CHAPTER 3

EMPIRICAL STUDIES OF CROSS COUNTRY GROWTH EXPERIENCES
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EMPIRICAL ANALYSIS OF CROSS COUNTRY GROWTH EXPERIENCE

In the last chapter we reviewed the theoretical literature on growth economics, stressing on some of the recent contribution in this area. In this chapter, we shall deal with the empirical literature. Since our own empirical research is based on cross country analysis, we shall restrict the scope of this review to only a part of the empirical literature on growth, which deals with cross country studies.

The use of cross-country regressions in empirical studies of growth is not a new practice. However, for long, the availability of data for a large number of countries was limited, restricting the scope of such studies. Recently though, exhaustive data sources were made available, giving comparable real national income and other economic variables for a large number of countries over a significant period of time. The PENN World Tables, prepared by Summers and Heston, and the World Bank’s World Tables are good examples of such data sources. The availability of these data sets has resulted in a large number of cross-country studies of growth. This has thrown up two different issues and most of these studies focus on either of these two issues. The first of these is the issue of convergence of per capita outputs; do poorer countries grow faster than richer ones? The second issue is the identification of the sources of economic growth. In the next few sections, we shall review some of
these studies. The next two sections deal with the issue of convergence. This will be followed up by a section that reviews the literature on the sources of economic growth. In the last two sections, we shall deal with the issues of robustness of the explanatory variables and the possibility of reverse causality.

**Convergence: Absolute Convergence**

The idea of absolute convergence of per capita output levels across countries has a long and illustrious tradition among economic historians. It was reflected in Veblen's writings on the penalties of being an industrial leader. Later on, Gerschenkron wrote in the same vein giving his views on the advantages of relative backwardness. In recent times, this idea has been established as an important aspect of the Neoclassical Growth model. According to the Solow model, the process of capital accumulation involves a continuous fall in the per capita growth rate due to the falling marginal productivity of capital, until in the long run, it is equal to the rate of labour augmenting technical progress. The transitional time path of per capita growth will definitely depend on the savings ratio, but the latter has no effect on the long run steady state growth rate, which is determined by the rate of labour augmenting technical progress. How can this theory be interpreted in a multi-country case? To do this, it may be noted that in the Solow framework, technical progress is in the nature of a free good that falls like manna from heaven. If this is true then it might be assumed that technological advances are costless to acquire, and so all economies must have the same rate of technical
progress. This implies that the long run (steady state) rate of growth of all economies is the same. Also, the Neoclassical framework assumes that savings ratios are determined by an economy's tastes and preferences, and since they are exogenous to the model, in a multiple economy case, all economies may be assumed to have the same savings ratios. Since the savings ratios and rate of technical progress is the same for all these economies, it follows that they are all moving along the same time path, with continuously diminishing rates of per capita growth, towards the steady state. Since growth rates are continuously diminishing, the above scenario implies that the richer countries, which are nearer to the steady state, grow at a slower rate compared to the poorer ones. Poorer countries, by growing at a comparatively faster rate, have a tendency to catch up with the richer countries and thus there is a convergence of per capita output levels of economies.

Recent empirical evidence, based on a cross section of countries, has proved to be inconsistent with the concept of absolute convergence.\(^1\) Baumol (1986) is one of the recent attempts to look at this issue, using the Summers and Heston Data. The concept of absolute convergence implies that there should be an inverse relationship between initial per capita output levels and subsequent rates of growth of per capita output (i.e., relatively richer countries should be growing at a slower rate). In his study, Baumol plots the 1950-80 real growth rates of GDP per capita against the per capita output level for 1950, for 72

\(^1\)Patel (1964) is an earlier paper that dealt with this issue.
countries. His findings are that the scatter points form no tight relationship and show no negatively sloping pattern. In fact, a regression yields a slightly positive slope as some of the poorest countries grow most slowly, rather than at a faster rate, compared to the richer countries. Another exercise that is quite similar to Baumol's is Barro (1991). Barro uses data from Summers and Heston (1988) for a group of 98 countries over the period 1960 to 1985. He finds that the average growth rate of per capita real gross domestic product, from 1960 to 1985, is not significantly related to the 1960 value of real per capita GDP; the correlation coefficient is 0.09. In Barro and Sala-i-Martin (1992), the same result is presented with the help of a regression analysis. The results show that there is a tendency for rich countries to grow as fast as the poor ones. Summers, Kravis and Heston (1984) prove the failure of absolute convergence in yet another way. This study is based on a heterogeneous group of economies consisting of subgroups representing industrialised countries, centrally planned economies, middle income economies and low-income economies. Summers, Kravis and Heston construct Gini coefficients of per capita income by decades, for these subgroups separately and for the group together. The period covered is 1950 to 1980. For the set of industrialised countries, the Gini coefficient falls from 0.302 to 0.129 over the decades - a sharp drop in inequality. For the centrally planned economies, the drop is much smaller, from 0.381 to 0.301. The middle income group exhibits an even smaller decline, from 0.269 to 0.258. The low-income economies, on the other hand, showed a rise over the period, from 0.103 to 0.112. However, for the group as a whole, the coefficient remained almost the same, changing from
0.493 to 0.498. This implies that for a heterogeneous group of countries, there is no significant evidence in favour of absolute convergence of per capita output levels.

The absence of statistical evidence from cross-country analysis in favour of absolute convergence has been an important motivating factor behind the development of the Endogenous Growth literature. As a result, two different groups of theories have come up that try to explain this evidence. According to the first group, the cross-country evidence indicates that growth rates do not diminish with the accumulation of capital and hence rich economies, on an average, grow as fast as poor ones. They try to explain this in terms of constant returns to some broad definition of capital, giving rise to the Endogenous Growth theories that we have reviewed in the last chapter. The second group tries to explain the empirical evidence in terms of what they call conditional convergence. We shall now discuss this explanation.

Convergence: Conditional Convergence

The inconsistency between empirical evidence and the concept of absolute convergence has robbed this concept of its credibility. It also puts a question mark on the Solow model for its capacity to explain the process of development. In response to this, followers of the Solow model have pointed out that it is not right to conclude that the Solow model implies absolute convergence. According to them, this model actually implies conditional
convergence. In order to explain this, these economists point out that the rate of technical progress may be exogenous in the Solow model but this does not imply that all countries have the same rate of technical progress. According to them, these countries are different in terms of important economic variables like the stock of Human Capital etc. that generate different rates of technical progress. However, since marginal productivity of capital is diminishing, convergence is still applicable within economies that have similar rates of technical progress. Thus convergence is conditional (or relative) to the rate of technical progress, i.e., it will be found only within a group with similar rates of technical progress.

Barro (1991), Barro & Sala-i-Martin (1992) and Barro and Sala-i-Martin (1995) covers an elaborate exercise that tries to test the concept of conditional convergence. Barro and Sala-i-martin (henceforth BS) tries to test this hypothesis using Summers and Heston (1988) data for a group of 98 countries for the period 1960 to 1985. Now, in order to test for conditional convergence, the variables that are responsible for differences in the rate of (labour augmenting) technical progress have to be controlled. In their series of studies, (Barro (1991) and Barro and Sala-i-Martin (1992)) these variables are assumed to be (a) primary and secondary school enrollment rates in 1960, (b) the average government consumption expenditure (exclusive of defense and education) to GDP ratio from 1970 to 1985, (c) proxies for political stability and (d) a proxy for market distortions. Though the exact relationship between the last three variables and the rate of technical progress is not specified, Barro (1991)
explains the inclusion of Human Capital (here school enrollment ratios) by pointing out that in Romer (1990) (described in previous chapter) higher levels of initial Human Capital stocks can generate higher rates of innovations and growth. In their studies, BS runs regressions with the rate of growth of per capita output, over 1960-1985, as the dependent variable and the log of per capita output in 1960, together with the four variables mentioned above, as the independent variables. From these regressions, BS find that there is a significant negative partial relation between growth rates and initial levels of per capita output, confirming the conditional convergence hypothesis. In Barro and Sala-i-Martin (1995), they add the investment ratio (i.e., the ex post savings ratio) to the list of independent variables. They find that the investment ratio has a significantly positive partial relation with growth rates while per capita output continues to have a significantly negative partial relation with the same. From these findings BS claim that conditional convergence is empirically proved.

There are at least two problems with the explanation of the cross-country evidence in terms of the conditional convergence approach. The first problem is that, the regression analysis has included some variables (e.g., proxies for political stability, market distortions, etc) without giving any theoretical analysis of how they influence the long run growth rate. This lack of theoretical backup makes the approach rather suspect from the methodological point of view. The second problem is that, the idea of conditional convergence implies that the variables that influence the long run growth rate must
themselves be uncorrelated with per capita income. However, some of these variables (like investment ratios or school enrollment rates) are highly likely to be correlated to the per capita income. In such a case, what is being described as conditional convergence may actually be steady growth (at a constant rate) or even divergent growth rates.

**Sources of Economic Growth: Identification of Significant Variables**

The convergence hypothesis implies that a lower level of per capita income give rise to comparatively higher growth rates. This however, does not rule out the possibility that there are other variables that have significant influence on the rate of growth of per capita output as well. As we have mentioned earlier, a number of cross country studies try to identify these variables.

Of all the probable sources, the investment ratio has emerged as the strongest candidate and has been found to be significant in a number of studies. We have seen in the last section that Barro and Sala-i-Martin (1995) is one of the studies that have found this to be true. Another important work in this area is DeLong and Summers (1991) (henceforth DS). In their study, DS deals with a specific kind of investment, namely equipment investment. According to DS, equipment investment is an important source of growth as it leads to industrialisation, a process that exhibits significant returns to scale. Using data from the United Nations comparison project and the PENN World Table, they
find that machinery and equipment investment has a strong association with growth. Over the period 1960-1985, each extra percentage of GDP invested in equipment is associated with an increase in GDP growth of one third of a percentage point per year. They also concluded from their analysis that causality runs from equipment investment to growth.

Other sources of growth have also been studied. Of particular significance were growth accounting specifications derived from production functions which added the growth in labour force to the growth in capital stock, as a source of output growth. More recent investigation have incorporated school enrollment ratios measuring Human Capital; shares of government consumption in GDP; fiscal and monetary policy indicators and dozens of other variables including several alternative measures of outward orientation. This last variable brings us to the effect of trade on growth.

One of the oldest ideas in economics, going back to Adam Smith, is that international trade is an engine of growth. Like all other possible sources of growth mentioned previously, this one too has been put to test in some cross-country studies. Using data from individual country studies, Krueger (1978) econometrically tested the hypothesis that a more liberalised trade sector has a positive effect on aggregate growth, both through an increase in efficiency resulting from the liberalised regime and through an increase in export growth. To do this, she ran multivariate regressions where the output growth is the dependent variable while an index of export growth and dummy variables for
the extent of trade liberalisation are independent variables. The extent of trade liberalisation is measured in terms of quantitative restrictions imposed on imports and the concomitant foreign exchange controls. The results of the regression showed that the coefficient of the export growth index was of the right sign and statistically significant but the coefficients of the dummy variables were not significant. From this she concluded that liberalization has a positive effect on growth through an increase in the growth rates of exports but there is no evidence to show that liberalisation has any effect on growth through increases in efficiency. Balassa (1982) is another attempt that tries to relate trade policy orientation and growth performance. He starts by criticising Krueger for concentrating on quantitative restrictions in her classification of trade regimes, while ignoring the protective effects of tariffs. In his own study, based on a group of eleven countries, Balassa assumed that the growth rate of exports itself was a proxy for policy orientation. His study shows that output growth is positively correlated with export growth in both primary as well as manufacturing items. From this he concludes that trade orientation has been an important factor contributing to inter country differences in growth.

One of the problems of testing the effect of openness on growth is the construction of proper classification of alternative trade regimes. Edward, (1992) recognises this problem and bases his analysis on the Leamer indices (Leamer 1988) which he claims are free from the above problems. On the basis of OLS regression using the Leamer indices, Edwards finds that there is a strong evidence that a robust relationship exists between trade orientation and growth.
However, as Bhattacharya (1996) points out, the problem with Leamer indices is that though they are available only for the year 1982, they must be assumed to represent the whole period (1970 to 1982). Another study by Harrison (1996) finds that the relationship between openness and growth cannot be established in cross section regressions that use averages of data over long periods as done by Edwards. The empirical specification of Harrison’s study assumes a production function that includes physical and human capital, labour, arable land, population and technology as the factors of production. Openness and other policy measures are assumed to affect output and growth through their effect on technology and its change. Seven different proxies of openness are considered in the regression exercise. Harrison first runs cross sectional regressions using twenty seven-year averages of the variables and finds that, controlling for the other inputs, only one of the proxies of openness (black market premium) is significant in explaining growth. She points out that this is because most developing countries have experienced large swings in commercial and exchange rates policies in the last 30 years, which would render any proxies for openness essentially meaningless. This would apply to the Leamer indices as well, and Harrison explicitly rejects these indices. In order to solve this problem, she uses panel estimation methods using annual data (pooling cross section and time series) and runs regressions on the basis of the Fixed Effects model. Here she finds more positive results, as three of the proxies are significant at 5% level and one at 10%. From this she concludes that openness is a significant factor explaining growth.
Sources of Economic Growth: The Robustness of Variables

Till date, numerous studies have tried to establish linkages between long run average growth rates and a variety of economic, political, sociological and even geographical factors. From these studies, more than sixty variables have been found to be statistically significant. In order to assess the robustness of these numerous results, Levine and Renelt (1992) (henceforth LR) carried out a sensitivity analysis of these variables. The idea behind this exercise is that most studies concentrate on a few significant variables in their analysis, thus ignoring other variables that play an important role. To correct this anomaly, LR defines only those variables as robust, which remain statistically significant and of a theoretically predicted sign, even when the conditioning set of variables in the regression change. To test for this robustness, LR uses the Extreme Bounds Test. The Extreme Bounds Tests work as follows. Suppose there is a pool of N variables that have been previously identified to be related to growth, and one is interested in finding out whether a particular variable Z is robust. One would estimate regression of the form

\[ \chi = \alpha_j + \beta_1 Y + \beta_2 Z + \beta_3 X_j + \varepsilon \]  

(1)

Here \( \chi \) is the vector of rates of economic growth, \( Y \) is a vector of some variables other than \( Z \) that is included in the regressions, \( Z \) is the variable of interest and \( X_j \) is a vector of (upto) three variables taken from the pool of \( N \) variables available. One needs to estimate this regression, or model, for all the possible combinations of \( X_j \), taken from \( N \). Note that for each regression, the
vector $X_j$ is different but the vector $Y$ remains the same. For each model $j$, there is an estimate $\beta_{2j}$ and a standard deviation, $\delta_{2j}$. The lower extreme bound is defined to be the lowest value of $\beta_{2j} - 2\delta_{2j}$ and the upper extreme bound is defined to be the largest value of $\beta_{2j} + 2\delta_{2j}$. According to the Extreme Bounds Test, if the lower extreme bound for $Z$ is negative and the upper extreme bound is positive, then variable $Z$ is not robust.

Using this Extreme Bounds Test to examine the robustness of the numerous variables that were previously found to be significant sources of growth, LR finds that,

a) There exists a positive and robust correlation between the share of investment in GDP and average growth rates.

b) There exists a positive and robust correlation between the share of investment in GDP and the average share of trade in GDP.

c) A large variety of trade policy variables were not robustly correlated with growth, when the model included the investment share.

d) None of the broad array of fiscal indicators that were studied was robustly correlated with growth or the investment share.

e) A large assortment of other economic and political indicators was also not robustly correlated with growth.

In a recent article, Sala-i-Martin (1997) has however challenged LR's use of the Extreme Bounds Test as a measure of robustness of a variable and put forward an alternative test to measure the robustness of a variable. Sala-i-
Martin starts by pointing out that in the Extreme Bounds framework, even if there is one single regression for which the sign of the coefficient $\beta_2$ changes or becomes insignificant, then the variable is non-robust. Thus, if the distribution of the estimators of $\beta_2$ has some positive and some negative value, then at least one regression can always be found in which the coefficient changes signs. This according to Sala-i-Martin makes the test too strong. Alternatively, he looks for variables whose estimators are distributed in such a way that (even if they have both positive and negative values) at least 95 per cent of the density function lies to the right of zero. Using this alternative test, Sala-i-Martin finds that 22 variables, including political, religious and economic ones, are significant.

The question of robustness of the OLS estimation results remains unresolved, as the two approaches described above show that there is an element of subjectivity in the choice of a test for robustness. Clearly, the easier the test one uses, the more will be the number of variables that pass such a test. There has been another line of criticism of the OLS approach, though, that has been more widely accepted. This is related to the direction of causality between economic variables. According to this criticism, regression analysis can only test for the degree of association between two variables and not the direction of causality. Thus even if some variables are found to be significant using regression analysis, it is difficult to say which is the cause and which the effect. This issue of causality has come up in the cross-country literature mainly in the context of the investment-growth relationship and we shall discuss this in the next section.
Sources of Economic Growth: The Investment Growth Relationship and the Direction of Causality

All the studies reviewed so far seem to indicate that there exists a strong and robust relationship between investment ratios and growth rates. This seems to indicate that the rate of capital formation determines the rate of a country’s economic growth. Some recent studies have however challenged this view by proving the existence of reverse causality between growth and the investment ratios. Barro and Sala-i-Martin (1995) (Henceforth BS) is one such study that tries to examine the relationship between growth and investment ratios. In their study, two separate sets of regressions are run, with per capita growth rates being regressed on the current investment ratio (as well as some other variables) in the first one, and on the lagged (previous periods) investment ratios (with the other variables remaining the same) in the second. The logic behind this exercise is that the current investment ratios may be influenced by (current) growth rates and hence they are not exogenous variables. In such a case, an instrument variable is needed as the independent variable in the regression, in place of the variable under suspicion, for an unbiased estimate. This instrument variable should be correlated to the current investment ratio but should be exogenous to (current) growth rates. BS claim that lagged investment ratios can be used as an instrument variable as it fulfills the above properties. From the regressions, it is found that the estimated coefficients of investment ratios are significant in the first but not in the second. From this, BS concludes that positive association between growth and investment in the first regression
reflects reverse causation from growth to investment, rather than the other way round.

Blomstrom, Lipsey and Zejan (1996) (Henceforth BLZ) is another study which tries to determine the direction of causality between capital formation ratios and rates of growth. The first exercise that they carry out is to run regressions on five-year growth rates of per capita GDP, with preceding, current and succeeding periods fixed capital formation rates. They find that the coefficients, t-statistics and R-squares all increase as one moves from the preceding period to the current period to the succeeding period. From this, they suspect that the effect of growth on subsequent capital formation is stronger than the effect of capital formation on subsequent growth. Next, BLZ apply the Granger-Sims causality tests to carry out a more formal analysis of the direction of causality between capital formation and growth. The results of these tests suggest that growth causes subsequent capital formation rather than the other way round.

Surprisingly, the empirical studies showing reverse causality between growth and the investment ratio do not offer any theoretical explanation for their results. It is not clear from their studies why growth rates cause subsequent investments rather than the other way round. Clearly, this makes their analysis incomplete and questionable.
A brief summary of the chapter

Our review of some of the empirical literature dealing with cross-country studies of growth is now complete. These studies have focused broadly on two issues, (a) convergence of per capita output across countries and (b) identification of the sources of economic growth. In the context of the first issue, we have dealt with the concepts of absolute convergence and conditional convergence. Moving on to the next issue, we have discussed the process through which numerous variables have been proved to be significant sources of growth. We have also looked at the question of robustness of these variables. Finally, studies addressing the question of the direction of causality, especially in the context of the investment growth relationship, have been described.