warm houses and cloths in the temperate zones whilst those in the tropics can survive with simpler housing and no clothing. In addition, presence of long winters at high latitudes provide people much time for siting indoors and inventing. Thirdly, geography is an important determinant of public health through nutrition, disease burden, prevalence of parasites and so on as noted by Bloom et al. (1998). For instance Gallup and Sachs (2001) point out that the location and severity of malaria is mainly determined by climate and ecology, not poverty per se. They show that countries with severe malaria prevalence (mainly countries in tropical zone) are almost all poor and continue to have low economic growth. Therefore, geography has a direct influence on shaping the quantity and quality of human capital. Fourthly, the endowment of natural resources is largely determined by geography. Finally, geography plays an important role on the diffusion of technology and knowledge across countries (Diamond (1998), Gallup et al. (1999)).

In addition to these direct effects, geography affects growth via two other factors, namely international trade and institutions (Bloom et al. (1998), Sachs (2001), Rodrik (2003)). Undoubtedly, international trade is costly for landlocked countries or countries with a great distance from the main trading centres in the world due to the transportation costs. Geography also influences the quality of institutions and hence growth. According to Engerman and Sokoloff (2003) geographical regions where crops are produced using large plantations lead to political and economic institutions protecting the landlords from peasants and thievery. These authors argue that different political and economic outcomes may be result of different crops. For instance, tropical climates in the Americas lead to large plantation-style agriculture on the basis of slave labour. In addition, as pointed out by Acemoglu et al. (2001) and Rodrik (2003), geography may affect current institutions in many developing countries through colonial experiences in the past. Especially because of these indirect effects, there has been an ongoing debate on the primacy of geography, institutions and international trade in explaining growth differences across countries.[13] Hence, we consider geography as an important growth theory. In the literature the most common proxy variable for geography is absolute latitude since it directly determines geographical factors such as temperature, insolation, precipitation and so on. However, as noted by Sachs (2001), absolute latitude may not be a good proxy for geography. The most important reason is that countries with the same latitudes may have different climatic characteristics. Moreover, proximity to main world trade market is more important than the distance from the equator. Sachs (2001) empirically demonstrates that latitude per se has very little explanatory power when it is tested against various direct climate and ecological measures.[14] Thus, we measure geography by two additional variables: the share of country's land area in tropics and the share of country's population living in tropics. Finally, we include a

[13]See, for instance, Easterly and Levine (2003), Sachs (2003) Rodrik et al. (2004) among others.

[14]While explaining differences in rate of spread of food production and inventions on different continents, Diamond (1998, p.189) argues that " [I] have been dwelling on latitude, readily assessed by a glance at a map, because it is a major determinants of climate, growing conditions, and ease of spread of production. However, latitude is of course not the only such determinant, and it is not always true that adjacent places at the same latitude have the same climate (though they do necessarily have the same day length). Topographic and ecological barriers, much more pronounced on some continents than others, were locally important obstacles to diffusion. "

dummy variable for landlocked countries, due to the possibility that sea-navigable regions are richer than the landlocked countries.

iii) Natural Resources: We investigate the impact of natural resources and economic growth separately, even though natural resource endowment are partly determined by geographical characteristics as mentioned above. The reason is that the recent literature on the link between natural resources and economic growth emphasises the "curse of natural resources" hypothesis. This hypothesis points out that the resource rich countries tended to grow slowly than the resource poor countries since the 1950s.

As noted by Gylfason and Zoega (2006) and Hausmann and Rigobon (2002), there are four important reasons for the adverse effect of resource abundance on economic growth during the last decades. First, according to Dutch disease models, natural resource abundance or a resource boom leads to contraction of the tradable non-resource (manufacturing) sector. At first sight, Dutch disease does not necessarily lead to slower growth since contraction in manufacturing does not imply any efficiency loss. However, if the positive externalities from natural resource sectors are less than those from manufacturing (as pointed out by Corden and Neary (1982) and Corden (1984)), and/or manufacturing is subject to increasing returns to scale and learning by doing compared to the natural resource sector or agriculture (as indicated by Matsuyama (1992) and Sachs and Warner (1999)), then Dutch disease may cause a slowdown in long run growth. Second, the terms of trade of primary products and raw materials have secularly worsened (also known Prebisch (1959) hypothesis). Third, natural resource production and/or a resource boom generates economic rents and hence rent-seeking activities, especially in the absence of good-quality institutions

(Auty (2001)). These rent-seeking activities may lead to destructive consequences such as sub-Saharan African's diamond wars. In addition, a natural resource abundant country may face the risk of foreign invasion and thus its military expenditures may be immense, as in the case of many oil producing and exporting countries in the Middle-East. Fourth, natural resource abundance may have a negative role on the incentives for the accumulation of human capital due to the high level of non-wage incomes in these countries (Gylfason (2001)).

On the other hand, natural resource abundance does not necessarily imply a curse. Rather it may be a blessing for economic growth and development. For instance, Botswana was one of the fastest growing countries during the 1960-2000 period and its rich natural resources have successfully contributed to its impressive growth performance. However, in spite of this fact, the negative association between resource abundance and economic growth during the last few decades has been confirmed by many cross-country growth studies.[15] Moreover, as argued by Sachs and Warner (2001), this finding is robust to omitted geographical and climate variables. Therefore, following Sachs and Warner (1997c), we employ the share of primary exports in total exports to test the resource curse hypothesis. In addition to primary exports intensity, we use the ratio of mineral production in GNP in order to show direct effect of mineral production rather than agriculture on economic growth.

iv) Culture : In the literature, the role of culture as one of the fundamental explanations of economic performance has been recently

[15]See, for instance, Sachs and Warner (1997c, 1999, 2001), Gylfason et al. (1999), Leite and Weidmann (1999), Ross (2001), Atkinson and Hamilton (2003), Isham et al. (2005), Gylfason and Zoega (2006), Gylfason (2007), among others. See Stijns (2001), Brunnschweiler and Bulte (2006) and Brunnschweiler (2007) for a critical evaluation of empirical basis for the resource curse hypothesis.

emphasised (Acemoglu et al. (2005), Engerman and Sokoloff (2002)). Culture may be defined as the values, preferences, and beliefs of individuals or societies and hence has some implications for economic growth. For instance, Véliz (1994) points out that the different development paths in Latin America and North America may be a result of differences in cultural heritages of these regions. According to Véliz (1994), North America is richer than Latin America since the former developed on the basis of Anglo-Saxon (British) heritage while Latin America has been based on Iberian (Spanish) tradition. Similarly, some authors argue that the fact that former socialist countries in Eastern Europe such as Poland, Hungary and Czech Republic have experienced more successful and faster transition period than those in Asia such as Russia and Ukraine can be explained by the different cultural factors (Fukuyama (2001)). In other words, the degree of western capitalism prior to socialist period is a key determinant in explaining different transition performances of former socialist countries. Another example can be given from the import substituting industrialisation experiences of many developing countries. As mentioned in Chapter 1, one of the well-known side effects of the import substitution development strategy is that it creates rent-seeking activities because of strong role of state or government in the industrial and economic polices. However, while import substitution strategy was less effective in Latin America, Africa and other many developing countries because of rent-seeking and corruption, generally East Asian countries did not suffer from the same problem. One possible explanation of this phenomenon is that the success of industrial polices in East Asian countries is mainly influenced by their cultural attitudes.

As argued by Fukuyama (2001), the effect of culture on economic behaviors and hence economic performance can be summarised as follows: First, different norms and preferences lead to different organizations for production (e.g., different organizations of an automotive factory in South Korea and Italy); Second, countries have different attitudes towards consumption, saving and work due to their different values and religions; Third, different cultural norms lead to differences in institutional quality and thus economic growth; Fourth, culture influences economic performance by shaping the social networks which have a key role for information flow in the economy.

Obviously one important aspect of culture is religious beliefs. In this respect, the well-known link between economic development and religion is suggested by Max Weber. As noted by Acemoglu et al. (2005), Max Weber argues that protestantism has an important role on Western capitalist development since it encourages hard working, saving, thrift, but other religions such as catholicism do not. Therefore, according to Weber, Western capitalism is a unique combination of particular institutions and cultural values and the other areas in the world such as India, China do not support the development of capitalism. Recently, Huntington (2002), emphasises the importance of religious affiliation as the primary determinant for development and conflict generated by that development. Huntington (2002) points out that the world consists of eight different religious zones namely Western Christianity, Orthodox Christianity, Islam, Hindu, Japanese, Confucian, Latin American and African areas. Even though all these zones have integrated to global capitalism, their different religious characteristics or attitudes have persisted for centuries and still have strong influences on economic outcomes.

The relationship between religious affiliations and economic growth has been supported by cross-country growth studies in the literature. For instance Hoover and Perez (2004) and Hendry and Krolzig (2004) conclude that fraction of protestants and fraction of confucians are associated with economic growth in the context of general-to-specific search for growth determinants. Similarly, these two variables are found to be robustly correlated with growth in the study by Sala-i-Martin et al. (2004). Barro and McCleary (2003) show that economic growth responds positively to religious beliefs, especially belief in hell and heaven. However, Durlauf et al. (2006) question this finding. Applying Bayesian model averaging method these authors evaluate the robustness of the link between religious and economic performance and conclude that findings of Barro and McCleary (2003) are not statistically robust.

In the light of this discussion, we consider culture and religious affiliation as another important growth determinant in our BMA application and measure this theory by three variables namely fraction of catholics, fraction of muslims and fraction of other religious affiliations in total population. We consider catholic and islamic religions as two separate variables since these two are the most common religions in the world. The other religions are captured by one variable. Notice that other religions do not include the fraction of protestants in order to prevent multicollinearity problem. We exclude protestantism since our aim is not to test specifically Weber's hypothesis. Hence the effect of protestantism is captured by the intercept term in growth models. We also employ two more variables related to language. These are fraction of population speaking English and fraction of population speaking a major European language except English. Undoubtedly, language is another important aspect of culture. Employing these variables allows us to investigate the effects of Anglo-Saxon and continental Europe traditions on economic development. In addition, countries with high fraction of population able to speak English have advantage to adopt new technologies since English is language of modern science and technology, as noted by Eris (2005). Furthermore, speaking English or one of the major European languages may facilitate international trade via communications.[16]

v) Population Heterogeneity: The effect of population heterogeneity on macroeconomic performance has received considerable attention in recent years. There has been a growing body of the literature on the relationship among ethnic, linguistic, and religious diversity, the quality of institutions and economic growth since the important studies by Mauro (1995) and Easterly and Levine (1997). While Mauro (1995) points out the negative correlation between ethno-linguistic fragmentation index (ELF)[17] and the level of investment, Easterly and Levine (1997) conclude a negative and statistically significant association between ELF and long run growth.[18] These results are generally confirmed in other works.[19]

[16]Because of this, in the literature these two variables are some times used as IV for international trade. Hall and Jones (1999) and Dollar and Kraay (2003a) are few examples among others.

[17]The ELF index based on the data from a Soviet atlas (Atlas Naradov Mira, 1964) shows the probability that two randomly selected persons of a given country will belong to the same ethnolinguistic group

[18]In particular, Easterly and Levine (1997) claim that the poor economic performance of sub-Saharan Africa is mainly a result of ethnic conflicts which leads to poor macroeconomic polices.

[19]For instance, Alesina et al. (2003) conclude that ethnic and linguistic fragmentation indexes have an adverse effect on economic growth but religious fragmentation index does not. Montalvo and Reynal-Querol (2005a) find that ethnic and religious diversity measured by polarization indexes have a large and negative impact on economic development indirectly through civil wars, investment and government consumption. Eris (2005) conclude that religious fragmentation index is negatively and significantly associated with economic growth. In addition, La Porta et al. (1999) emphasise the role of ethnolinguistic fragmentation on government performance. Similarly, Montalvo and Reynal-Querol (2005b) show that ethnic diversity measured by polarization index have a significant effect on the incidence of civil wars.

Population heterogeneity along ethnic, religion and language lines may have strong conflict dimension and hence may have a direct negative impact of macroeconomic activities. More clearly, this conflict dimension may directly introduce some frictions among the economic agents, prevent the diffusion of knowledge and technology over the whole economy, and result in inefficient resource allocation. In addition to these direct effects, population heterogeneity may indirectly affect macroeconomic performance through domestic violence and civil wars, rent-seeking activities, corruption and so on. Finally, when the institutions of conflict management are weak, the conflict dimension of population heterogeneity substantially increases the economic costs of external shock such as a sharp deterioration of terms of trade as pointed out by Rodrik (1999b).

Therefore, we consider population heterogeneity as an important growth theory in our BMA analysis. For this purpose we employ ethnic, religious and linguistic fragmentation indexes provided by Alesina et al. (2003) instead of using ELF index which has become one of the standard explanatory variables in the cross-country growth literature. The reason for this is that these fragmentation indexes are not only better measures with respect to ELF index but also more useful in highlighting which dimension of heterogeneity is more important.[20]

vi) War and Unrest: It is obvious that both external and internal wars impose substantial costs on an economy. In the empirical

[20]As noted by Eris (2005), socia-economic fragmentation generally measured by GINI coefficient is another important line of population heterogeneity. However, we discard this line since our specific aim is to highlight the relation between openness and economic growth while controlling other important growth theories and since the literature on heterogeneity and growth mainly is focused on ethnolinguistic and religious diversity. In addition, it would be better to employ polarization indexes rather than fragmentation ones. However, due to the complexities related to calculation of polarization indexes, we prefer to use fragmentation indexes. The reader can apply Montalvo and Reynal-Querol (2005a,b) and Eris (2005) and references therein for more information about the polarization and fragmentation indexes of population heterogeneity.

cross-country growth literature, many previous studies have concluded the negative association between growth and war, social and political unrest. In this regard, the number of revaluations and coups, number of assassinations, a dummy variable for external war have been extensively used in order to capture this effect on economic growth.[21] We include two variables namely a dummy for war participation and number of revaluations.[22]

vii) Country Size: We consider whether country size has an effect on economic growth. For this purpose we measure country size by the logarithm of land area and logarithm of the average labour force. This theory has not often been considered and hence there are a few studies accounting the direct effect of country size in the cross-country growth literature. For instance, Sala-i-Martin (1997a,b) and Barro and Sala-i-Martin (2004) use log of initial level of labour force for capturing a scale effect although they conclude that country size does not matter for economic growth.

However, as noted by Alesina et al. (2005), there are some reasons for believing that the country size has a positive effect on economic growth. First, the economies of scale in the production of public goods are higher in the large countries. The reason is that, in a large country, the per capita cost of many public goods (such as infrastructure for telecommunications, judical system, public health and so on) is lower because of large number of tax payers. Second, a large country is less subject to the risk of foreign invasion and hence the degree of safety of public goods rises with country size. In addition, smaller countries

[21] Barro (1991), Barro and Lee (1994b), Sachs and Warner (1995), Easterly and Levine (1997), Wacziarg and Welch (2003), Alesina et al. (2003) are few examples among others.

[22] As noted by Wacziarg and Welch (2003), using the number of revaluations and coups in a cross-country growth regression may not be appropriate due to the double counting problem.

spend proportionally higher on military expenditures. Third, larger countries can better manage cross-regional differences than smaller countries. Similarly, a large country has more opportunities to overcome a regional economic recession in its territory. Fourth, in the light of recent endogenous growth models a positive association between growth and country size may be expected due to the increasing returns to scale. Moreover, even technology is subject to constant returns to scale, there are more opportunities for within country trade as mentioned in Chapter 5.

In this regard, Alesina et al. (2000, 2005) develop a theoretical model such that there is an inverse relation between openness to international trade and country size. This means that, in a world of trade restrictions, large countries enjoy more economic benefit from international trade than small countries. However, under the free international trade, small countries benefit more from international trade. This implies that more open countries benefit less from country size than more closed countries.

viii) Macroeconomic Stability: It is commonly accepted that macroeconomic stability is a necessary factor for sustainable economic growth. As noted by Fischer (1993) a stable macroeconomic environment can be described by low and predictable inflation, sound and stable fiscal polices and competitive and predictable real exchange rate. Hence, we measure macroeconomic stability by three variables: Average inflation, the share of government consumption in GDP and standard deviation of black market market premium. One can argue that standard deviation of black market premium is not an appropriate proxy for this theory since it may also capture some dimension of trade policy. We have two answers for this objection: First, we employ variability of black market premium as proxy for macroeconomic uncertainties related to monetary and exchange rate polices rather than the black market premium per se; Second, our empirical investigation in Chapter 5 shows that it is more likely that black market premium reflects macroeconomic imbalances rather than its restrictive effect on international trade.

Consideration of this theory is very important while investigating growth-openness link because trade policy is closely associated with other macroeconomic polices as pointed out by Harrison and Hanson (1999) and Rodrik and Rodríguez (2000).

ix) Openness to International Trade: The final growth theory is openness, the main subject of this PhD dissertation. As mentioned in the previous chapters, economic theory is not decisive about the impact of openness on economic growth in the long-run. In other words, the relation between long-run economic growth and openness to international trade may be positive or negative. A third possibility is that there may be no significant association between these two at all.

In order to consider these possibilities, we measure openness by six proxies: The first two are the ratios of trade volume to GDP, namely current openness and real openness. Both measures are filtered for its relation in a regression including initial income and country size. The fraction of open years based on the Sachs and Warner (1995) and the Wacziarg and Welch (2003) liberalization dates over the 1960-2000 period is used as third proxy. Finally, we employ three composite trade policy indexes which consist of weighted the average tariff rate, non-tariff barriers and black market premium (see Chapter 5 for details of these measures).

Priors on Model Parameters

After defining priors over the models in the framework of theory categorization mentioned above, the second difficulty arises in assigning priors to the parameters of each model. For this, FLS provide a general framework for the priors on the parameters within a model. Employing theoretical considerations and extensive simulations, these authors suggest priors over the model parameters which have little impact on the posterior inference. Therefore, following FLS, we employ improper noninformative priors for the common parameters in all models, namely γ and σ; and a g-prior structure for the coefficients of additional explanatory variables in each model, namely ψ_j as follows:

$$p(\gamma, \sigma) \propto \frac{1}{\sigma} \tag{6.18}$$

and

$$p(\psi_j|\gamma, \sigma, M_j) = f_N^{k_j}(\psi_j|0, \sigma^2(gZ_j'Z_j)^{-1}) \tag{6.19}$$

where$f_N^q(w|m, V)$ is the density function of q-dimensional Normal distribution on w with mean m and covariance matrix V. FLS point out that determining $g = 1/max\{n, k^2\}$ yields a reasonable result. Hence, we choose $g = 1/k^2$ due to the fact that $k^2 > n$ in our BMA application.

6.4.2 Computation of Marginal Likelihood of Model, M_j

After specifying priors over the models and parameters, we evaluate the marginal likelihood of model, M_j which expressed by the integral in equation (6.17). In the light of prior structure for the parameters of model, M_j, FLS conclude that this integral can be computed analytically as follows

$$\ell_{\varrho}(M_j) \propto \left(\frac{g}{g+1}\right)^{k_j/2} \left(\frac{1}{g+1}\varrho' M_{Y_j}\varrho + \frac{g}{g+1}(\varrho - \bar{\varrho}\imath_n)'(\varrho - \bar{\varrho}\imath_n)\right)^{-(n-1)/2} \tag{6.20}$$

where $Y_j = (\imath_n : Z_j)$, $\bar{\varrho} = \imath_n'\varrho/n$, $M_{Y_j} = I_n - Z_j(Z_j'Z_j)^{-1}Z_j'$ and, without loss of generality, the additional explanatory variables are demeaned such that $\imath_n'Z = 0$. Employing analytical computation of marginal likelihoods of models, one can calculate the posterior model probabilities expressed in equation (6.16). Then using posterior model probabilities as weights, BMA estimate of coefficient of variables and their t-statistics which are given in equation (6.15) are obtained. Moreover, as pointed by Eris (2005), the posterior inclusion probabilities of variable, Z_k can be calculated as follows

$$\mu_k \equiv \sum_{j:k^{th}\ component\ of\ \psi_k \neq 0\ in\ M_j} p(M_j|\varrho) \tag{6.21}$$

where μ_k is the posterior inclusion probability for additional explanatory variable, Z_k. Likewise, computation of the theory inclusion probability for j^{th} theory is given by

$$\mu_{T_j} \equiv 1 - \sum_{j:T_t\ is\ not\ in\ M_j} p(M_j|\varrho) \tag{6.22}$$

where μ_{T_j} denotes the posterior inclusion probability for j^{th} theory of T different growth theories.

6.4.3 Computation of Posteriors: MC^3 Technique

The exact calculation of the posterior quantities of interest (expressed in equations 6.7, 6.16 and 6.17) is practically infeasible when the number of regressors and hence the size of model space is too large. In this regard, most applications of BMA use a subset of model space as a reliable approximation to model space instead of searching all possible models. One approach, developed by Madigan and York (1995), is known as Markov chain Monte Carlo model composition (MC^3 henceforth) technique.[23]

The MC^3 method employs a Markov chain moving through the model space and it is essentially based on a Metropolis algorithm. A Markov chain $\{M_t,\ t \geq 0\}$ can be constructed over the model (state) space such that each time $t \geq 0$, the next model is drawn from the distribution $p(M_{t+1}|M_t)$ which depends only upon the current model, M_t. This means that given the current model in the chain, the probability distribution of the next model does not depend further on the previous models, $\{M_0, M_1, \ldots, M_{t-1}\}$. This is known as "Markov property" and $p(.|.)$ is called as the transition probabilities of the chain. We also assume that a time-homogenous Markov chain such that transition probabilities do not depend on time.[24] A time-homogenous Markov chain can be expressed as follows:

$$p(M_{t+1} \in A \mid M_0, \ldots, M_t) = p(M_t, A)\ for\ \forall\ A \subset \mathcal{M} \tag{6.23}$$

where $\mathcal{M}$ denotes the model space as before. The probability distribution of M_0 is known as the initial distribution of the chain. In this regard, the conditional distribution of the current model, given the initial model is described as:

$$p(M_t \in A|M_0) = p^t(M_0, A) \tag{6.24}$$

[23] An alternative approach is Occam's window which produces a reduced set of models for calculation of model averaging (See Madigan and Raftery 1994, Hoeting 1995).

[24] See Gilks et al. (1996) for a nice introduction to Markov chain Monte Carlo technique.

where p^t is the t^{th} iteration (or application) of the chain. The last expression indicates that the current model in the chain depends directly on the initial model, M_0. Under certain regularity conditions, the chain gradually forgets its initial state and $p^t(M_0, A)$ eventually converges to a unique stationary distribution. If the Markov chain is aperiodic and irreducible with a unique stationary distribution, then as pointed out by Smith and Roberts (1993), the typically available asymptotic results indicate that:

$$M_t \ \underset{\rightarrow}{d} \ M \ \sim \pi(.) \ \ as\ t \ \rightarrow \infty \tag{6.25}$$

and

$$\frac{1}{t}\sum_{i=1}^{t} f(M_t) \rightarrow E_\pi[f(M)] \ \ as\ t \ \rightarrow \infty \ almost\ surely \tag{6.26}$$

where $\pi(.)$ is the unique stationary distribution and $f(.)$ is any function of interest over the model space with respect to $\pi(.)$. The equation (6.25) implies that, as t increases, the sampled models $\{M_t\}$ will be increasingly similar to those from $\pi(.)$. Therefore, if one simulates a Markov chain with a stationary distribution sufficiently long, the sampled points on the chain will be a reliable approximation to dependent samples from $\pi(.)$. Equation (6.26) indicates that, for any real valued function of interest with respect to $\pi(.)$, the average of this function over the realisations of the chain converges to its expected value as t approaches infinity, almost surely.

In this framework, in order to compute posterior estimates of parameters in the growth model, we just need to set $\pi(.)$=$p(M_j|\varrho)$ and $f(M) = p(\gamma, \psi_j, \sigma|M_j, \varrho)$, which are the posterior model distribution of M_j and the posterior distribution of its parameters, respectively.

In order to construct a Markov chain, we also need to define a transition matrix showing the transition probabilities from one model to another. For this, we follow Madigan and York (1995) and define a neighbourhood for each possible model M_j, $nbd(M)$ which consists of the models including the same growth theories as well as the one more and less theories with respect to the model M_j. In this respect, we define the transition matrix q as follows

$$\begin{aligned} q(M_t \rightarrow M_{t+1}) &= 0 \quad if \quad M_{t+1} \notin nbd(M_t) \\ &= min\{1, \frac{p(M_{t+1}|\varrho)}{p(M_t|\varrho)}\} \quad if \quad M_{t+1} \in nbd(M_t) \end{aligned} \tag{6.27}$$

The transition matrix indicates that, if the Markov chain is currently in the model M_t, the next model in the vicinity of current model, M_{t+1} is drawn with the probability $min\{1, p(M_{t+1}|\varrho)/p(M_t|\varrho)$ and stays in model M_t with the probability $1 - q$. It is obvious that the probability that models outside of the neighbourhood are visited by the chain as a next model is zero. As can be easily seen, the Markov chain with the transition matrix in (6.27) visits only models with high posterior model probabilities.[25]

6.5 Findings

In this section, we present the findings obtained from our BMA application on the cross-country growth model expressed in equation (6.12).

[25] Notice that the term $p(M_{t+1}|\varrho)/p(M_t|\varrho)$ in the transition matrix is equal to posterior odds for model M_{t+1} vis-a-vis model M_t. Using the equations (6.5) and (6.10), one can easily obtain Bayes factor for model M_{t+1} against M_t such that

$$B_{t+1,t} = \frac{\ell(M_{t+1})}{\ell(M_t)} = \frac{p(M_{t+1}|\varrho)}{p(M_t|\varrho)} \div \frac{p(M_{t+1})}{p(M_t)}$$

where $p(M_{t+1})$ and $p(M_t)$ are corresponding prior model probabilities. Following FLS, we also take the advantage of the fact that the marginal likelihood expressed in equation (6.17) can be calculated analytically through equation (6.20).

Our dependent variable is the growth rate of GDP per worker over the period 1960-2000. As noted before, we include four variables (namely initial income, population growth, and the saving rates for physical and human capital) suggested by the augmented neoclassical growth model as fixed regressors. In addition, we allow 29 variables capturing 9 different growth theories described in the previous section in order to account model uncertainty. This means that our model space consists of 2^{29}(= 536,870,912) different models. We employ a completed data set covering 66 countries. All variables and their sources and summary statistics as well as list of countries are given in the Appendix.

6.5.1 Posterior Estimates

Since our model space is substantially large, we employ the MC^3 technique. The success of this technique depends on the stationary distribution which are corrected at each iteration in the simulation such that the approximate distribution is converging to the true distribution (Gelman et al. (2004)). This means that the key aspect of the MC^3 method is simulating the Markov chain with enough draws in order to estimate the relevant posterior quantities with reasonable accuracy. Therefore, we ran our BMA exercise with 400,000 and 500,000 draws of the MC^3 sampler, respectively and then compare the results. We find that posterior estimates are extremely close to each other. This implies that Markov chain is converging to true posterior distribution and we do not need to increase draws. Thus, we report posterior estimates obtained from 500,000 draws as reliable estimates in Table 6.1.

As can be seen from Table 6.1, the posterior coefficient estimates of all openness measures are almost equal to zero and they have very low levels of posterior inclusion probabilities. The posterior theory in-

Table 6.1: Posterior Estimates of Additional Growth Variables

Variable	Posterior Mean	Posterior t-statistic	Posterior t-probability	Posterior Inclusion Probability
ICRG measure	0.267	4.103	0.000	0.901
Democracy	-0.007	-0.461	0.646	0.213
Absolute Latitude	0.000	0.000	1.000	0.032
Land Area in Tropics	-0.042	-0.428	0.670	0.147
Population in Tropics	-0.077	-0.798	0.428	0.248
Landlocked Country Dummy	-0.002	-0.010	0.992	0.018
Primary Exports	0.000	-0.002	0.998	0.013
Mineral Production	-0.120	-0.306	0.761	0.110
Fraction of Catholics	0.005	0.042	0.967	0.020
Fraction of Muslims	0.033	0.276	0.784	0.080
Fraction of Other Religions	0.001	0.006	0.995	0.007
Fraction of English Speaking	0.000	0.001	1.000	0.004
Fraction of European Lang. Speaking	0.000	0.000	1.000	0.004
Ethnic Fragmentation	-0.005	-0.028	0.978	0.018
Linguistic Fragmentation	-0.007	-0.051	0.959	0.029
Religious Fragmentation	-0.027	-0.181	0.857	0.075
War Dummy	0.001	0.006	0.995	0.013
Number of Revaluations	-0.001	-0.005	0.996	0.011
Land Area	0.000	0.004	0.997	0.012
Labour Force	0.000	0.004	0.997	0.012
Average Inflation	-0.086	-3.451	0.001	0.931
Government Consumption	-3.144	-3.195	0.002	0.863
Standard Deviation of BMP	0.000	0.002	0.998	0.038
Current Openness	0.000	-0.001	0.999	0.001
Real Openness	-0.001	-0.003	0.998	0.001
Number of Open Years	0.000	0.001	0.999	0.001
Trade Policy 1	0.000	0.000	1.000	0.001
Trade Policy 2	0.000	0.000	1.000	0.000
Trade Policy 3	0.001	0.000	1.000	0.001

clusion probabilities are reported in Table 6.2. Recall that we assign equal prior probabilities over the growth theories such that prior probability that a particular growth theory is included in the true model is equal to 0.5. Therefore, growth theories with the posterior inclusion probabilities less than 0.5 do not definitely have a significant relation with the long-run economic growth once the model uncertainty is accounted for. As can be seen from Table 6.2, openness to international trade has the lowest posterior inclusion probability amongst the growth theories. Hence, our BMA exercise does not suggest that openness is

Table 6.2: Posterior Inclusion Probabilities of Growth Theories

Theory classess	Posterior theory inclusion prob.
Institutions	0.902
Geography	0.398
Resource Impact	0.118
Culture	0.083
Population Heterogeneity	0.110
War and Unrest	0.024
Scale Effects	0.023
Macroeconomic Stability	0.984
Trade Openness	0.003

fundamental to growth in the long-run.

Concerning the other growth theories, we conclude that only two theories have posterior inclusion probabilities higher than 50 percent. The posterior inclusion probabilities of macroeconomic stability and institutions are found to be very high (more than 90 percent). When we consider the proxy variables capturing institutions, our findings indicate that ICRG index, measuring the quality of economic institutions is positively and significantly correlated with economic growth. The posterior coefficient estimate of this variable (0.260) implies that an increase in the ICRG index by one standard deviation (which is equal to 1.131 over the 1984-2000 period) would raise the growth rate on impact by 0.294(=0.260x1.131). However, the same is not true for the average democracy index. Its coefficient estimate is negative and almost zero with a very low posterior inclusion probability, implying that there is no significant relationship between growth and democracy. The high level of posterior probability for macroeconomic stability stems from average inflation rate and ratio of government consumption to GDP. Both variables are negative with high posterior inclusion probabilities, while standard deviation of black market premium is found to be almost zero with very low posterior probability. As in the case of openness, data evidence is not in favour of the remaining growth theories.

In summary, our BMA exercise shows that economic institutions and macroeconomic stability related to inflation and government expenditures are important determinants of economic growth. Neither openness to international trade nor other theories matter for growth.

6.5.2 Bayes Factors and Hypothesis Testings

In this section we carry out hypothesis tests using the Bayes factors. Different from classical approach, in the Bayesian context hypothesis tests are based on the comparison of two hypothesis, denoted by H_0 and H_1. The posterior probability of each hypothesis shows how much H_0 and H_1 being correct, given data. In this setting, as we noted before, the posterior odds ratio in favour of H_0 relative to H_1 calculated by

$$K_{01} = \frac{p(H_0|y)}{p(H_1|y)} \tag{6.28}$$

where y denotes the sampled data as before. As can be seen in (6.28), the aim of hypothesis testing in the Bayesian context is to provide the statistical evidence in favour of one hypothesis with respect to another.[26] However, the most common measure for hypothesis testing is Bayes factors (see Kass and Raftery (1995) and Wasserman (2000)) and defined as follows

$$B_{01} = \frac{p(H_0|y)}{p(H_1|y)} \div \frac{p(H_0)}{p(H_1)} \tag{6.29}$$

[26] Therefore, different from classical approach, in the Bayesian framework we do not require to accept or reject each of the hypothesis.

Table 6.3: Jeffreys' Criteria for Bayes Factors

Bayes Factor, B_{01}	Evidence in Favour of H_o
$1 < B_{01} < 3.2$	Not worth more than a bare mention
$3.2 < B_{01} < 10$	Substantial
$10 < B_{01} < 100$	Strong
$B_{01} > 100$	Decisive

The Bayes factors in (6.29) show how much the data have changed our prior odds in favour of hypothesis H_0 against hypothesis H_1.

In this setting, we define the hypothesis H_0 as a particular growth theory t being included in the true growth model and the hypothesis H_1 as that theory being excluded in the true growth model. Since we assume that each growth theory is *a priori* equally likely, the Bayes factors, B_{01} is equal to the posterior odds ratio and shows the evidence in favour of that theory. In order to interpret Bayes factors, a criteria is proposed by Jeffreys (1983) in Table 6.3.[27]

In the light of these explanations, we test the data evidence in favour of each theory under the consideration of our BMA application. The Bayes factors, B_{01} for the inclusion of each theory is given in Table 6.4. Together with Jeffreys' criteria, Bayes factors in Table 6.4 show that there is no significant data evidence for the inclusion of openness in the true growth model. However, we find strong data evidence in favour of macroeconomic stability. Similarly, data evidence for institutions to be included in the true model is substantial.

The same analysis can be carried out for individual proxies with the exception of equal priors. For this, we just need to define the

[27]Table 6.3 is adopted from Kass and Raftery (1995) reporting a slight modification of Jeffreys' criteria. In addition, following the standard notation for Bayes factors, we slightly changed the version by Kass and Raftery (1995) such that in our version Bayes factors provide evidence in favour of the hypothesis H_0.

Table 6.4: Bayes Factors for the Inclusion of Growth Theories

Theory classes	Posterior inclusion prob.	Bayes Factors, B_{01}
Institutions	0.902	9.25
Geography	0.398	0.66
Resource Impact	0.118	0.13
Culture	0.083	0.09
Population Heterogeneity	0.110	0.12
War and Unrest	0.024	0.02
Scale Effects	0.023	0.02
Macroeconomic Stability	0.984	61.89
Trade Openness	0.003	0.00

hypothesis H_0 as a particular growth variable being included in the true growth model and hypothesis H_1 as the complement of hypothesis H_0. Table 6.5 reports the Bayes factors for the inclusion of proxy variables. The results show that there is no evidence for the inclusion of openness variables under Jeffrey's criteria. However, we conclude strong evidence in favour of average inflation. Similarly, we find that data evidence for the inclusion of economic institutions and government consumption is substantial.

6.6 Conclusion

In this chapter, we investigate the robustness of the relationship between openness and growth applying Bayesian model averaging technique over the 1960-2000 period in order to account for model uncertainty. We find no evidence that openness is directly and robustly correlated with economic growth in the long run. We further evaluate individual proxies for openness, namely current openness, real openness, fraction of open years based on the Sachs and Warner (1995)

Table 6.5: Bayes Factors for the Inclusion of Additional Growth Variables

Variable	Posterior Inclusion prob.	Bayes Factors, B_{01}
ICRG measure	0.901	4.53
Democracy	0.213	0.14
Absolute Latitude	0.032	0.03
Land Area in Tropics	0.147	0.15
Population in Tropics	0.248	0.29
Landlocked Country Dummy	0.018	0.02
Primary Exports	0.013	0.01
Mineral Production	0.110	0.06
Fraction of Catholics	0.020	0.02
Fraction of Muslims	0.080	0.08
Fraction of Other Religions	0.007	0.01
Fraction of English Speaking	0.004	0.00
Fraction of European Lang. Speaking	0.004	0.00
Ethnic Fragmentation	0.018	0.01
Linguistic Fragmentation	0.029	0.02
Religious Fragmentation	0.075	0.06
War Dummy	0.013	0.01
Number of Revaluations	0.011	0.01
Land Area	0.012	0.01
Labour Force	0.012	0.01
Average Inflation	0.931	10.06
Government Consumption	0.863	4.72
Standard Deviation of BMP	0.038	0.03
Current Openness	0.001	0.00
Real Openness	0.001	0.00
Number of Open Years	0.001	0.00
Trade Policy 1	0.001	0.00
Trade Policy 2	0.000	0.00
Trade Policy 3	0.001	0.00

criteria and weighted averages of tariff rate, non-tariff barriers and the black market premium. However, we find that none is robustly correlated with economic growth. On the other hand, data evidence here indicates that economic institutions and macroeconomic uncertainties relating to inflation and government consumption are key factors in explaining economic growth.

It is possible to say that our findings support the recent related work. For instance, estimating regressions of the levels of income on various measures of openness, institutions and geography, Easterly and Levine (2003) and Rodrik et al. (2004) conclude that institutions have an important effect on the economic growth while geography and openness do not. Differently from these studies, we find that fiscal and monetary policies are also important for economic growth. One reason for this different finding is that our analysis is based on growth regressions, and testing the impact of macroeconomic policies in level regressions may not be appropriate as Rodrik et al. (2004) point out. Compared to other model averaging studies such as those by Fernández et al. (2001a) and by Sala-i-Martin et al. (2004), we conclude that a small number of growth variables is robustly correlated with growth. Obviously one reason for this is differences in data set and time period. Second, differently from these studies, we keep all variables of augmented neoclassical growth model in each possible model in explaining the direct effect of growth variables. Finally and more importantly, our priors over the model space are different than Fernández et al. (2001a) and Sala-i-Martin et al. (2004). A recent study by Durlauf et al. (2007) applies Bayesian model averaging approach, in some ways very similar to that in this chapter, on cross-country growth data. These authors conclude that none of the growth theories is directly and robustly correlated with growth.

6.A Appendix

6.A.1 Descriptions and Sources of Variables used in BMA Application

Augmented Neo-classical Growth Model

Real GDP per capita (RGDPCH) : 1996 international prices, chain series. **Source**: Global Development Network Growth Database (2005) which rely on Heston, Summers and Aten (2002)

Population (TP) : Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. **Source**: The World Bank World Development Indicators.

Labour force (LF) : Labour force or economically active population defined as the total population between ages 15 and 64. **Source**: The World Bank World Development Indicators

Share of labour force (SLF) : Share of labour force in total population. The exact calculation is LF/TP.

Real GDP per worker (PWGDP) : 1996 international prices, chain series. The exact calculation is $PWGDP = RGDPCH*(1/SLF)$.

Growth : Average growth rate of real GDP per worker over the 1960-2000 period. The exact calculation is $log(PWGDP2000/PWGDP1960)$, where PWGDP1960 and PWGDP2000 is the real GDP per worker in 1960 and 2000, respectively. Because of missing variables, for the countries Bahamas, Belize, Haiti, Hungary, Malta, Oman, Puerto Rico, Sierra Leone, Sudan and Tunisia, 1961 values are used instead of 1960 values.

Initial income (PWGDP1960) : Real GDP per worker in 1960. Because of missing variables, for the countries Bahamas, Belize, Haiti, Hungary, Malta, Oman, Puerto Rico, Sierra Leone, Sudan and Tunisia, 1961 values are used instead of 1960 values.

Population growth (n) : Average rate of population growth between 1960 and 2000. The exact calculation is $(1/40) * log(TP2000/TP1960)$, where TP1960 and TP2000 are total population in 1960 and 2000, respectively.

(g+δ) : Sum of exogenous rates of technological process and depreciation over the 1960-2000 period and assumed to be equal to 0.05.

(n+g+δ) : Sum of rates of population growth, technical process and depreciation over the 1960-2000 period.

Investment rate (INV) : Average of Investment share in GDP at constant prices over the 1960-2000 period. The data are averages for Tunisia and Sierra-Leone over 1961-2000 period, for Hungary and Malta 1965-2000 period, for Namibia, Cyprus, Botswana, Mauritania, Haiti, Central African Republic, Guyana and Fiji, over 1960-1999 period instead of 1960-2000 period. **Source**: Heston, Summers and Aten (2002). In order to increase number of observations, data of seven countries are filled up by using gross capital formation data from the World Bank World Development Indicators. These countries are Puerto Rico for 1986-1991 period, Hungary for 1965-69 period, Malta for 1965-1993 period and years 1999, 2000, Sierra Leon for years 1997, 1999 and 2000, Cyprus for 1997-99 period, Angola for 1997-2000 period, for Congo Democratic Republic for 1998-2000 period.

School enrolment rate (SCH) : Average gross rate of secondary school enrolment over the 1960-2000 period. Gross secondary school enrollment ratio is defined as the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of secondary education. For countries Chad, Ethiopia, Portugal, Niger and Mauritania, the variable is calculated over the 1965-2000 period. **Source**: The World Bank World Development Indicators.

Institutions

Economic Institutions (*ICRG* Measure) A measure of economic institutions based on four International Country Risk Guide (ICRG) components of Political Risk Services Group: 1) Investment Profile as a average of three subcomponents namely, contract viability, profits repatriation and payment delays; 2) law and order; 3) corruption; 4) bureaucratic quality. The index is calculated as the equal weighting average of these four categories for the years 1984-2000 (annual observations are calculated as the averages of the monthly indexes). The higher points indicate the greater institutional quality. **Source**: Political Risk Services

Democracy : Institutionalised democracy measure of Polity IV project. The variable is calculated as the average over the 1960-2000 period. The democracy index is constructed from three essential elements: 1) the competitiveness of political participation; 2) the openness and competitiveness of executive recruitment and 3) the constraints on the chief executive. The index ranges between 0 and 10 and the higher points indicate the greater institutionalised democracy in given country. **Source**: Marshall et al. (2005)

Geography

Absolute Latitude : Absolute latitude of country centroid. **Source**: Center for International Development at Harvard University

Land Area in Tropics (TROPICAR) : The proportion of the country's land area in the geographical tropics. **Source**: Center for International Development at Harvard University

Population in Tropics (TROPICPOP) : The fraction of population living within the geographical tropics. **Source**: Center for International Development at Harvard University

Landlocked Country (LANDLOCK) : A dummy variable for landlocked countries, except those in Europe (Andorra, Austria, Belarus, Czech Republic, Hungary, Luxembourg, Liechtenstein, Moldova and Switzerland). **Source:** Gallup et al. (1999) and author's calculation.

Natural Resources

Primary Exports (PX) : The ratio of primary exports to total exports in 1970. **Source**: Sachs and Warner (1997c).

Mineral Production (PGNP) : Share of mineral production in GNP in 1971. **Source**: Sachs and Warner (1997c).

Culture

Fraction of Catholics (Catholics) : The share of the population that belongs to Roman Catholic religion in a given country. **Source**: La Porta et al. (1999).

Fraction of Muslims (Muslims) : The share of the population that belongs to Islamic religion in a given country. **Source**: La Porta et al. (1999).

Fraction of Other Religions (OtherRel.) : The share of the population that belongs to other religions in a given country. The variable is calculated as the residuals from three most widely spread religions in the world namely Roman Catholic, Protestant and Muslims and thus does not include Protestant. **Source**: La Porta et al. (1999).

Fraction Speaking English (ENGLISH) : The fraction of population speaking English as a first language. **Source**: Dollar and Kraay (2003).

Fraction Speaking European Language (EUROPE) : The fraction of population that is able to speak one of the major languages of Western Europe, namely French, German, Portuguese, or Spanish, as a first language. **Source**: Dollar and Kraay (2003) and author's calculation.

Population Heterogeneity

Ethnic Fragmentation (ETHNIC) : Ethnic fragmentation index. The variable shows the probability that any randomly selected two persons of a given country will be from different ethnic groups and ranges between 0 and 1. The higher points indicates the grater ethnic fragmentation. **Source**: Alesina et al. (2003).

Linguistic Fragmentation (LINGUISTIC) : Linguistic fragmentation index. The variable shows the probability that any randomly selected two persons of a given country will be from different linguistic groups and ranges between 0 and 1. The higher points indicates the grater linguistic fragmentation. **Source**: Alesina et al. (2003).

Religious Fragmentation (RELIGIOUS) : Religious fragmentation index. The variable shows the probability that any randomly selected two persons of a given country will be from different religious groups and ranges between 0 and 1. The higher points indicates the grater religious fragmentation. **Source**: Alesina et al. (2003).

War and Unrest

War Dummy (WARDUM) : Dummy variable for war participation between 1960 and 1990. **Source**: Barro and Lee (1994a).

Number of Revolutions (REVOL) : Number of revolutions per year over the period 1960-1999. **Source**: Banks (2001)

Country Size

Land Area (AREA) : Land area in square km. **Source**: The World Bank World Development Indicators (2002, 2006).

Labour Force (LFORCE) : Average labour force or economically active population over the period 1960-2000. **Source**: The World Bank World Development Indicators (2002, 2006).

Macroeconomic Stability

Inflation Rate (INFLATION) : Average inflation rate based on consumer price index over the 1960-2000 period. For some countries missing data are filled using the inflation rate based on GDP deflator. **Source:** The World Bank World Development Indicators (2002, 2006) based on International Monetary Fund, International Financial Statistics and data files.

Government Consumption (GOVCONS) : The ratio of general government final consumption expenditure in GDP. Variable includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation. **Source**: The World Bank World Development Indicators (2002, 2006) based on World Bank national accounts data, and OECD National Accounts data files.

Standard Deviation of BMP (SDBMP) : Standard deviation of black market premium over the period 1960-1999. **Source**: Global Development Network Growth Database (2005).

6.A.2 List of Countries in BMA Application

Algeria	Ghana	Norway
Argentina	Greece	Pakistan
Austria	Guatemala	Paraguay
Bangladesh	Guyana	Peru
Belgium	India	Philippines
Bolivia	Indonesia	Portugal
Brazil	Iran	Senegal
Burkina Faso	Ireland	Sierra Leone
Cameroon	Italy	Spain
Canada	Jamaica	Sri Lanka
Chile	Japan	Sweden
China	Jordan	Switzerland
Colombia	Kenya	Syria
Congo, Dem. Rep.	Korea, Republic of	Thailand
Congo, Republic of	Madagascar	Trinidad &Tobago
Costa Rica	Malawi	Tunisia
Cyprus	Malaysia	Turkey
Denmark	Mexico	United Kingdom
Ecuador	Morocco	United States
Egypt	Netherlands	Uruguay
Finland	Nicaragua	Venezuela
France	Nigeria	Zambia

Table 6.6: Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
Benchmark Model				
GROWTH	0.6823	0.6114	-1.3525	2.0918
log of Initial Income	8.4527	0.8304	6.6964	10.0252
log $(n_i + g + \delta)$	-2.6921	0.1482	-2.9388	-2.3655
log INV	-1.8934	0.5199	-3.5589	-1.1426
log SCH	-0.7343	0.6579	-2.8062	0.1363
Institutions				
ICRG Measure	3.9638	1.1306	1.3983	6.0453
DEMOCRACY	4.9384	3.7555	0	10
Geography				
ALATITUDE	26.8072	18.4467	0.4221	67.4700
TROPICAR	0.4757	0.4771	0	1
TROPICPOP	0.4626	0.4851	0	1
LANDLOCK	0.0909	0.2897	0	1
Natural Resources				
PX	0.6992	0.2876	0.07	1
PGNP	0.0635	0.1017	0	0.51
Culture				
CATHOLIC	0.3852	0.3933	0	0.9690
MUSLIM	0.2109	0.3498	0	0.9940
OTHERREL.	0.2649	0.2964	0.004	0.9850
ENGLISH	0.0900	0.2645	0	0.9740
EUROPEAN	0.2377	0.3807	0	1.0040
Population Heterogeneity				
ETHNIC	0.4350	0.2775	0.0020	0.8791
LANGUAGE	0.3451	0.3018	0.0021	0.8898

Continued on Next Page...

Table 6.6 – *Continued*

RELIGION	0.3986	0.2490	0.0035	0.8241
War and Unrest				
WARDUM	0.3939	0.4924	0	1
REVOL	0.1706	0.1874	0	0.825
Country Size				
log AREA	12.6909	1.6067	8.5429	16.0484
log LFORCE	15.9509	1.5065	12.9059	20.2160
Macroeconomic Stability				
INFLATION	0.5492	1.5069	0.034	8.864
GOVCONS	0.1416	0.0426	0.060	0.249
STDEVBMP	223.8899	1062.4580	0	8339.58
Trade Openness				
COPEN	-0.0106	0.2148	-0.3797	0.7102
ROPEN	-0.0075	0.1836	-0.3179	0.5407
OPENYEARS	0.5096	0.3924	0	1
POLICY1	-0.0800	0.0765	-0.3978	-0.0110
POLICY2	-0.0899	0.0813	-0.4942	-0.0116
POLICY3	-0.0754	0.0643	-0.3666	-0.0076

Note: Data cover the only 66 countries subject to BMA application.

Chapter 7

Conclusion

In this dissertation, we empirically investigated the relationship between trade openness and economic growth for a cross-section of countries over the period 1960-2000. To do this, we firstly tested the augmented neoclassical growth model as a benchmark specification. Our findings showed that this model explains a considerable part of variation in growth and thus appears appropriate as a baseline growth model. Then, employing various openness measures we empirically examined the openness-growth relation. Two strategies were carried out in empirical investigation. First, in the framework of augmented neoclassical growth model, we tested a large number of openness measures suggested in the literature and concluded that most of them were positively and significantly correlated with growth. However, in some cases this result was driven by a few outlying countries. More importantly, we found that existing openness variables are very sensitive to the inclusion of other growth determinants into the baseline growth model. To show this, we examined the impact of institutions, geography, ethnolinguistic fractionalization and fiscal policies as well as trade openness and other variables of augmented neoclassical growth model. Our findings indicate that openness measures become insignificant whilst other variables remain significant with the expected signs.

The second strategy we took was Bayesian model averaging. By integrating model uncertainty into subsequent statistical inference, this method serves as a useful robustness check on the determinants of cross-country growth differences. We classified a wide range of different growth theories and their proxies systematically and concluded that economic institutions, the average inflation rate and government consumption were directly and robustly correlated with growth. Neither openness nor the remaining growth theories were found to be robustly associated with growth.

In sum, in contrast to many previous cross-country growth studies, this dissertation does not support the proposition that openness has a direct robust relationship with economic growth. In the light of data evidence here, one may conclude that trade openness does not matter for economic growth in the long run. However, it may be more reasonable to conclude that, without better institutions and sound and stable fiscal and monetary polices, openness to international trade will not guarantee economic growth. This is also the main policy suggestion of this dissertation.

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