Chapter: 3

Growth - Saving Causality in India

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The close relationship between the saving rate of the economy and the growth rate is a stylised feature which has been well documented in a number of empirical investigations. In fact, it is one of the few, if not the only, relationship which cannot be erased when other possible growth influences are conditioned on. The close connection between saving and growth has been a key finding in the empirical saving literature.

Saving and income are closely associated in the sense that the rate of saving tends to be higher in countries with higher per-capita income, and vice-versa [Schmidt-Hebbel et. al, 1996]. In less-developed economies, as the per-capita income is not uniform the rate of saving also varies considerably.

The relationship between saving and income can be viewed in two different ways. One point of view is that economic growth influences savings. Economic growth increases the propensity to save which leads to increase in the aggregate savings. Income growth enhances the volume of savings by affecting the marginal and average propensities to save. Income is the most important determinant of saving as hypothesised by Keynes. Income is the epitome of economic growth, influencing the saving behaviour of households.

In the other view, saving seems to be causing growth. Saving rate is a major factor influencing economic growth and development. The significance of savings as a source of capital accumulation was recognised as early as 1776 by Adam Smith in his 'Wealth of Nations.' He stated that the productive capital can be increased only if economic resources could be diverted from the production of those goods and services which are consumed to the production of producer's capital. In other words, it means that a country's progress depends upon its ability to save and invest in productive enterprises.

Saving gives rise to capital formation or investment, known to be the engine of growth, in the sense that growth in capital formation is directly proportional to that part of additional output which is not immediately consumed but saved for future utilisation. Savings are invested, which through the operation of investment multiplier transforms into capital formation, and consequentially into economic growth. The greater the investment of savings, the more will be employment and production, resulting into multiple increases in capital accumulation and GDP growth.

Both theory and logic confirm that just as economic growth leads to savings, savings may lead to economic growth. This idea was substantiated by Lahiri's [1989] study which undertook extensive research on the subject of savings, highlighting the close nexus between savings, capital accumulation and growth. The interdependence of growth and saving is at the root of theories of self-generating growth and development, the "virtuous circle of development".

Although the long-run behaviour of saving and growth in an economy may be closely related, the close association does not establish causation between the two. The causation is important, not just for understanding the process, but for the design of policy. If saving is merely the passive adjunct to growth or to investment, then policies for growth should presumably be directed at investment [in people, plant or equipment] or at the efficiency of such investment, with saving allowed to look after itself. But if saving is the prime mover, the focus should be on framing saving incentive policies.

What has been the growth-saving experience in India? Is it growth that causes saving or saving which leads to growth? This chapter studies the growth-saving causality in India.

The present chapter has been divided into two parts, covering the theoretical and empirical aspects respectively. In the first part, *Section 3.1* brings out the theory and the relationship between saving and growth. The study discusses the growth-saving behaviour in India and carefully examines the peculiar features of the 'high saving and low growth' puzzle in India. This is followed by a comprehensive review of literature on the issue of causality between saving and economic growth in *Section*

3.2. The second part of the chapter covers the empirical aspects. *Section 3.3* presents a review of the methodological issues and techniques. *Section 3.4* gives the methodology used in the chapter. It includes the statement of the problem, specification of variables, steps involved in causality test and time period and sources of data used in the study. *Section 3.5* presents the empirical results followed by conclusions and observations in *Section 3.6.*

3.1 Growth - Saving Experience in India

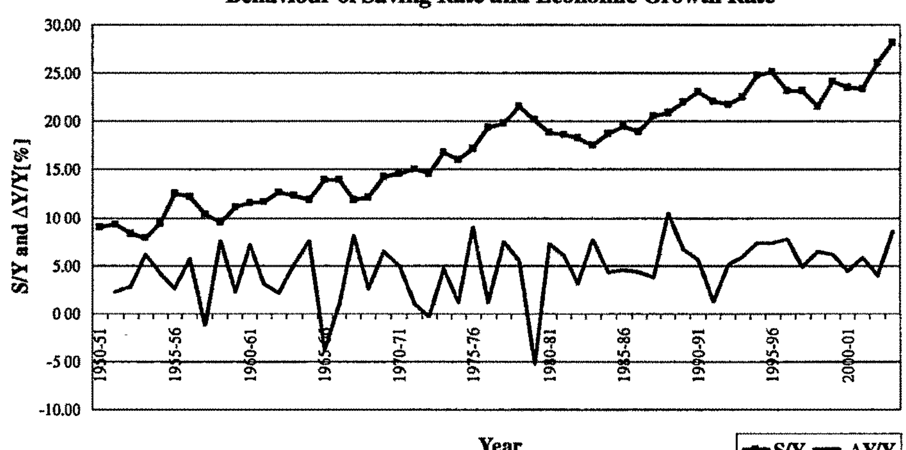
The growth in Indian savings has been quite impressive as discussed in the earlier chapter. The economic growth rate has however not matched the high saving rates in India. The Indian economy has been known to be characterised by the peculiar feature of high saving and low growth puzzle.

In order to understand the underlying economics of saving and growth and to find out the reasons for the riddle of high saving and low growth in India, this section undertakes a detailed study on the growth-saving behaviour in India over the post-planning era and explores the causes for the high saving-low growth phenomenon in the country.

a. Growth-Saving Behaviour

Chart 1 exhibits the behaviour of saving rate [GDS/GDP rate] and economic growth rate [real GDP growth rate] in India in the planned economic era.

Chart: 1 **Behaviour of Saving Rate and Economic Growth Rate**



Note: S/Y refers to nominal gross domestic saving rate [GDS/GDP] in the economy and ΔY/Y stands for economic growth rate [real GDP growth rate]. GDP is measured at factor cost [1993-94 prices].

Some important observations that can be made from Chart 1 above are:

i. Saving rates have been higher than growth rates throughout the planned economic era.

ii. The gap between saving rate and growth rate has widened over time.

iii. Both saving rate and growth rate exhibit an upward trend with many fluctuations over time. The fluctuations are more prominent in case of growth rate.

iv. During the five decades [1950-51 to 2003-04], saving rate has scaled from a low of 8.2 percent in 1952-53 to a high of 28.1 percent in 2003-04. Growth rate has ranged from a bottom of -5.2 percent in 1979-80 to a maximum of 10.5 percent in 1988-89, during the same period.

The decadal behaviour of saving rate and real GDP growth rate is shown in Table 1.

Table : 1 Saving and Growth Relationship

	Time Period	*Saving Rate*	*Real GDP growth rate*
1.	**1950-51 to 1959-60**	9.97	3.59
2.	**1960-61 to 1969-70**	12.65	3.95
3.	**1970-71 to 1979-80**	17.50	2.95
4.	**1980-81 to 1989-90**	19.39	5.81
5.	**1990-91 to 1999-00**	23.15	5.77
6.	**2000-01 to 2003-04**	25.27	5.8
7.	**1950-51 to 2003-04**	17.18	4.52

Note: The gross domestic product is measured at factor cost [1993-94 prices].

The decadal behaviour of saving rates and real GDP growth rates are presented in Table 1 below. Saving rate has consistently increased from an average of 9.97 percent in the 1950s to an average of 25.27 percent in the early 2000s. The decadal growth rates have however experienced fluctuations. A rise in saving rate from almost 10.0 percent in the 1950s to over 12.0 percent in the 1960s is accompanied by a negligible rise in growth rate from 3.59 percent to 3.95 percent during the same period. The rise in saving rate was most in the 1970s by over 5.0 percent from the previous decade, reaching 17.5 percent. During this decade, the growth rate declined to 2.95 percent. In the 1980s, although saving rate increased, the growth in saving rate was only 11.0 percent whereas the growth rate had doubled from 2.95 percent in the 1970s to 5.81 percent in 1980s. After the eighties, the decadal growth rates stagnated through the 1990s and 2000s. In the 1990s and early 2000s, when saving rate increased substantially, the growth rate had stagnated at around 5.8 percent.

In order to observe the behaviour of saving [GDS] and nominal national income [GDP at current market prices] in the post-planning period, two charts have been presented below. Chart 2 shows the behaviour of saving and national income over the period 1950-51 to 1975-76 and Chart 3 shows the saving-national income behaviour for the period 1976-77 to 2003-04.

Chart: 2 **Behaviour of Saving and Income: 1950-1975**

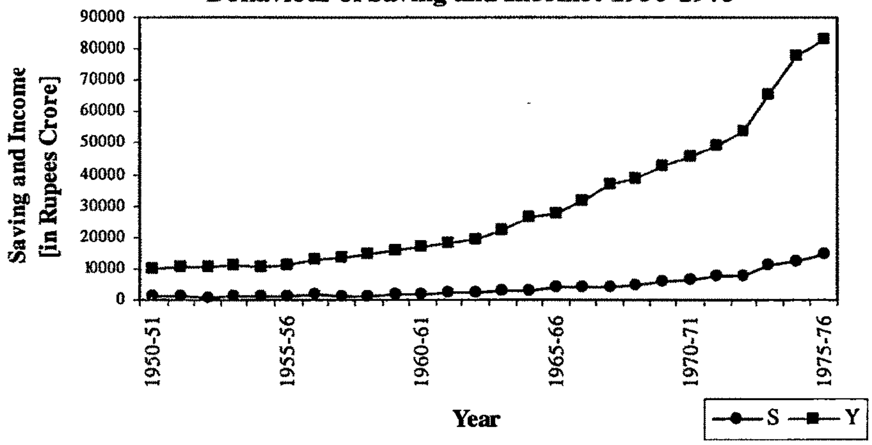
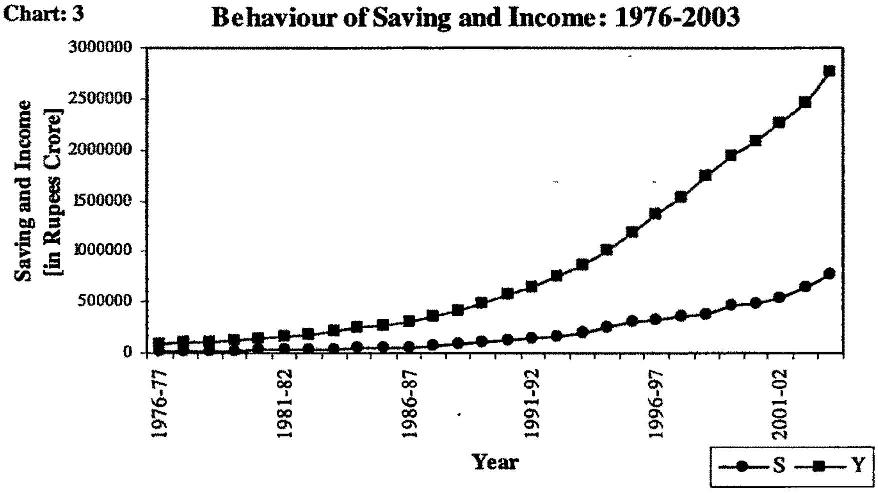


Chart: 3 **Behaviour of Saving and Income: 1976-2003**



Note: S refers to nominal gross domestic savings [GDS] in the economy and Y stands for nominal national income [GDP at current market prices].

The following observations have been made from the above charts:

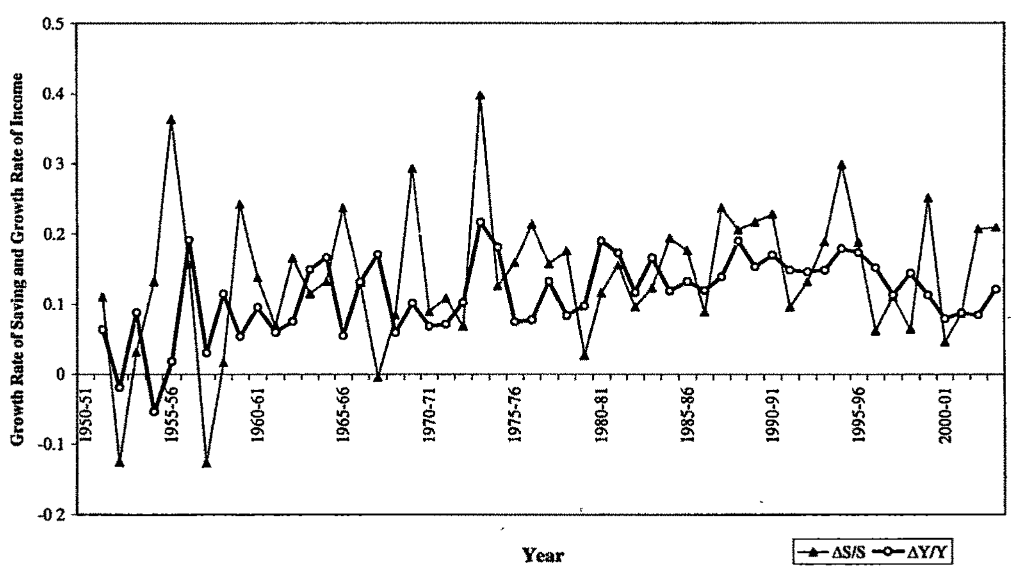
i. Both savings and national income witnessed an upward rising trend throughout the planning period.

ii. Savings have remained below the level of national income in the country.

iii. There has been a widening gap between savings and national income in the country. The rise in savings is prominent in the post-reform period.

Chart 4 below shows the behaviour of growth rate of saving [ΔGDS/GDS] and growth rate of nominal national income [ΔGDP/GDP] in the planned economic period.

Chart: 4 **Behaviour of Growth Rate of Saving and Growth Rate of Income**



Note: ΔS/S refers to growth rate of nominal gross domestic savings [growth rate of GDS] in the economy and ΔY/Y stands for growth rate of nominal national income [growth rate of GDP at current market prices].

The following observations can be made from the above chart:

i. There have been high fluctuations in the growth rates of saving and national income. The growth rate of saving has been fluctuating with greater amplitude.

ii. Overall, the growth rate of saving has been higher than the growth rate of income. For most part of the planning period, a rise in growth rate of saving is accompanied with a rise in the growth rate of national income.

b. <u>High Saving and Low Growth Puzzle</u>

The riddle of 'high saving and low growth' in India has attracted much attention from researchers and economists. Studies by Shetty and Menon [1980] and Rakshit [1982] point towards the puzzling behaviour of saving and growth variables in India, particularly in the second half of seventies. The rate of economic growth during this period was woefully below what the high rates of savings and investment would lead one to expect. Even the Planning Commission, baffled by the size of domestic saving, wrote: *"It is apparent that the country has achieved a high saving rate despite its low per capita income. In fact our saving rate is comparable to the rate in middle-income and even some high-income industrialised countries."*

Growth models by Solow [1956] as well as the endogenous growth model by Romer [1987] predict that 'more saving generates more growth'. According to the Solowian model, high saving leads to higher per capita income in steady state and higher growth rate in the transitional trajectory, while in the endogenous growth model, higher saving leads to a permanently higher rate of growth. Nevertheless, if higher saving does not matter per se for growth, then we may be able to find an explanation for the Indian puzzle of 'high saving and low growth'.

Some of the important explanations given in the literature for high savings and low growth phenomenon in India are as follows:

i. Investment Multiplier
ii. Low Productivity
iii. Estimation Problems
iv. Low Investment Demand
v. Low Capacity Utilization
vi. Structural Factors

i. ***Investment Multiplier***

Savings are invested, which through the role of financial markets and institutions, and the operation of investment multiplier gets converted into capital formation resulting into growth. Hence, any change in saving would cause a proportionate change in investment. On this basis, an increase in saving should atleast lead to a proportionate increase in income or growth. However, this is not so. Despite the high investment of savings, growth is low. Perhaps the problem lies with the investment multiplier. Also, it could possibly be the lack of efficiency in investment of savings. Therefore, even sufficient savings fail to generate higher income.

Moreover, the public sector which plays a dominant role in the Indian economy has been giving a staggering performance. This sector has immensely contributed towards a low value of investment multiplier and thereby to a low economic growth. The government has been involved in all kinds of production activities beyond its conventional confines of public utilities and infrastructure, leading to serious budget deficits and pulling down economic growth. The role of the government in investment invites severe criticism from economists like Bhagwati [1993], Muhleisen [1997] and Ray and Bose [1997].

ii. ***Low Productivity***

The weak growth performance reflects, not a disappointing saving performance but rather a disappointing productivity performance. The misallocation of savings is more predominant in the infrastructure segment. Lack of proper infrastructural facilities and deterioration in the existing conditions has become a major obstacle to growth.

The overall efficiency of the economy has been further impaired due to extensive bureaucratic controls over production, investment and trade, and inward looking trade and foreign investment policies.

Increase in the incremental capital-output ratio well explains the low productivity in the Indian economy as examined by Ray and Bose [1997]. Table 2 shows the growth rate, saving rate and Incremental Capital Output Ratio [ICOR] for various time periods between 1950-51 and 1995-96. Saving rate experienced a secular rising trend whereas the growth rate has been fluctuating between the four time periods.

Although saving rate increased from 16.56 percent during 1951-64 to 19.94 percent during 1965-75, the growth rate declined from 4.22 to 3.52 percent. During the same period, ICOR which measures the capital used per unit of output produced has risen from 3.92 to 5.66. This was largely the consequence of heavy public sector investment in the industrial sector, investment being channelled into infrastructure, heavy industries, and defence. The private sector had only limited role and a low share in aggregate investment on account of the restrictive policies of the government towards the sector. Naturally, the ICOR climbed up.

Table: 2 Saving Rate, ICOR and Growth Rate of Real GDP

[at Market Prices]

Period	*Growth Rate*† *[Percent]*	*Saving Rate*# *[Percent]*	*ICOR**
1 1951-52 to 1964-65	4.22	16.56	3.92
2 1965-66 to 1975-76	3.52	19.94	5.66
3 1976-77 to 1991-92	5.05	22.62	4.48
4 1992-93 to 1995-96	6.67	26.71	4.00
Whole Period : 1950-51 to 1995-96	4.12	20.11	4.88

Source: Ray and Bose [1997], and Datt and Sundharam [2000].

† Average of real GDP [at market prices] growth is on the basis of semi-log trend.

Saving rate is calculated as real gross domestic capital formation of a year as a percentage of GDP at constant market prices of the preceding year; period averages are calculated as geometric means.

* ICOR is calculated as per Rangarajan-Kannan [1994] method; period averages are on the basis of geometric means.

From the second period 1965-1975 to the fourth period 1992-1995, the rise in saving rate has been accompanied by a rise in growth rate which also coincides with a fall in the ICOR from 5.66 to 4.00. It was found that after the initial phase of building the infrastructure, the focus of government shifted towards wage goods industries, changing with it the attitude of the government towards the private sector. This was accompanied by greater autonomy and reforms in the public sector management. All of these collectively had a salutary effect in reducing ICOR after the seventies. The efficiency of investment whether it is made in the public or private sector, will eventually determine ICOR.

iii. Estimation Problems

There are certain estimational problems involved in saving and investment estimates, which may be useful in solving the high saving-low growth puzzle.

Rakshit [1982] dealt extensively with the technical problems in the estimation of saving and investment in the country. He found that the CSO estimates of investment and saving ratios have an upward bias.[1]

There are three major sources of over-estimation. First, the use of commodity-flow method injects an upward bias in investment estimates. This is due to the fact that the ratio of labour intensive construction *[kutcha]* seems to have declined over the years, which CSO failed to account for even in the early eighties. Second, in calculating household financial saving, the official statistics fails to account for the 'bunching effect' of intra-year fluctuations. Third, there is also an upward bias in the estimation of changes in stocks.

The Raj Committee [RBI, 1982] and the Expert Group on Saving and Capital Formation [Government of India, 1996] [Chelliah Committee] also recognised various sources of errors in estimating saving and capital formation in India.[2] Hence, one of the major clue to the puzzle lies in the bias in estimation of household financial saving, and to that extent in household sector saving and aggregate domestic saving.

The phenomenon of 'high saving, low growth' has also been explained in terms of an underestimation of the real growth achieved by the Indian economy. It is argued that the growth in the parallel economy remains unrecorded in the official national income statistics, and to that extent, the overall economic growth is underestimated [Chakravarty (1984), National Accounts Statistics of India, EPWRF (1996)]. However, some economists are of the view that there could be a flaw in this argument. The non-inclusion of the parallel economy cannot be held responsible for the saving-growth dilemma. Supporting which is Bhagwati's [1993] statement that "we would have to assume either that the parallel economy's income is unrecorded more relative to its investment or that, if both are symmetrically unrecorded, the productivity of investment in the parallel economy exceeds that in the recorded, legal economy." Bhagwati and Srinivasan [1984] quantitatively examined this argument and tried to measure the extent of differential undeclared income and investment that is needed for explaining low growth. They arrived at the conclusion that such differentials have to be substantial for explaining low growth.

In the post-independence period, with the expansion of economic activity, the black sector or the illegal economy has grown and magnified to disturbing proportions, playing a dominant role in the moulding of state policies, in changing the structure and composition of output, and in promoting a class which derives its maximum source of power from black money.

The income generated in the illegal economy is not reported in the official GNP estimates. In that sense, the estimates of GNP used as the base for estimation of the black economy income are serious underestimates. Also, the exclusion of black market activity biases all the important economic indicators. History reveals that the amount of black money has not only been growing in absolute terms, but also in relative terms as a percentage of GNP. It would be the least to state that the black economy has grown at a rate even faster than the official economy. Obviously, the perpetrators of this kind of massive unsanctioned activity are running a full-fledged 'parallel economy'.

As the parallel economy estimates of income are not reported in the official income statistics, we have not included the corresponding black market estimates for saving or any other measure used in the study.

iv. Low Investment Demand

Low investment demand is another explanation for the saving-growth incompatibility. If in a given period of time, savings rise more than investment demand, or if investment demand fails to rise sufficiently, 'high savings would result into low growth.' Therefore, high savings must attract larger investment and vice versa, to raise growth.

The expenditure commitment of the government has shifted from infrastructure to non-infrastructure areas, in favour of the bureaucracy and infructuous anti-poverty programmes; with no corresponding rise in private investment in infrastructure [Roy, 1997].

v. Low Capacity Utilization Structural Factors

In spite of the investments taking place in manufacturing sector, the capacity utilisation retarded on account of inadequate infrastructural facilities. Thus, savings are in surplus, but deficient capacity utilisation points towards a weak saving to growth causality [Roy, 1997].

vi. Structural Factors

Indian economists have drawn attention to numerous constraints retarding the growth of the economy since the mid-sixties, such as low propensity to save, the foreign exchange constraint, slow growth of agricultural productivity, inadequate expansion of infrastructural facilities, deceleration of public sector investment, movement of the terms-of-trade against industries, demand deficiency due to the exhaustion of the possibilities of import substitution and worsening distribution of income [Rakshit, 1983].

Shetty and Menon [1980] explained that the increase in domestic savings have been on account of extraneous factors like compulsory deposit schemes, foreign inward remittances, revised accounting of government budget, inflationary sources and those having large incomes and assets. Thereby, implying that savings does not seem to have come as a result of better real income growth. However, on the growth side, the physical supply of goods has not kept pace with the rise in savings. It is very likely that these savings have been absorbed by unprecedented increases in the financial costs of projects, whether in the agricultural sector or in the industrial sector. To this extent, the economic sector has failed to take advantage of the increased domestic savings. The situation is one where for want of effective demand for consumer goods, the growth momentum is contained.

3.2 The Review of Literature

There are two basic ingredients of the econometrician's concept of causality,

i. First, causality implies *'predictability according to a law'*

ii. Second, it is based on the concept that *'cause precedes effect in time'*.

Theoretical as well as empirical relationship between the saving rate and economic growth rate is ambiguous. Saving rate is a long-run combination of two non-stationary variables, toward which output and saving tend to gravitate. To establish whether incentives to increase saving are really growth promoting, one should concentrate on determining the causal chains linking total saving and output.

The causal relationship refers to the direction of relationship between saving and growth. *Is it growth that causes saving or saving that causes growth?* A survey of causality studies focussing on the relationship between saving and growth brings out a substantial divergence of outcomes.

➢ ***International Evidence***

The views on saving-growth relationship are contradictory. The 'capital fundamentalist' view identifies and interprets the strong connection between saving and growth variables as a causal chain running from saving to growth. Lewis [1955] stressed upon the role of savings in initiating economic growth in poor countries. The central idea of Lewis's traditional development theory was that increase in savings would accelerate growth. This notion gets support from a pioneer study on the issue by Andersson [1999]. The result of this cross-country study reveals either causal chain running from saving to growth or mutual causation.

Levine and Renelt [1992] interpreted the causal channel from high investment to high growth, and in that view from saving to growth. Bacha [1990], Otani and Villanueva [1990], De Gregorio [1992] and Japelli and Pagano [1994] analysed cross-section data on saving and growth. They concluded that a higher saving rate led to higher economic growth. A recent study of Kreickhaus [2002] also supports the view that higher savings lead to higher investment and eventually higher growth in the economy.

Majority of the studies associated with the issue oppose the capital fundamentalist view. These are Modigliani and Brumberg [1954, 1979], Houthakker [1960, 1965], Fei and Ranis [1964], Marglin [1976], Bosworth [1993], Dekle [1993], Carroll and Weil [1994], Edwards [1995], Blomstrom, Lipsey and Zejan [1996], Gavin, Hausmann and Talvi [1997], Loayza et. al [1998], Rodrik [1998], Attanasio et. al [2000] and Carroll et. al [2000]. At large, the empirical evidence from these literatures suggests that economic growth is the driving force behind saving. High growth leads to high saving, and not the other way around.

One of the most extensive researches on saving-growth causal relationship was conducted by Carroll and Weil [1994], with a large cross-section of countries over the globe. They found causality from growth to saving both for fast-growing and slow-growing nations and for the aggregate and household levels. Using the Granger causality test, they arrived at two basic results. One, growth Granger-causes saving with a positive sign. Second, saving does not Granger-cause growth; even the insignificant causation from saving to growth is with a negative sign.

Gavin et. al [1997] examined the case of a low saving country like Latin America and high saving Asian 'miracle' economies in view of their growth-saving relationship. They performed Granger causality test for the Asian 'miracle' economies and found that in all cases, growth was high early and saving high later. They could detect Granger causality running from growth to saving alone. According to them, Latin America's chronically low rate of saving is primarily the consequence, more than the cause, of the region's history of low and volatile economic growth, while the high saving observed in the Asian 'miracle' economies is due to their high and less volatile rate of economic growth.

In the quest of finding what comes first, whether saving or growth, Plies and Reinhart [1998] arrived at diverse results. There is no clear consensus. In some cases, growth seems to be causing saving; for others either there is mutual causation between growth and saving or no link at all. Edwards [1995] found that per capita growth is one of the most important determinants of both private and public savings. Carroll, Overland, and Weil [2000] demonstrated that "if utility depends partly on how consumption compares to a habit stock determined by past consumption, an otherwise standard growth model can imply that increases in growth can cause increased saving."

One of the most recent studies [Mohan, 2006] on this subject very well reviews the dynamic relationship of savings and economic growth using the concept of Granger causality. Sinha used dynamic models to examine the relationship between savings and economic growth in a number of countries. Sinha [1996] presented evidence that economic growth Granger causes growth rate of savings in Pakistan. Further, Sinha and Sinha [1998] found that causality was from the economic growth rate to growth rate of savings in Mexico. For Sri Lanka, Sinha [1999] found that causality was in the opposite direction from growth rate of gross domestic savings to economic growth rate. However, Sinha [2000] did similar studies in the Philippines and once again found causality from economic growth rate to growth rate of domestic savings.

Saltz [1999] investigated the direction of causality in 17 third world countries, using the Vector Error Correction [VEC] model for eight countries and Vector Auto Regressive [VAR] model for the other nine countries. The study found that for nine countries, the causality was from the economic growth rate to growth rate of savings. For only two countries was the direction of causality reversed. There were four countries where no causality was identified, and for the other two countries bi-directional causality was detected.

Anoruo and Ahmad [2001] investigated the causality of savings and economic growth in seven African countries using VEC. The authors found that in four out of seven countries, economic growth Granger-causes the growth rate of domestic savings. However, they obtained a bi-directional causality in Cote d'Ivoire and South Africa. Only in the Congo, did the opposite result prevail, that is, the growth rate of domestic savings Granger-caused economic growth.

Mavrotas and Kelly [2001] used the Toda and Yamamoto method to test for Granger causality. Using data from India and Sri Lanka, the relationships among gross domestic product, gross domestic savings, and private savings was examined in this study. The authors found no causality between GDP growth and private savings in India. However, bi-directional causality was found in Sri Lanka.

Baharumshah et. al [2003] investigated growth rate of savings behavior in five Asian countries: Singapore, South Korea, Malaysia, Thailand, and the Philippines. They found that growth rate of savings does not Granger-cause economic growth rate in the countries, except for Singapore.

Mohan [2006] found that income class of a country plays an important role in determining the direction of causality. The empirical results for high income countries confirmed causality from economic growth to growth rate of savings, except for Singapore. Bi-directional causality was observed for upper-middle income countries. Most of the low-middle income countries also experienced causality from economic growth to growth rate of savings whereas the results were mixed for low-income countries.

Despite the findings of various studies, there seems to be more to the saving-growth relationship than the 'capital fundamentalist' view. On the other hand, it is argued that fluctuations of the saving rate, or another measure of the long-run relationship between saving and output, precede positive growth. Hence, the issue of causal chains is much more complex than this, and the temporal dependence between output and gross saving will depend on country characteristics and what type of dynamics one is studying.

- ***Indian Evidence***

Unlike the international literature, we have come across only a few Indian studies on causality between saving and economic growth. There has been only limited research in this area, in the Indian context.

Studies by Krishnamurty and Saibaba [1981], Balakrishnan [1996], Muhleisen [1997] and Ray and Bose [1997] support the case for a positive and significant impact from economic growth to savings.

Krishnamurty and Saibaba [1981] argued that there are lags in the response of consumption to changes in income in the case of households, and consequently, household saving rates tend to rise with increase in per-capita income.

Balakrishnan [1996] supports the impact from growth to saving. This study identified the decline in saving rate in 1991-92 to a fall in growth rate in the initial years following liberalisation. The downward impact on growth rate was observed to be maximum in the non-agricultural segment which has a high marginal propensity to save. As a result the industrial growth rate remained depressed which in turn lowered the overall saving rate in the economy.

The other two studies by Muhleisen [1997] and Ray and Bose [1997] examined the growth-saving relationship by conducting Granger causality tests. Muhleisen [1997] conducted tests of Granger causality running bivariate vector autoregressions [VAR] on real GDP growth and total, public and private savings over the period 1950-1994. His results supported Granger causality form economic growth to savings.

Ray and Bose [1997] examined Granger causality between real GDP and real GDS both for aggregate and disaggregated components of GDS. Causality directions were found to be uniformly from growth to saving. Their results were very similar to those of Carroll and Weil [1994] in that, they also found a negative insignificant impact of saving on growth. They went a step further and checked the pattern of impulse responses between first difference of real GDP and real GDS, along with their sectoral components. The results indicate that any shock to saving influences output positively, atleast it is not adverse in nature. This confirmed that "generating growth is perhaps the best incentive for saving, but saving matters for growth too."

Another study by Sethi [1999] tried to test the causality behaviour between aggregated and disaggregated saving and income variables with the help of cross-autocorrelation method for almost the same period of time as the other Indian studies. Only in a few cases, causality was found to be running in the usual income to saving direction. In majority of the cases, this channel of causality was rejected. In such cases, causality was observed either to have run from saving to income; or to be feedback in nature; or to be instantaneous; or to have remained undetected. Thus, the nature of causal relationship between saving and growth is not explicitly known.

A study by Joseph [1997] supports a two-way causal relationship between saving rate and growth rate in India. There appears to be a virtuous circle in operation of higher economic growth leading to higher saving which in turn, by financing higher investment stokes even higher growth. However, Mishra [2006] found that there is no causal relationship between economic growth and saving in India.

➢ *Conclusions from Literature Survey*

The collective evidence from the international as well as Indian literature provides no conclusive support to any of the investigations concerning the causal links between saving and growth. The results are varied, with some supporting a link from growth to saving while others confirming the reverse causality from saving to growth. A number of researchers accept bi-directional or mutual causation between saving and growth whereas some deny any causal link between these two macroeconomic variables. Therefore, the debate on causality between economic growth and savings in the Indian context remains unresolved.

The general acceptance however, is for causality running from growth to saving as majority of the studies have arrived at a uni-directional positive causal influence from growth to saving. In the Indian case too, the causal channel from growth to saving is more universally accepted. And even if saving causes growth, it is insignificant and carries a negative sign. Among the Indian studies, Sethi's study [1999] is an exception which lends greater support to cases like causal influence from saving to growth, bi-directional causation, and instantaneous causality. Some of the recent international studies such as Saltz [1999], Sinha [1999], Anoruo and Ahmad [2001] and Baharumshah et. al [2003] found growth rate of savings to Granger-cause economic growth rate in some of the countries.

The research on growth-saving causality is wide spread. A number of studies have used additional variables such as lagged population growth, openness and political instability along with growth and saving. There are studies which have taken panel data for a large sample of countries, and others that have used statistical tools for testing causality between growth and saving. The studies differ considerably in terms of the countries under inspection, between fast-growing and slow-growing countries, from period to period, that is short-run and long-run, aggregated or disaggregated levels such as the country or household, as well as in terms of the different variable definitions used.

The issue of causality between saving and growth is unsettled because of the wide variation in results between the studies conducted on causality. The direction of causality between saving and growth may change because of differences in the methodology used. Another reason could be the choice of variable specifications for causality analysis and the definitions of the variables used. The causal relationship may also change from country to country.

3.3 The Review of Methodological Issues and Techniques

There are several statistical methods for testing the causal relationship between saving and growth. Some of the most commonly used tests for causality found in the literature are Granger Test [1969], Sims Test [1972], McClave-Hsiao Tests [1978, 1979, 1981], Haugh-Pierce Tests [cross-correlation analysis], Transfer-Function Test, Modified Sims Test by Geweke, Meese and Dent [1983] and the recently used cointegration technique which is an advanced approach towards testing for causality. The present section discusses the following causality techniques:

a. Granger Test
b. Sims Test
c. McClave-Hsiao Tests
d. Cointegration Technique

a. <u>Granger Test</u>

Granger's [1963, 1969] notion of causality is perhaps the only viable and empirically testable notion that has been widely applied to economic relationships. The test procedure developed by Granger [1969] is based on the axiom that only the past causes the future.

Granger's definition of causality is couched in terms of predictability. Granger defines simple causality as follows: X causes, Y, if knowledge of past X reduces the variance of the errors in forecasting Y as compared to the variance of the errors which would be made from knowledge of past Y alone.

According to Koop [2000], the future cannot predict the past since time does not run backward. That is, if event A happens before event B, then it is possible that A is causing B. However, it is not possible that B is causing A.

The test procedure by Granger involves regressing the dependent variable [Y] on the lagged values of the dependent variable [Y], on the current value and the lagged values of the explanatory variable [X].

In principle, X is said to cause Y if the current and lagged values of X are significant in explaining variations in Y; or equivalently, if the coefficients on all explanatory X variables, as a group, are statistically significant or different from zero. Causation in the opposite direction is determined in a similar manner.

It is important to note that the statement "X Granger causes Y" does not imply that Y is the effect or the result of X. Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term.

b. <u>Sims Test</u>

In a twist of Granger causality, Sims [1972] developed a test procedure which is based on the principle that the future does not cause the past. It involves regressing Y on past, present and future values of X and regressing X on past, present and future values of Y.

In this case, X is said to cause Y if coefficients on the future values of Y, as a group, are statistically significant in explaining variations in X; or that the sum of coefficients of the lead X terms must be statistically equal to zero. The reverse would be true if Y is said to cause X.

Validity of both Granger and Sims test depends on two important conditions:

1. X_t and Y_t must be covariance stationary[3], and
2. The error terms in the regression equations follow the usual assumptions of the classical regression model[4].

In order to ensure compliance with these conditions, both series [i.e. X and Y] are often prefiltered. Sims [1972] study used the filter $[1\text{-}0.75L]^2$, where L is a lag operator. Sims justified this arbitrarily chosen filter on the ground that it reduces both series to covariance stationarity.

c. **McClave-Hsiao Tests**

McClave [1978] and Hsiao [1979, 1981] developed this group of tests for determining causation between a set of two variables. The test is based on the criterion of Minimum Final Prediction Error [FPE] as supported by Akaike [1969]. The test also has an inbuilt lag selection criterion worked out on the basis of FPE of each regressed equation.

The principle underlying the test is that if inclusion of lagged values of X in equations explaining Y reduces their prediction error i.e., improve their predictive performance then the hypothesis that X causes Y gets support.

The test procedure for testing causality from X to Y is that: if the inclusion of lagged X variables lowers the prediction error of the regression below the lowest of FPE's without the lagged X variables, X is said to cause Y.

The above mentioned tests require the underlying time series to be stationary. A stationary time series is one that has a mean, variance and autocovariance independent of time. An econometric model failing to comply with the condition of stationarity of data leads to violation of the basic assumption of time series research. This may give rise to various problems in empirical analysis too.

The statistical inferences drawn on the assumptions of stationary time series would yield misleading results when the series is actually non-stationary. Besides, when one non stationary series is regressed upon another, it can lead to a spurious regression [a regression with an R^2 value > D-W value], which tends to indicate a relationship between variables when in fact none exists. Therefore, nonstationarity of time series data has important implications on our understanding of the economy and forecasting.

Tests of stationarity should precede the tests of causality or else, the test statistics for the causality models follow non-standard distribution which can lead to many complications.

d. <u>Cointegration Technique</u>

Cointegration between economic variables implies the existence of a long-term, or equilibrium relationship between them. From a statistical point of view, a long-term relationship means that the variables move together over time so that short-term disturbances from the long-term trend will be corrected. However, any deviation from equilibrium would eventually be self revising [McNown and Wallace (1992) and Manning and Andriacanos (1993)].

If two or more nonstationary time series variables are cointegrated, it means that in the long-run they move closely together such that even though they themselves are trended, the difference between them is constant. A lack of cointegration between such variables implies that there is no long-run or stable relationship between them and they may wander arbitrarily away from each other [Dickey et. al, 1991].

Cointegration captures the long-run relationship between variables having a unit root unconditionally.

Granger and Newbold [1974] were the early ones to highlight the dangers of regressing one nonstationary time series on another. As already discussed, a regression between two nonstationary time series variables often yields a spurious regression. Later, Engle and Granger [1987] identified a situation when such a regression did not yield a spurious relationship. According to them, if two nonstationary series integrated of the same order are cointegrated, then there is no threat of spuriosity in the linear regression resulting from these two series. Dickey et. al [1991] also support this theory. In their view, "time series variables are not stationary individually; one or more linear combinations of variables are stationary even though individually they are not."

The first and foremost step towards testing for cointegration between a set of variables is to test whether the variables are integrated of the same order. This is a pre-condition for undertaking a cointegration test. Once this condition is fulfilled, one can proceed with the test for cointegration. If both the variables are integrated of order zero, and are thus stationary, there is no need to proceed any further with cointegration tests because standard estimation techniques can be used for studying the relationship between such variables.

Cointegration is shown to be an exception to a general rule. The general rule is that if two series, Y_t and X_t are both first difference stationary [I(1)], then any linear combination of the two series will yield a series which is also first difference stationary [I(1)].

The exception to this general rule is when a linear combination of two [or more] first difference [I(1)] series is integrated of a lower order, that is, stationary at zero level [I(0)]. In this case, the common stochastic trends have cancelled out yielding a series that is stationary [I(0)]. Thus, for a regression between two first difference [I(1)] series, we do not obtain something that is spurious but something that may be relatively sensible in economic terms. Engle and Granger [1987] have shown to this effect that if a linear combination of two I[d] variables is integrated at any order less than d, then these variables are said to be cointegrated.

The test for cointegration occupies a strategic place in the causality analysis because the existence of cointegration between two time series variables rules out Granger non-causality. Two cointegrated series are bound to share a causal relationship in atleast one direction.

A number of cointegration methods have been applied in time series literature. Some of these tests are the Cointegrating Regression Durbin-Watson Test [CRDW], Engle-Granger Tests [EG and AEG], ECM based F-Test for cointegration, Johansen Test and Weighted Symmetric Cointegration Test.

➢ ***Steps Involved in Cointegration Approach***

The 'cointegration analysis' for causality testing involves the following steps:

1. Tests for Unit Roots [or Stationarity]
2. The Cointegrating Regression
3. Tests for Cointegration
4. Error Correction Mechnaism
5. Causality Tests

The first step is to test the time series variables for the presence of unit roots. The absence or presence of unit roots determines the stationarity or nonstationarity of the time series data. Once unit roots are established, the next step is to estimate the cointegrating regression for examining the long-run relationship between variables. The cointegrating regression is needed for deriving the residual series for further tests.

This is followed by the tests for cointegration for determining the stationarity of the residual variable. If the residual series, which is a linear combination of two nonstationary time series of the same order of integration, is integrated to a lower order, then the two time series are cointegrated or have a stable long-run relationship. In that case, the next step is employed wherein the error correction model is formulated for modelling the short-run dynamics. Any short-run disequilibrium can be corrected by the Error Correction Mechanism [ECM].

The existence of cointegration is in itself an indication of a causal relationship between variables which can be confirmed by conducting causality tests between the concerned variables in the final step.

The methodological details of tests for cointegration in the present study are based on studies by Demirbas [1999], Gujarati [2003] and the ninth e-tutorial series of econometrics lecture [2005].

1. Tests for Unit Roots [or Stationarity]

Time series research requires testing the variables under consideration for the unit roots. It is the presence of unit roots which determines the stationarity or nonstationarity of a time series. Unit roots in a series confirms that it is non-stationary or a random walk time series. An I[1] series is said to have a single unit root while an I[d] series has d unit roots. To elaborate upon this, a series which is stationary after being differenced once is integrated of order one and denoted as I[1]. In general, a series which is stationary after being differenced d times is said to be integrated of order d and denoted I[d]. A series which is stationary without differencing is integrated of order zero and is denoted I[0]. However, differencing an I[0] series does not alter its stationarity property in any way.

The most commonly used methods for detecting the presence of unit roots in time series are the Dickey-Fuller [DF] and Augmented Dickey-Fuller [ADF] tests, Phillips-Perron [PP] tests, Ng and Perron [NP] tests and Kwiatkowski, Phillips, Schmidt and Shin [KPSS] tests. As these tests enable us to find out whether a time series is integrated or not and at what level, they are also known as the *'tests of integration'*.

Earlier studies used the Dickey-Fuller [DF] test for unit root testing but the recent researches have adopted the more advanced Augmented Dickey-Fuller [ADF] test for determining unit roots in time series.

The ADF test is more advanced than the other tests of unit roots in the sense that it is based on the assumption that the error terms [u_t] are correlated. The ADF test is widely regarded as one of the most efficient test for integration level. In practice, it is considered as the most favourite test among the practitioners.

➢ *Augmented Dickey-Fuller [ADF] Test*

The use of ADF test was the main recommendation by Engle and Granger [1987], which by far became the most popular test being used in applied time series research on unit roots.

As ADF test is derived from the DF test procedures, we first undertake a discussion on the methodological aspects of the DF test.

The Dickey-Fuller [DF] test used in the earlier studies, assumes that error terms [u_t] are uncorrelated. A pure random walk process [without drift] can be expressed as:

$$\mathbf{Y_t = \rho\, Y_{t-1} + u_t} \qquad \text{Eq.1.}$$

Where u_t is a stochastic error term with constant mean, constant variance and non-autocorrelated. u_t is also called the 'white noise' error term.

The DF equation can be estimated in three different forms. A random walk model may have no drift term, or it may have a drift, or it may contain both a drift and a stochastic trend. The three different specifications will take the following form:

i.	Y_t is a random walk without drift	:	$\mathbf{\Delta Y_t = \delta\, Y_{t-1} + u_t}$
ii.	Y_t is a random walk with drift	:	$\mathbf{\Delta Y_t = \beta_1 + \delta\, Y_{t-1} + u_t}$
iii.	Y_t is a random walk with drift and a stochastic trend [where t is the trend variable]	:	$\mathbf{\Delta Y_t = \beta_1 + \beta_2 t + \delta\, Y_{t-1} + u_t}$

If $\rho = 1$ in Equation [1], unit root exists in the underlying time series implying that the series Y_t is nonstationary.

Subtracting Y_{t-1} from both sides of Equation 1 will give the 'first difference' form of the equation which can be presented as:

$$\mathbf{\Delta Y_t = [\rho - 1]\, Y_{t-1} + u_t} \qquad \text{Eq.2.}$$

Equation 2 can be re-expressed as:

$$\mathbf{\Delta Y_t = \delta\, Y_{t-1} + u_t} \qquad \text{Eq.3.}$$

Where $\delta = \rho - 1$.

Equation 3 is the DF test equation which is used in practice for testing unit roots in series Y_t. The method for estimating the equation is Ordinary Least Squares method.

The competing hypotheses for the above stated model are:

H_o: $\delta = 0$ [$\rho = 1$ or Y_t is integrated of order one or nonstationary]

H_a: $\delta < 0$ [$\rho < 1$ or Y_t is integrated of order zero or stationary]

The decision to reject or not to reject the null hypothesis that series Y_t is nonstationary depends more importantly on the computed t statistic. It is also known as τ [tau] statistic when the regression is testing for unit roots. The tau statistic is commonly referred to as the Dickey-Fuller [DF] test in the honour of its discoverers.

If the computed absolute value of the τ statistic for Y_{t-1} [independent variable in Equation 3] exceeds the DF absolute critical value, then we reject the null hypothesis of a nonstationary Y_t series. In other words, if the computed τ value is more negative than the tabulated DF critical value, then Y_t is integrated of the order zero [I(0)] or stationary series.

It is to be noted that the critical values vary from one specification to another and from one sample size to another.

In case Y_t is nonstationary and contains a unit root, we need to go one step further and test whether the first differenced series ΔY_t is stationary. The regression model for unit root testing will now take the following shape:

$$\Delta^2 Y_t = \delta \Delta Y_{t-1} + u_t \qquad \text{Eq.4.}$$

Where $\Delta^2 Y_t$ is the second difference of Y_t.

Once again the null and alternative hypotheses are stated and DF test [τ values] values are compared with the critical values to draw inference about the presence of unit roots in ΔY_t series.

H_o: $\delta = 0$ [$\rho = 1$ or ΔY_t is integrated of order one or nonstationary]

H_a: $\delta < 0$ [$\rho < 1$ or ΔY_t is integrated of order zero or stationary]

Therefore, for any time series containing a unit root problem, this process of successive differencing goes on until stationarity is achieved.

The ADF test is a modification of the DF test and involves 'augmenting' the DF test equations of different specifications by the lagged values of the dependent variable ΔY_t. This is done to ensure that the error process in estimating equation is residually uncorrelated and also capture the possibility that Y_t is characterized by a higher order autoregressive process. A failure to introduce variables designed to capture omitted dynamics leads to biased standard errors. Therefore, it is important to introduce lagged terms in the DF test equations.

The lag length to be used in the ADF test equation is partly determined by the frequency of the data but also by the structure of serial correlation that characterizes the regression model. It might also be useful to choose lag lengths on the basis of information criterion where Akaike Information Criterion [AIC] and Schwarz Information Criterion [SIC] tend to be preferred by many applied investigators. These criteria tend to be weak, though. Charemza and Deadman [1992] rightly stated that "the practical rule for establishing the value of [*m*] ... is that it should be relatively small in order to save degrees of freedom, but large enough not to allow for the existence of autocorrelation in e_t. For example, if for [*m*] = 2 the Durbin-Watson autocorrelation statistic is low, indicating first order autocorrelation, it would be sensible to increase *m* with the hope that such autocorrelation will disappear".

The general form of ADF test equation can be estimated as:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \epsilon_t \qquad \text{Eq.5.}$$

Where, ϵ_t is a pure white noise error term; the lags of the dependent variable are calculated as $\Delta Y_{t-1} = [Y_{t-1} - Y_{t-2}]$, $\Delta Y_{t-2} = [Y_{t-2} - Y_{t-3}]$, and so on; m is the number of lags and t is time. If i = 1 we have ADF [1], if i = 2 we have ADF [2], and so forth.

Here again, the ADF test equation can take different forms after the three specifications such as a random walk process with no drift, with drift and the third with drift and a stochastic trend.

The conventional set of hypotheses for the ADF test is the same as before:

H_o: $\delta = 0$ [$\rho = 1$ or the Y_t series is integrated of order one or nonstationary]

H_a: $\delta < 0$ [$\rho < 1$ or the Y_t series is integrated of order zero or stationary]

Once again, the distributions tabulated by Dickey and Fuller are used for this test. Hence, the ADF test follows the same critical values as DF test. The t-ratio on the δ coefficient provides the ADF test statistic. If the computed τ value of Y_{t-1} series is greater than the tabulated critical τ value for the specification and sample size under consideration, the null hypothesis of a random walk time series is rejected in favour of a stationary Y_t series.

In case the null in the above model [Equation 5] is upheld, the following regression should be estimated:

$$\Delta^2 Y_t = \beta_1 + \beta_2 t + \delta \Delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta^2 Y_{t-i} + \epsilon_t \qquad \text{Eq.6.}$$

The ADF tests are then performed to inform on the following hypotheses:

H_o: $\delta = 0$ [$\rho = 1$ or the ΔY_t series is integrated of order one or nonstationary]

H_a: $\delta < 0$ [$\rho < 1$ or the ΔY_t series is integrated of order zero or stationary]

In this way, successive differencing can be carried out until the series becomes stationary.

2. *The Cointegrating Regression*

Once the time series variables are tested for unit roots and the level of stationarity is confirmed, the cointegrating regression is estimated for examining the long-run relationship between variables.

Cointegration captures the long-run relationship between variables having a unit root unconditionally. Granger [1986] rightly mentioned that "a test for cointegration can be thought of as a pre-test to avoid spurious regression situations".

The cointegrating regression obtained by regressing one unit root time series on another unit root time series is aimed at establishing a long-run relationship between the variables.

The cointegrating regression can be estimated as a simple linear regression equation involving variables Y_t and X_t, at levels. Ordinary Least Squares method is applied to estimate the following cointegrating regression:

$$Y_t = \beta_1 + \beta_2 X_t + u_t \qquad \text{Eq.7.}$$

Where β_2 is the cointegrating parameter.

The cointegrating regression [Equation 7] can be extended to a regression model containing k regressors having k cointegrating parameters.

The residual series can be derived from the cointegrating regression for further analysis.

3. *Tests for Cointegration*

Tests for cointegration are performed on the 'residual' obtained from the cointegrating regression estimated above for examining the long-run relationship between X and Y.

When a linear combination of two nonstationary series yields a stationary series, the nonstationary series are cointegrated and share a stable long-term relationship. The methods commonly used for testing cointegration between variables are:

a. Engle-Granger Test [EG and AEG-Residual based Unit Root Tests]
b. Cointegrating Regression Durbin-Watson [CRDW] Test

Between these two tests of Cointegration, Engle-Granger test is the stronger test of cointegration. Generally, Augmented Engle-Granger [AEG] test is used as a standard test for cointegration. Cointegrating Regression Durbin-Watson [CRDW] test is used only for making a quick estimation on the presence or absence of cointegration between variables.

As a preliminary exercise, one can also plot the residual series [or error term] obtained from the cointegrating regression [in Step 2] against time. This is done simply as a double check for confirming the stationarity of the residual series.

a. *Engle-Granger Tests*

These tests are employed for determining whether the residual series derived from the cointegrating regression is stationary or not. They are referred to as the ***'residual based unit root tests'***.

Engle and Granger [1987] have shown to this effect that if a linear combination of two I[d] variables is integrated at any order less than d, then these variables are said to be cointegrated.

In order to find out if the residual is stationary [I(0)] or not, the DF or ADF tests for unit roots are applied to the residuals. These tests are known as Engle-Granger [EG] and Augmented Engle-Granger [AEG] tests respectively. The only difference from the traditional DF and ADF tests to the Engle-Granger tests are the critical values. The critical values are no longer the same as provided by Dickey and Fuller but instead has been provided by Engle and Granger [1987]. These values can also be found in other sources as in Engle and Yoo [1987] and Hamilton [1994], or computed on the basis of Mackinnon [1991] tables.

The residual from the cointegrating regression [Equation 7] can be estimated as expressed below:

$$u_t = Y_t - \beta_1 - \beta_2 X_t \qquad \text{Eq.8.}$$

The DF and ADF test equations to be performed on the residual, for testing the presence of unit roots in the residual series are:

$$\Delta u_t = \delta u_{t-1} + v_t \qquad \text{Eq.9.} \quad \textbf{[DF/EG test]}$$

Or,

$$\Delta u_t = \delta u_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta u_{t-i} + v_t \qquad \text{Eq.10.} \quad \textbf{[ADF/AEG test]}$$

It is necessary to emphasise that the residual equation has no drift term since a constant was already included in the long-run equation [or cointegrating regression] and the mean residual is therefore zero. There is also no trend included in the equation.

The residual based DF and ADF tests are similar to those used for testing time series stationarity in Step 1. Hence, the same procedure is followed for conducting unit root tests on residuals too. Studies which use ADF test for detecting unit roots in variables will use the AEG test for testing unit roots in the residuals too.

Inference on cointegration between variables is drawn on the basis of the competing hypotheses:

H_o: $\delta = 0$ [u_t is nonstationary $\Rightarrow$ No Cointegration between Y_t and X_t]

H_a: $\delta < 0$ [u_t is stationary $\Rightarrow$ Cointegration between Y_t and X_t]

The presence of unit root in the residual implies that the nonstationary variables in the cointegrating regression are not cointegrated, that is, they do not share a long-run relationship. On the other hand, if the null hypothesis of a unit root in u_t is rejected, the estimated residual is stationary suggesting that Y_t and X_t are cointegrated and share a stable long-run relationship between them. In the latter circumstance, one can proceed to the next step of formulating an error correction model. In any case, it is always desirable to proceed to the next stage, as this offers an additional framework for cointegration testing.

b. Cointegrating Regression Durbin-Watson [CRDW] Test

It is a very simple method for examining the long-run relationship between variables and it is by this virtue of CRDW test that it is often used for making quick approximates. After running the cointegrating regression, the Durbin-Watson test statistic is examined to determine if the residuals appear stationary.

The hypotheses for this test can be stated as:

H_o: D-W = 0 [Residual is not stationary ⇒ No Cointegration between Y_t and X_t]

H_a: D-W > 0 [Residual is stationary ⇒ Cointegration between Y_t and X_t]

If the Durbin-Watson statistic approaches zero, the test cannot reject the null of non-cointegration between the given set of variables Y_t and X_t. As a thumb rule, if D-W value is away from zero then the test rejects the hypothesis of no cointegration and the residuals are said to be stationary. The critical values for D-W statistic are available only for a sample of 100 observations. The 1%, 5% and 10% critical values are 0.511, 0.386 and 0.322, respectively. As D-W critical values are not available for a sample of 50 observations, the thumb rule is followed that if D-W is 0.5 and above, the residual is stationary.

Although the CRDW test is a quicker method for cointegration testing, the final judgement is based on the outcome of Engle-Granger tests only. There is considerable debate about the superiority of CRDW over DF. The debate revolves around the power of the two statistics, that is, the probability of not committing a Type II error [Gujarati, 2003]. Engle and Granger preferred the ADF to the CRDW test.

4. *Error Correction Mechanism*

After establishing a long-run equilibrium relationship between time series variables, the error correction model is formulated to check for model adequacy. It aims at modelling the short-run dynamics. The concept of error correction refers to the adjustment process between short-run disequilibrium and a desired long-run position. It also enables one to understand the short-run and long-run causal relationship between two variables.

A set of cointegrated variables share a long-run equilibrium relationship, but in the short-run there may be disequilibrium. This disbalance can be corrected by the *Error Correction Mechanism [ECM]*. The *Error Correction Term [ECT]* is a proxy for the stationary residual from the cointegrating regression. It is also called the 'equilibrium error'.

The Granger representation theorem states that if two variables Y and X are cointegrated, then the relationship between the two can be expressed as ECM. The error correction model shows that ΔY_t depends on ΔX_t and also on the equilibrium error term.

The ECM equation can be presented as:

$$\Delta Y_t = \alpha_0 + \alpha_1 \Delta X_t + \alpha_2 u_{t-1} + \epsilon t \qquad \text{Eq.11.}$$

Where ϵ_t is a random error term, $u_{t-1} = [Y_{t-1} - \beta_1 - \beta_2 X_{t-1}]$ which is one period lagged value of the residual from the cointegrating regression, and α_2 is the speed of adjustment parameter.

The absolute value of α_2 determines how quickly the equilibrium is restored. A stable error correction model requires that the estimated α_2 parameter is negative, so that the system is convergent and equilibrium is maintained. In case of a positive value of the adjustment parameter, the system is divergent and tends to wander away from the equilibrium. Therefore, the error correction mechanism is a means of reconciling the short-run behaviour of an economic variable with its long-run behaviour.

The ECM also supplements as an additional test for cointegration based upon the value of coefficient [or α_2 parameter] of the equilibrium error term [u_{t-1}].

The set of hypotheses to be evaluated are:

H_o: $\alpha_2 = 0$ [No Cointegration between Y_t and X_t]

H_a: $\alpha_2 < 0$ [Cointegration between Y_t and X_t]

If α_2 is significantly less than zero, the cointegration between Y_t and X_t variables is confirmed.

5. *Causality Tests*

As discussed earlier, different causality tests have been used in the literature. We have used one of the most popular *Granger causality test* for investigating the causal relationship between growth and saving.

Engle and Granger [1987] have shown that if two time series are cointegrated, there ought to be a causal relationship in at least one direction. Existence of cointegration rules out Granger non-causality. However, it does not give the direction of causality. This does not mean that in the event of absence of cointegration between variables, they cannot be causally related. Even though a long-run relationship between two time series variables cannot be established, it may still be possible that the variables are causally related in the short-run. Short-term dynamics can be modelled by applying Granger causality test for non-cointegrated variables.

Standard Granger causality test can be employed only for time series variables that are not cointegrated. When two time series are cointegrated, to use simple Granger causality test is inappropriate as it will be able to capture only the short-run effects when in fact the long-run effects need to be examined. For this purpose, standard Granger causality tests are augmented with error correction terms derived from the appropriate long-run cointegrating relationships. Such tests are carried out on time series that are stationary to guarantee that inferences made from the tests are valid.

In all, there are three ways of conducting the Granger causality tests, two of which require the dependent and independent variables to be cointegrated.

For the cointegrated pair of variables, Granger causality test can be modified as presented in Method 1 and Method 2.

Method 1

$$X_t = \alpha + \sum_{i=1}^{m} \beta_i X_{t-i} + \sum_{j=1}^{n} \gamma_j Y_{t-j} + u_t \qquad \text{Eq.1.1}$$

$$Y_t = a + \sum_{i=1}^{q} b_i Y_{t-i} + \sum_{j=1}^{r} c_j X_{t-j} + v_t \qquad \text{Eq.1.2}$$

Where X_t and Y_t are first difference stationary [I(1)] variables, u_t and v_t are random error terms and m, n, q, r are lag lengths assigned on the basis of the chosen lag selection criterion [by minimising Akaike's Final Prediction Error [FPE] following Giles et.al (1993)].

In the above set of equations, causality direction can be determined as follows:

Y granger causes X if,
H_o: $\gamma_1 = \gamma_2 = \gamma_3 = \ldots\ldots\ldots = \gamma_n = 0$ is rejected against H_a: at least one $\gamma_j \neq 0$, $j = 1, \ldots\ldots. n$.

X Granger causes Y if,
H_o: $c_1 = c_2 = c_3 = \ldots\ldots\ldots = c_r = 0$ is rejected against H_a: at least one $c_j \neq 0$, $j = 1, \ldots\ldots r$.

Method 2

$$\Delta X_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta X_{t-i} + \sum_{i=1}^{n} \gamma_j \Delta Y_{t-j} + \delta\, ECM_{t-1} + u_t \qquad \text{Eq.2.1}$$

$$\Delta Y_t = a + \sum_{i=1}^{q} b_i \Delta Y_{t-i} + \sum_{i=1}^{r} c_j \Delta X_{t-j} + d\, ECM_{t-1} + v_t \qquad \text{Eq.2.2}$$

Where ΔX_t and ΔY_t are stationary variables after the levels variables [X_t and Y_t] are first differenced to induce stationarity. ECM is the error correction mechanism term obtained as residual from the cointegrating regression and δ and d denote the speed of adjustment along the long-run equilibrium path.

Interpretation of the above set of equations involves the following:

ΔY Granger causes ΔX if,
H_o: $\gamma_1 = \gamma_2 = \gamma_3 = ... = \gamma_n = 0$ is rejected against H_a: at least one $\gamma_j \neq 0$, $j = 1,.....n$; or $\delta \neq 0$.

ΔX Granger causes ΔY if,
H_o: $c_1 = c_2 = c_3 = ... = c_r = 0$ is rejected against H_a: at least one $c_j \neq 0$, $j = 1,......r$; or $d \neq 0$.

The Vector Error Correction Model [VECM] for Granger causality establishes two kinds of relationship. One, it helps to derive the short-run causality which can be tested by the joint significance of the coefficients of independent variable. Second, the long-run causality can be examined by looking at the significance of the coefficient of the Error Correction Mechanism [ECM] term. If the coefficients of the explanatory variable are jointly significant, the variables are causally related in the short-run. On the other hand, if the adjustment parameter is significantly away from zero, there exists long-run causality between variables. VEC offers another advantage that the lost information due to differencing is brought back into the system through error correction term [Soytas and Sari, 2003].

Method 3

Standard Granger causality test is used for data that are first difference stationary [I(1)] but not cointegrated. In such cases, the variables have to be transformed to induce stationarity at level. The causality model employed here differs from that in Method 2 in terms of non-inclusion of the ECM term.

$$\Delta X_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta X_{t-i} + \sum_{j=1}^{n} \gamma_j \Delta Y_{t-j} + u_t \qquad \text{Eq.3.1.}$$

$$\Delta Y_t = a + \sum_{i=1}^{q} b_i \Delta Y_{t-i} + \sum_{i=1}^{r} c_j \Delta X_{t-j} + v_t \qquad \text{Eq.3.2.}$$

Where ΔX_t and ΔY_t are stationary variables after the levels variables [X_t and Y_t] are first differenced to restore stationarity in the variables. The optimal lag lengths: m, n, q and r are determined by minimising Akaike's Final Prediction Error [FPE].

For drawing inference, the following set of hypotheses is considered:

ΔY Granger causes ΔX if,
H_o: $\gamma_1 = \gamma_2 = \gamma_3 = \ldots\ldots = \gamma_n = 0$ is rejected against H_a: at least one $\gamma_j \neq 0$, $j = 1, \ldots\ldots n$.

ΔX Granger causes ΔY if,
H_o: $c_1 = c_2 = c_3 = \ldots\ldots = c_r = 0$ is rejected against H_a: at least one $c_j \neq 0$, $j = 1 \ldots\ldots r$.

[Refer Oxley and Greasley (1998) for empirical details on Granger causality tests.]

➢ ***Limitations of Cointegration Analysis***

In recent research, cointegration analysis has become an indispensable tool for studying long-run relationship between time series variables. But still, the tests for cointegration are subject to a number of limitations.

The cointegration tests are based on the tests of residuals obtained from the co-integrating equation. The residual variance is by purpose reduced in size so that it tends to influence the DF and ADF test results. In that sense, the tests are prejudiced in finding a stationary error process. The tests are also sensitive to the direction of the estimated cointegrating equation. It is important to note which way the regression is inverted, whether X is regressed upon Y or Y is regressed upon X.

The omission or inclusion of certain variables from the cointegrating regression can dramatically affect the results obtained from cointegrating regressions. Also, if there are more than two variables, the cointegration tests will not allow discrimination between different cointegrating vectors. There may be more than one cointegrating relationship present in the data as the number of variables in the set increases. Therefore, the tests are relatively weak in the case of multiple cointegrating relationships. The testing procedure does not make use of all available data and utilizes no information on dynamics. Hence, it is a static model.

The usual t or F tests used in time series research have non-standard distributions. Therefore, tests of unit roots and cointegration require the use of appropriate tabulated critical values which are often very difficult to find. Once located, these critical value tables are beset with two major problems. One is that they provide values only for a limited set of discrete sample sizes and the other is that they are all calculated on the basis that the lag order in the ADF test is zero, thus limiting consideration to the AR [1] model. Another difficulty with the tabulated critical values is that they lack consistency. There is often variation in the critical values provided by different studies.

In cointegration analysis, the use of the term "equilibrium" for explaining long- run relationship between variables might lead to some confusion since economists and econometricians differ in their opinion regarding this term. Economists view 'equilibrium' as describing equality between actual and desired transactions. The cointegration concept does not require the long-run relationship between variables to be generated by market forces or behavioural rules of agents acting in the market. Econometricians on the other hand, believe that the equilibrium relationship may be causal, behavioural or reduced form and need not necessarily be structural. Therefore, the term equilibrium relates to a statistical equilibrium relationship rather than an equilibrium condition soundly rooted in economic theory.

3.4 Methodology

The objective of the study is to empirically test for the growth-saving causality in India, using a suitable methodology.

This section elaborates on the methodology adopted for empirical analysis. It undertakes a discussion on the following:

a. Problem Stated
b. Specification of Variables
c. Steps in Causality Test
d. Time Period and Sources of Data

a. Problem Stated

The problem is one of identifying the causal relationship between growth and saving. *Whether it is economic growth that causes saving or is it saving which leads to growth?* The following algebraic relationships are to be tested for causality.

$$S = f[Y]$$
$$Y = f[S]$$

There are several possible cases of causation which may be stated as:

i. Y causes S but S does not cause Y,
⇒ Uni-directional causation from Y to S [Y→ S]

ii. S causes Y but Y does not cause S,
⇒ Uni-directional causation from S to Y [S→Y]

iii. Y causes S and S causes Y,
⇒ Bi-directional causation between Y and S [Y⇄ S]

iv. Y does not cause S and S does not cause Y,
⇒ Y and S are independent
Or, no causal relationship between Y and S [Y~~ S]

b. <u>Specification of Variables</u>

Before we commence to test causation between saving and economic growth through statistical techniques, an important question arises, *whether one should take the level of income, or rate of growth in income, or first difference of income as the income variable? On the saving side, the choice varies between saving levels, saving rate, change in saving and rate of growth in saving.* IMF study by Muhleisen [1997] opted to test causality between real GDP growth and levels of saving, and also between growth and change or difference in saving. RBI study by Ray and Bose [1997] ran causality regressions between first difference of income [ΔY] and saving [ΔS] for detecting the causal link between real saving and real GDP in the Indian economy. Sethi [1999] tried to test the causal linkage between saving and income, at levels.

Recent studies [such as Sinha and Sinha (1998), Sinha (1999), Sinha (2000), Anoruo and Ahmad (2001), Baharumshah et. al (2003) and Mohan (2006)] examined the causal relationship between the growth rate of saving and economic growth rate. Majority studies are using the growth rate of saving vis-à-vis economic growth rate because of the problem of unit roots in other definitions of savings.
The variable definitions used in the study are discussed below.

Saving

The Saving variable used are -

S : Saving at Levels

ΔS/S : Growth Rate of of Saving

Saving [S] has been defined as Gross Domestic Saving [GDS] at current prices.

Income

The Income measures used for the causality analysis are -

Y : Income at Levels

ΔY/Y : Growth Rate of Income [Economic Growth Rate]

The income measures have been alternatively defined as -

Y : Nominal National Income
[Gross Domestic Product at current market prices]

Y_{fc} : Nominal National Income at factor cost
[Gross Domestic Product at factor cost current prices]

YNA_{fc} : Nominal Non-agricultural Income at factor cost
[Non-agricultural Income at factor cost current prices]

Why Non-agricultural Income?

It is important to find out the effect of income accruing in the non-agricultural sector of the economy on savings, or the role of savings in income generation in this sector. The agricultural sector is characterised by paucity of funds, as evident from the figures of investment in agriculture. Investment in agriculture as a percent of GDP has generally been low ranging between 1.4 percent and 1.6 percent over the seven years from 1993-94 to 1999-00. In 1999-00, when investment in agriculture stood at 1.5 percent of GDP, the ratio of capital formation in agriculture to agricultural GDP was only 8.0 percent. Moreover, the share of agriculture in GDP has moved downhill from 56.0 percent in the decade of fifties to 28.5 percent in 1990s, the sector contributing only 14.8 percent to GDP growth in the post reform phase.

On the contrary, the share of industry and services in GDP has increased perceptively over the last five decades, particularly the service sector, with a contribution of 57.6 percent to GDP growth in the 1990s. Thus, the facts and figures indicate that the inclusion of agricultural sector's income dilutes the national income data, as obviously, this sector receives an unfavourably low investment, which leads to low capital formation, low productivity, declining share in GDP, low agricultural growth rate and a low contribution towards GDP growth. Savings appear to be largely directed towards the non-agricultural sector for investment and growth. A large part of non-agricultural savings also enters the capital market through financial institutions, which becomes available for capital formation and growth.

c. **Steps in Causality Test**

The present study uses Granger causality test using the cointegration approach, which involves the following steps:

1. Unit Root Test
2. Cointegrating Regression
3. Cointegration Test
4. Error Correction Model
5. Granger Causality Test

1. Unit Root Test

The first step employed for testing Granger causality between saving and growth in India is to test the variables for stationarity or the presence of unit roots. The Augmented Dickey-Fuller [ADF] test has been performed on the respective saving and income variables using Ordinary Least Squares method. The ADF test equation has a constant term and number of lag = 1.

The model for ADF test with Saving [S] as the variable to be tested for unit roots is stated as:

$$\Delta S_t = \beta_1 + \delta S_{t-1} + \alpha \Delta S_{t-1} + \varepsilon_t \qquad \text{Eq.1.}$$

If the relevant test statistics confirm that series S is stationary, S is said to be integrated of the order zero [I(0)]. In case the series is not stationary, the ADF test is repeated for the first differenced saving series [ΔS]. In that case, ΔS becomes the variable to be tested for unit roots.

The ADF test equation thus estimated is:

$$\Delta^2 S_t = \beta + \delta \Delta S_{t-1} + \lambda \Delta^2 S_{t-1} + \varepsilon_t \qquad \text{Eq.2.}$$

If ΔS becomes stationary, we conclude that S is integrated of the order one [I(1)], or else, repeat the same exercise of ADF test with successive differencing of time series till it becomes stationary.

All the three Income variables [Y, Y_{fc}, and YNA_{fc}] are also tested for unit roots following the same procedure.

If both the saving and income variables are integrated of the same order, say I[d], we proceed with the test for cointegration between them. This condition has to be fulfilled since it is a pre-condition for testing cointegration.

2. Cointegrating Regression

Once the unit root test has been conducted, the long-run equation is estimated for the non-stationary series of Saving [S] and Income [Y, Y_{fc}, YNA_{fc}]. Ordinary Least Squares method is used to estimate the cointegrating regression of the form:

$$S_t = \beta_1 + \beta_2 Y_t + u_t \qquad \text{Eq.3.}$$

The residual series u_t is derived from the above cointegrating regression for the purpose of cointegration test. The cointegrating equation is useful in analyzing the long-run response of variables.

3. Cointegration Test

Cointegration test requires the residual series obtained in the earlier step to be tested for unit roots. If a linear combination of two I[d] time series yields a residual series which is stationary or integrated of an order lower than I[d], then the two I[d] time series are cointegrated.

In order to find out if the residual series derived from Equation 3 is stationary or not, we have plotted the residual series [u_t] against time. This is only a preliminary exercise for confirming the level of stationarity of the residual series. Graphs have been plotted for each one of the residuals or error terms obtained from the respective cointegrating regressions.

➢ *Augmented Engle-Granger [AEG] Test*

The Augmented Engle-Granger [AEG] test has been used to detect the presence of unit roots in the residual series derived from the cointegrating regression. It is similar to the ADF test stated earlier.

A linear combination of S_t and Y_t yields the residual series u_t:

$$u_t = S_t - \beta_1 - \beta_2 Y_t \qquad \text{Eq.4.}$$

The model for the ADF regression estimated for examining stationarity of the residual variable has been stated as:

$$\Delta u_t = \delta u_{t-1} + \alpha \Delta u_{t-1} + v_t \qquad \text{Eq.5.}$$

The ADF test equation is without a constant and a trend, and the number of lags of the dependent residual variable is equal to one.

If the residual is found to be stationary at a lower order than that of S_t and Y_t, the latter pair of variables are said to be cointegrated, that is, S_t and Y_t share a long-run equilibrium relationship.

Cointegration between a pair of variables implies Granger causality in atleast one direction although it does not tell the actual direction of causal influence.

[The CRDW test is used only for making a quick approximate on cointegration between saving and income variables. The CRDW test results have been reported in Appendix I. The final inference on cointegration is however based on the outcome of AEG test alone.]

4. Error Correction Model

Once cointegration is established between S_t and Y_t series, we proceed with the error correction modelling to detect the direction of causality between savings and income. The Error Correction Mechanism [ECM] is modelled for stationary S_t and Y_t variables. Assuming that S_t and Y_t are first difference stationary [I(1)] variables, the ECM can be estimated as:

$$\Delta S_t = \alpha_0 + \alpha_1 \Delta Y_t + \alpha_2 u_{t-1} + \varepsilon_t \qquad \text{Eq.6.}$$

Where u_{t-1} is the lagged residual term of the cointegrating regression and is also called as the Error Correction Term [ECT]. The ECM has mainly been used to study the short-run response of variables. Also, the sign and significance of the coefficient of the error correction term provides an additional parameter for confirming cointegration between S_t and Y_t.

5. Granger Causality Test

The direction of causal relationship between saving and income is examined using the Vector Error Correction Model [VECM]. This model enables the identification of short-run as well as long-run causality. The Error Correction Term [ECT] which is the lag of residual variable is augmented in the standard causality regressions for the VECM. The VECM uses stationary saving and income variables: ΔS and ΔY, in this case.

The model for Granger Causality can be presented as:

$$\Delta S_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta S_{t-i} + \sum_{j=1}^{n} \gamma_j \Delta Y_{t-j} + \delta \, ECT_{t-1} + u_t \qquad \text{[Eq.7.]}$$

$$\Delta Y_t = a + \sum_{i=1}^{q} b_i \Delta Y_{t-i} + \sum_{j=1}^{r} c_j \Delta S_{t-j} + d \, ECT_{t-1} + v_t \qquad \text{[Eq.8.]}$$

ECT is the error correction term obtained as a residual from the cointegrating regression in Step 2. δ and d denote the speed of adjustment along the long-run equilibrium path.

Interpretation of the above set of equations involves the following:

ΔY Granger causes ΔX if,
H_o: $\gamma_1 = \gamma_2 = \gamma_3 = \ldots\ldots = \gamma_n = 0$ is rejected against H_a: at least one $\gamma_j \neq 0$, $j = 1, \ldots.n$; or $\delta \neq 0$.

ΔX Granger causes ΔY if,
H_o: $c_1 = c_2 = c_3 = \ldots\ldots = c_r = 0$ is rejected against H_a: at least one $c_j \neq 0$, $j = 1, \ldots.r$; or $d \neq 0$.

Equation [7] in the causality model determines whether Y_t Granger causes S_t and Equation [8] confirms whether S_t Granger causes Y_t, or not. There are three outcome possibilities of Granger causality test for cointegrated variables:

i. Y_t Granger causes S_t *uni-directionally.*
ii. S_t Granger causes Y_t *uni-directionally.*
iii. Y_t Granger causes S_t and S_t Granger causes Y_t, *bi-directionally.*

d. Time Period and Sources of Data

The analysis on saving-growth causality in India covers the entire post-planning period ranging from 1950-51 to the recent 2003-04.

The analysis is conducted using annual data of relevant variables. Majority of the data for the present analysis have been compiled from various issues of the Handbook of Statistics on Indian Economy [RBI]. Nominal Non-agricultural income at factor cost [YNA_{fc}] has been obtained from two sources - National Accounts Statistics of India [EPWRF] for the years 1950 to 1969 and from Handbook of Statistics on Indian Economy [RBI] for the period 1970 to 2003.

3.5 Empirical Results

To examine the causality between saving and economic growth in India, Granger causality test has been performed using the *cointegration approach.* Causality is tested between saving and income variables of two different specifications. The saving specifications used in the study are Saving at Levels [S] and Growth Rate of Saving [$\Delta S/S$]. The income specifications taken in the study are Income at Levels [Y] and Growth Rate of Income or Economic Growth Rate [$\Delta Y/Y$].

Saving is defined as Gross Domestic Saving [GDS] throughout the analysis and income has been used alternatively as Nominal National Income [Y], Nominal National Income at factor cost [Y_{fc}] and Nominal Non-agricultural Income at factor cost [YNA_{fc}].

Suffice to mention here that the a priori requirement for cointegration test is that both dependent and independent variables should be stationary at the same level. Hence, the saving variables [S and $\Delta S/S$] and income variables [Y, Y_{fc}, YNA_{fc} and $\Delta Y/Y$, $\Delta Y_{fc}/Y_{fc}$, $\Delta YNA_{fc}/YNA_{fc}$] have been subject to unit root test to find out the level of stationarity. Thereafter, these variables have been paired [based on the level of stationarity] for cointegrating regressions.

In the second step, after finding out the residual series from the cointegrating regression, the existence or absence of the long-run relationship between the saving and income variables have been examined using the Augmented Engle-Granger [AEG] test. And finally, these pairs were tested for causality using Granger causality test. The empirical results have been presented in the following order:

1. Unit Root Test
2. Cointegrating Regression
3. Cointegration Test
4. Error Correction Model
5. Granger Causality Test - VEC Models
6. Granger Causality Test - Wald's F test

1. <u>Unit Root Test</u>

The results of the Augmented Dickey-Fuller [ADF] test for unit root have been given in Table No.3 and 4. Table No.3 provides the ADF test and the order of integration for Saving [S] and Income [Y, Y_{fc} and YNA_{fc}] at levels. It also gives the Mackinnon critical values for rejection of hypothesis of a unit root in the variables tested for stationarity.

Table No.4 provides the ADF test and the order of integration for Growth Rate of Saving [ΔS/S] and Growth Rate of Income [ΔY/Y, $\Delta Y_{fc}/Y_{fc}$ and $\Delta YNA_{fc}/YNA_{fc}$].

➢ <u>Saving and Income</u>

Table: 3 — **Unit Root Test [Saving and Income at Levels]**

Augmented Dickey-Fuller Test with a Drift Term
Lag = 1
Time Period : 1950-51 to 2003-04

Variables	ADF Test Statistic[@]			Order of Integration
	Level	First Difference	Second Difference	
Saving				
1. S	6.24	0.89	-6.36*	I [2]
Income				
1. Y	3.38	2.19	-3.68*	I [2]
2. Y_{fc}	3.45	2.48	-3.98*	I [2]
3. YNA_{fc}	2.31	2.49	-5.44*	I [2]
	Mackinnon Critical Values : 1% = -3.565	5% = -2.920	10% = -2.598	

@ Significance is based on Mackinnon critical values for rejection of hypothesis of a unit root.
* = Significant at 1%, ** = Significant at 5%, *** = Significant at 10%

➢ Growth Rate of Saving and Growth Rate of Income

Table: 4 **Unit Root Test #**

[Growth Rates of Saving and Income]

Augmented Dickey-Fuller Test with a Drift Term
Lag = 1
Time Period : 1950-51 to 2003-04

Variables	Level	First Difference	Order of Integration
Saving			
1. $\Delta S/S$	-7.44^{*}	-	I[0]
Income			
1. $\Delta Y/Y$	-4.06^{*}	-	I[0]
2. $\Delta Y_{fc}/Y_{fc}$	-4.16^{*}	-	I[0]
3. $\Delta YNA_{fc}/YNA_{fc}$	-3.39^{**}	-	I[0]
	Mackinnon Critical Values : 1% = -3.565 5% = -2.920 10% = -2.598		

Significance is based on Mackinnon critical values for rejection of hypothesis of a unit root.
* = Significant at 1%, ** = Significant at 5%, *** = Significant at 10%

The following inferences are made from the unit root test results:

i. With reference to Table No.3, it is observed that both saving and income are integrated of the same order [I(2)] and hence can be used for the following cointegrating regressions.

$$S = f\,[Y]$$
$$S = f\,[Y_{fc}]$$
$$S = f\,[YNA_{fc}]$$

ii. The observation made from Table No.4. is that growth rate of saving [ΔS/S] as well as growth rate of income [ΔY/Y] are integrated of the order zero [I(0)] and are therefore stationary at levels. As both these variables are stationary, the two are not subject to cointegration test. Causality between these two variables is tested using Granger causality based on Wald's F-test.

$$\Delta S/S = f\,[\Delta Y/Y]$$
$$\Delta S/S = f\,[\Delta Y_{fc}/Y_{fc}]$$
$$\Delta S/S = f\,[\Delta YNA_{fc}/YNA_{fc}]$$

2. Cointegrating Regression

After finding out the order of integration for saving and income variables, we proceed with the estimation of long-run equations by regressing Saving [S] upon each one of the Income variables [Y, Y_{fc}, YNA_{fc}] individually. We estimated the following cointegrating regressions:

$$S = a + bY \quad \text{Eq.1.}$$

$$S = a + bY_{fc} \quad \text{Eq.2.}$$

$$S = a + bYNA_{fc} \quad \text{Eq.3.}$$

The cointegrating regressions are presented in Table 5.

Table: 5 **Cointegrating Regressions**

Method : Ordinary Least Squares *Dependent Variable : Nominal Gross Domestic Saving [S]*
Time Period : 1950-51 to 2003-04

Eqn. No.	Coefficient of Independent Variables and [t-values]				R^2	$\bar{R}^2$	D-W
	Intercept	*Y*	Y_{fc}	YNA_{fc}			
1.	-8159.633 [2.79]	0.251 [73.70]*	-	-	0.99	0.99	0.72
2.	-7816.370 [2.69]	-	0.275 [73.96]*	-	0.99	0.99	0.78
3.	-2452.252 [1.08]	-	-	0.365 [93.375]*	0.99	0.99	1.025

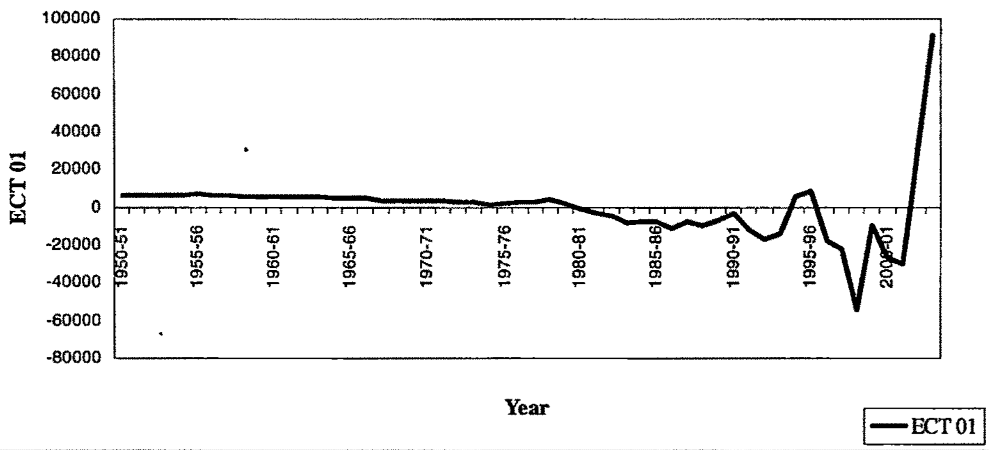
* t-values are significant at 1% level.

The coefficient values of the explanatory variables represent the long-run marginal propensity to save [MPS]. The long-run marginal propensity to save is strongest in the case of income from the non-agricultural sector, which is 0.365.

The cointegrating regressions are mainly required to derive the residual series which are to be used further in the analysis for test for cointegration.

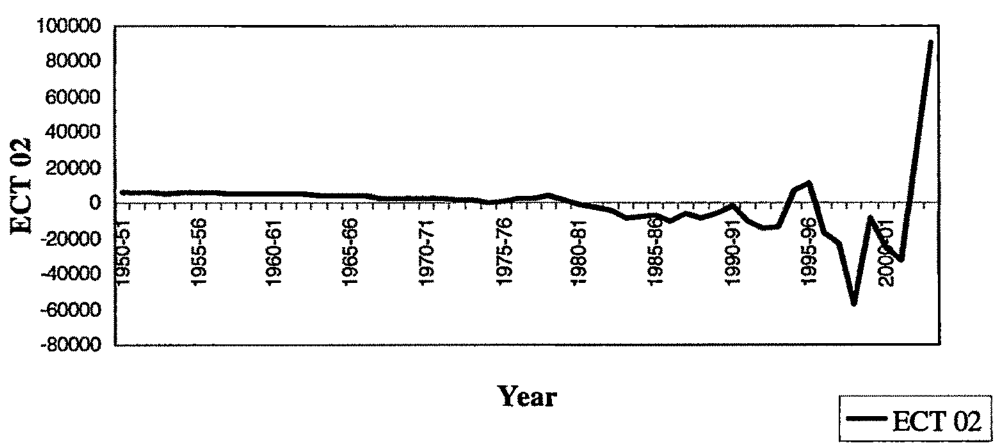
The results of cointegration test are presented in Table 6. But prior to it, we have plotted the residuals obtained from each cointegrating regression against time. The residuals derived from the three regressions [stated above - Eq. 1, Eq. 2 and Eq. 3] are denoted by ECT 01, ECT 02 and ECT 03 respectively. The residual series have been plotted against time for observing whether they are stationary or not. This is only a preliminary exercise for confirming stationarity in the residuals.

Chart: 5 **Residual [ECT 01] against Time**

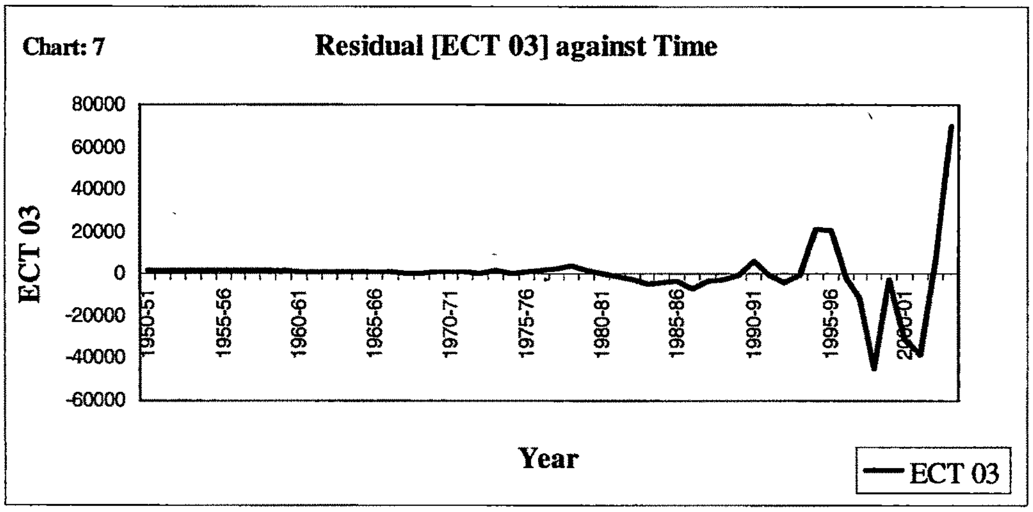


The above Chart 5 shows the behaviour of the residual obtained rom the cointegrating regression between S and Y. ECT 01 is stationary since it does not exhibit a continuous rising or falling trend.

Chart: 6 **Residual [ECT 02] against Time**



The above Chart 6 shows that the residual series obtained from the cointegrating regression between S and Y_{fc} is stationary. ECT 02 does not exhibit a sustained upward or downward trend and is therefore stationary.



The above Chart 7 shows the behaviour of the residual series derived from the cointegrating regression between S and YNA_{fc}. ECT 03 fluctuates around the x-axis and is free of any continuous upward or downward trend. Therefore, ECT 03 appears to be stationary.

The final inference on whether there exists a stable long-run relationship or cointegration between saving and income variables respectively is based on the results of Augmented Engle-Granger [AEG] tests.

3. Cointegration Test

The Augmented Engle-Granger [AEG] test results are presented in Table 6.

Table: 6 **Test for Cointegration**

Time Period : 1950-51 to 2003-04

Eqn. No.	Variables		AEG Test# — ADF Test Statistic for Residual$				Inference
	Dependent	*Independent*	*Residual*	*Level*	*Order of Integration*	*Cointegration*	
1.	S	Y	ECT 01	-2.49**	I[0]	Yes	Cointegrated : implies Granger causality
2.	S	Y_{fc}	ECT 02	-2.76*	I[0]	Yes	Cointegrated : implies Granger causality
3.	S	YNA_{fc}	ECT 03	-4.30*	I[0]	Yes	Cointegrated : implies Granger causality
			Mackinnon Critical values: 1% = -2.607		5% = -1.947	10% = -1.619	

ADF test equation for unit root test of residual is without a constant and trend. It carries a lag of one-period for the dependent residual variable.
$ Significance is based on Mackinnon critical values for rejection of hypothesis of a unit root.
* = Significant at 1%, ** = Significant at 5%, *** = Significant at 10%

The results of the AEG test confirm the absence of unit root in the series of residuals. All the three residual series ECT 01, ECT 02 and ECT 03 are integrated of the order zero [I(0)] which is less than the order of integration of saving and income variables which are integrated of the second order [I(2)]. Therefore, as per Engle and Granger [1987] specifications, the following variable pairs - S and Y, S and Y_{fc}, and S and YNA_{fc} are cointegrated. The test confirms a stable long-run relationship between the three pairs of saving and income variables. This obviously implies the existence of Granger causality between S and Y, S and Y_{fc} and S and YNA_{fc}.

In order to determine the direction of causality and whether causality is uni-directional or bi-directional, we have developed the Vector Error Correction Model [VECM] for Granger causality test. But before that, we present the results of the Error Correction Model [ECM] which examines the short-turn dynamics between saving and income.

4. Error Correction Model

After establishing the long-run relationship between sets of saving and income variables, the Error Correction Model [ECM] is estimated to understand the short-run dynamics of saving-income relationship. The error correction model has been estimated for each pair of saving and income variables [S - Y, S - Y_{fc} and S - YNA_{fc}]. The ECM is estimated for stationary saving and income variables, including a lagged Error Correction Term [ECT] obtained from the cointegrating regression. The error correction models have been presented in Table 7 below.

Table: 7 **Error Correction Mechanism**

Method : Ordinary Least Squares — *Dependent Variable :* $\Delta^2 S$

Time Period : 1950-51 to 2003-04

Eqn. No.	Coefficient of Independent Variables and [t-values]									
	Intercept	$\Delta^2 Y$	$\Delta^2 Y_{fc}$	$\Delta^2 YNA_{fc}$	$ECT\ 01_{-1}$	$ECT\ 02_{-1}$	$ECT\ 03_{-1}$	R^2	$\bar{R}^2$	*D-W*
1.	-613.576 [0.265]	0.295 [2.72]*	-	-	-0.801 [4.54]*	-	-	0.33	0.31	2.41*
2.	253.020 [0.11]	-	0.147 [1.19]	-	-	-0.843 [4.54]*	-	0.29	0.27	2.14*
3.	-954.365 [0.48]	-	-	0.529 [2.82]*	-	-	-1.114 [6.15]*	0.53	0.51	2.46*

* Significant at 1% level

The stationary saving and income variables are:

$\Delta^2 S$	=	Second Difference of Nominal Gross Domestic Saving
$\Delta^2 Y$	=	Second Difference of Nominal National Income
$\Delta^2 Y_{fc}$	=	Second Difference of Nominal National Income at factor cost
$\Delta^2 YNA_{fc}$	=	Second Difference of Nominal Non-agricultural Income at factor cost

The following observations can be made from the Error Correction Model [ECM] stated above:

i. The error correction model for the saving and income pairs are not spurious. The D-W values are higher than the R^2 values. D-W values for all the three models are significant at 1% level of significance, indicating that there is no problem of either positive or negative first-order autocorrelation in the residuals.

ii. The R^2 and $\bar{R}^2$ values are very poor for two of the models as given in Equations 1 and 2. The short-run marginal propensity to save with respect to national income is almost same as the long-run marginal propensity to save. The short-run marginal response of saving to national income at factor cost is only 0.147, implying that their long-run marginal relationship is stronger than the short-run marginal relationship.

   The model for saving and non-agricultural income at factor cost [Equation 3] gives better results with a high value of short-run marginal propensity to save, significant t-values of explanatory variables and an improvement in other significance parameters.

iii. The coefficients of all the three error correction terms [ECT 01, ECT 02 and ECT 03] or speed of adjustment parameters are significantly negative, which reconfirms cointegration between the respective saving and income pairs, thereby providing an additional support for cointegration or the existence of a long-run equilibrium relationship between saving and income.

iv. The coefficients of the error correction terms show the speed of adjustment between saving and income variables. The adjustment parameters indicate that 0.80 of the discrepancy between saving and national income, and 0.84

of the discrepancy between saving and national income at factor cost in the previous year is eliminated in the current year. Savings would fall by 1.11 points in the current year to restore long-run equilibrium between saving and non-agricultural income at factor cost.

5. Granger Causality Test - VEC Model

Granger causality results provide evidence on the direction of causality between saving and income. Granger tests based on Vector Error Correction Models [VECM] also explain the existence or absence of short-run and long-run causality between variables, and the direction of causal link between them, whether uni-directional or bi-directional.

The following tables display the causality results. Tables 8a and 8b present the VECM for the pair of saving and national income [S and Y]. The nature of causal relationship between saving and national income at factor cost [S and Y_{fc}] is given by Tables 9a and 9b whereas Tables 10a and 10b present the causality results between saving and non-agricultural income at factor cost [S and YNA_{fc}].

The interpretation of the tables mentioned above involves the following:

i. If the coefficients of the independent variables are jointly significant [as a group], or coefficient of at least one independent variable is significantly away from zero, it explains the short-run causality from the independent to the dependent variable.

ii. If the coefficient of the error correction term [ECT] is significantly away from zero, it indicates long-run causality from the independent to the dependent variable.

If the above two conditions are satisfied, it can be deduced that the independent variable Granger causes the dependent variable uni-directionally both in the short-run and long-run.

The same principle is applied for examining the causal influence in the opposite direction. The final conclusion on uni-directional or bi-directional causality between the variables is made on the basis of the results obtained from the above two cases.

Table: 8a	**Granger Causality Test [Y to S]**			
Dependent Variable: Δ^2S				
Method: Ordinary Least Squares				
Time Period : 1950-2003				
Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
C	4590.730	1790.805	2.564	0.014
Δ^2S_{-1}	-0.445	0.182	-2.438	0.019
Δ^2S_{-2}	-0.278	0.194	-1.430	0.160
Δ^2S_{-3}	-0.436	0.159	-2.747	0.009
Δ^2Y_{-1}	0.382	0.113	3.393	0.002
Δ^2Y_{-2}	-0.505	0.148	-3.401	0.002
Δ^2Y_{-3}	-0.396	0.183	-2.165	0.036
ECT 01_{-1}	-0.501	0.150	-3.335	0.002
R-squared :	*0.739*	*F-statistic :*		*16.613*
Adjusted R-squared :	*0.695*	*Prob[F-statistic] :*		*0.000*
D-W statistic :	*1.419*			

Inference:

The explanatory variables Δ^2Y are jointly significant in explaining Δ^2S. This explains the short-run causality from Y to S. Also, the coefficient of error correction term is significantly away from zero which indicates long-run causality from Y to S. **Therefore, Y Granger causes S uni-directionally both in short-run and long-run.**

Table: 8b	**Granger Causality Test [S to Y]**			
Dependent Variable: Δ^2Y				
Method: Ordinary Least Squares				
Time Period : 1950-2003				
Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
C	5921.358	2888.737	2.050	0.047
Δ^2Y_{-1}	-0.167	0.182	-0.921	0.363
Δ^2Y_{-2}	-0.394	0.239	-1.645	0.108
Δ^2Y_{-3}	0.609	0.295	2.061	0.046
Δ^2S_{-1}	0.594	0.294	2.020	0.050
Δ^2S_{-2}	-0.207	0.314	-0.661	0.512
Δ^2S_{-3}	-0.803	0.256	-3.138	0.003
ECT 01_{-1}	0.180	0.243	0.741	0.463
R-squared :	*0.429*	*F-statistic :*		*4.393*
Adjusted R-squared :	*0.331*	*Prob[F-statistic] :*		*0.001*
Durbin-Watson stat :	*1.464*			

Inference:

The joint significance of the explanatory variables Δ^2S confirm short-run causality from S to Y. However, there is lack of long-run causality from S to Y since the adjustment parameter for the error correction term is not significantly away from zero. **Therefore, S Granger causes Y uni-directionally in short-run but not in long-run.**

Final Conclusion:

Short-run causality is bi-directional between S and Y. However, long-run causality runs uni-directionally from Y to S.

Table: 9a	**Granger Causality Test [Y_{fc} to S]**			
Dependent Variable: $\Delta^2 S$				
Method: Ordinary Least Squares				
Time Period : 1950-2003				
Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
C	3807.404	1651.352	2.306	0.026
$\Delta^2 S_{-1}$	-0.375	0.178	-2.107	0.041
$\Delta^2 S_{-2}$	-0.311	0.167	-1.867	0.069
$\Delta^2 S_{-3}$	-0.561	0.141	-3.985	0.000
$\Delta^2 Y_{fc-1}$	0.534	0.107	5.016	0.000
$\Delta^2 Y_{fc-2}$	-0.366	0.157	-2.337	0.024
$\Delta^2 Y_{fc-3}$	-0.485	0.186	-2.605	0.013
ECT 02_{-1}	-0.481	0.139	-3.455	0.001
R-squared :	*0.781*	*F-statistic :*		*20.891*
Adjusted R-squared :	*0.744*	*Prob[F-statistic] :*		*0.000*
Durbin-Watson stat :	*1.420*			

Inference:

There exists short-run causality from Y_{fc} to S as revealed by the joint significance of the explanatory variables $\Delta^2 Y_{fc}$. Adjustment parameter of the error correction term is also significantly away from zero, explaining long-run causality from Y_{fc} to S. **Therefore, Y_{fc} Granger causes S uni-directionally in short-run as well as in long-run.**

Table: 9b	**Granger Causality Test [S to Y_{fc}]**			
Dependent Variable: $\Delta^2 Y_{fc}$				
Method: Ordinary Least Squares				
Time Period : 1950-2003				
Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
C	4924.049	2706.489	1.819	0.076
$\Delta^2 Y_{fc-1}$	-0.192	0.175	-1.097	0.279
$\Delta^2 Y_{fc-2}$	-0.333	0.257	-1.294	0.203
$\Delta^2 Y_{fc-3}$	0.786	0.305	2.579	0.014
$\Delta^2 S_{-1}$	0.600	0.292	2.056	0.046
$\Delta^2 S_{-2}$	-0.265	0.274	-0.968	0.339
$\Delta^2 S_{-3}$	-0.463	0.231	-2.006	0.052
ECT 02_{-1}	0.338	0.228	1.478	0.147
R-squared :	*0.422*	*F-statistic :*		*4.280*
Adjusted R-squared :	*0.324*	*Prob[F-statistic] :*		*0.001*
Durbin-Watson stat :	*1.401*			

Inference:

The explanatory variable $\Delta^2 S$ is jointly significant in explaining $\Delta^2 Y_{fc}$. This implies the existence of short-run causality from S to Y_{fc}. There is no evidence of long-run causality from S to Y_{fc} as suggested by the speed of adjustment [coefficient of the error correction term] which is insignificant. **Therefore, S Granger causes Y_{fc} uni-directionally only in the short-run.**

Final conclusion:

There exists bi-directional causality between S and Y_{fc} in the short-run whereas long-run causality is found to be running uni-directionally from Y_{fc} to S.

Table: 10a	Granger Causality Test $[YNA_{fc}$ to S]			
Dependent Variable: $\Delta^2 S$				
Method: Ordinary Least Squares				
Time Period : 1950-2003				
Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
C	2364.764	1805.120	1.310	0.198
$\Delta^2 S_{-1}$	-0.690	0.134	-5.135	0.000
$\Delta^2 S_{-2}$	-0.634	0.191	-3.316	0.002
$\Delta^2 S_{-3}$	-0.348	0.171	-2.028	0.049
$\Delta^2 YNA_{fc-1}$	0.745	0.188	3.966	0.000
$\Delta^2 YNA_{fc-2}$	0.167	0.215	0.778	0.441
$\Delta^2 YNA_{fc-3}$	-0.676	0.193	-3.510	0.001
ECT 03_{-1}	-0.854	0.155	-5.500	0.000
R-squared :	*0.763*	*F-statistic :*		*18.900*
Adjusted R-squared :	*0.723*	*Prob[F-statistic] :*		*0.000*
Durbin-Watson stat :	*1.628*			

Inference:

The joint significance of the explanatory variables $\Delta^2 YNA_{fc}$ reveals short-run causality from YNA_{fc} to S. A highly significant error correction term also indicates long-run causality from YNA_{fc} to S. **Therefore, YNA_{fc} Granger causes S uni-directionally in short-run as well as in long-run.**

Table: 10b	Granger Causality Test [S to YNA_{fc}]			
Dependent Variable: $\Delta^2 YNA_{fc}$				
Method: Ordinary Least Squares				
Time Period : 1950-2003				
Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
C	1967.561	1439.779	1.367	0.179
$\Delta^2 YNA_{fc-1}$	0.367	0.150	2.447	0.019
$\Delta^2 YNA_{fc-2}$	-0.310	0.171	-1.809	0.078
$\Delta^2 YNA_{fc-3}$	0.502	0.154	3.267	0.002
$\Delta^2 S_{-1}$	0.093	0.107	0.867	0.391
$\Delta^2 S_{-2}$	-0.271	0.152	-1.780	0.082
$\Delta^2 S_{-3}$	0.007	0.137	0.050	0.960
ECT 03_{-1}	-0.162	0.124	-1.307	0.198
R-squared :	*0.469*	*F-statistic :*		*5.166*
Adjusted R-squared :	*0.378*	*Prob[F-statistic] :*		*0.000*
Durbin-Watson stat :	*2.091*			

Inference:

Atleast one explanatory variable $\Delta^2 S_{-2}$ is significantly explaining $\Delta^2 YNA_{fc}$. Therefore, short-run causality runs from S to YNA_{fc}. The adjustment parameter for the error correction term is insignificant, thereby unable to explain long-run causality from S to YNA_{fc}. **Therefore, S Granger causes YNA_{fc} uni-directionally in short-run alone.**

Final Conclusion:

Bi-directional short-run causality exists between S and YNA_{fc}. However, long-run causality is uni-directional from YNA_{fc} to S.

➢ Final Summary - VEC Model

Causality Test Results			
Sr. No.	***Variables***	***Short-run Causality***	***Long-run Causality***
1.	S - Y	S $\rightleftarrows$ Y	Y $\rightarrow$ S
2.	S - Y_{fc}	S $\rightleftarrows$ Y_{fc}	Y_{fc} $\rightarrow$ S
3.	S - YNA_{fc}	S $\rightleftarrows$ YNA_{fc}	YNA_{fc} $\rightarrow$ S

Granger causality test results for the VEC Models indicate that:

i. Short-run causality is bi-directional in the Indian case for all the three pairs of saving and income at levels - S and Y, S and Y_{fc}, S and YNA_{fc}.

ii. Long-run causality is however uni-directional from Y to S, Y_{fc} to S, YNA_{fc} to S.

In addition to the above tests of Granger causality using the cointegration approach, we have also tried to examine the causal relationship between growth rate of saving and growth rate of income using the Wald's F test. This part of causality analysis has been carried out in the following section.

6. Granger Causality Test - Wald's F test

As found in the unit root tests earlier, the growth rate of saving and growth rate of income are stationary variables, or integrated of the order zero [I(0)]. Hence, standard causality test has been performed on them for determining the nature of causal relationship between them. Wald's F-statistic is used for the purpose.

As already mentioned, the growth rate of saving has been used alternatively with three specifications of growth rate of income. The three pairs of growth rate of saving and growth rate of income tested for Granger causality are;

$\Delta S/S$ and $\Delta Y/Y$
$\Delta S/S$ and $\Delta Y_{fc}/Y_{fc}$
$\Delta S/S$ and $\Delta YNA_{fc}/YNA_{fc}$

The results for Granger causality between growth rate of saving and growth rate of income for these three pairs are reported below. Table 11 presents the Granger causality test results between ΔS/S and ΔY/Y and Table 12 which presents the Granger causality results between ΔS/S and $\Delta Y_{fc}/Y_{fc}$, followed by Table 13 which presents the causality results between ΔS/S and $\Delta YNA_{fc}/YNA_{fc}$.

Table: 11 **Granger Causality Test**

Growth Rate of Saving and Economic Growth Rate

[ΔS/S and ΔY/Y]

Time Period: 1950-2003

Lag: 1

Null Hypothesis:	***Observation***	***F-Statistic***	***Probability***
ΔY/Y does not Granger Cause ΔS/S	52	0.19300	0.66236
ΔS/S does not Granger Cause ΔY/Y	-	3.24728	0.07770

The significance of the F-statistic values in the above table are studied in order to accept or reject the stated null hypothesis. If the computed F-statistic is significant, one can reject the null hypothesis in favour of the alternative hypothesis. The probability results for F-statistic clearly reveals that we cannot reject the null hypothesis that ΔY/Y does not Granger cause ΔS/S but we do reject the hypothesis that ΔS/S does not Granger cause ΔY/Y. **Therefore, our results support one-way Granger causality from ΔS/S to ΔY/Y and not the other way.**

The results of the causality test between ΔS/S and $\Delta Y_{fc}/Y_{fc}$ is presented in Table 12.

Table: 12 **Granger Causality Test**

Growth Rate of Saving and Economic Growth Rate

[ΔS/S and $\Delta Y_{fc}/Y_{fc}$]

Time Period: 1950-2003

Lag: 1

Null Hypothesis:	***Observation***	***F-Statistic***	***Probability***
$\Delta Y_{fc}/Y_{fc}$ does not Granger Cause ΔS/S	52	0.09057	0.76473
ΔS/S does not Granger Cause $\Delta Y_{fc}/Y_{fc}$	-	3.04638	0.08719

In Table 12, the probability results for F-statistic reveal that we cannot reject the null hypothesis that $\Delta Y_{fc}/Y_{fc}$ does not Granger cause ΔS/S but we can reject the null hypothesis that ΔS/S does not Granger cause $\Delta Y_{fc}/Y_{fc}$. **Therefore, in this case too, the results support a uni-directional causation from ΔS/S to $\Delta Y_{fc}/Y_{fc}$.**

The Wald's F-test results for testing causality between $\Delta YNA_{fc}/YNA_{fc}$ and $\Delta S/S$ is presented in Table13.

Table: 13	Granger Causality Test *Growth Rate of Saving and Economic Growth Rate* [$\Delta S/S$ and $\Delta YNA_{fc}/YNA_{fc}$]		
Time Period: 1950-2003 Lags: 1			
Null Hypothesis:	***Observation***	***F-Statistic***	***Probability***
$\Delta YNA_{fc}/YNA_{fc}$ does not Granger Cause $\Delta S/S$	52	0.08072	0.77752
$\Delta S/S$ does not Granger Cause $\Delta YNA_{fc}/YNA_{fc}$	-	5.30435	0.02556

Once again, the probability results for F-statistic confirm that the null hypothesis that $\Delta YNA_{fc}/YNA_{fc}$ does not Granger cause $\Delta S/S$ cannot be rejected whereas the null hypothesis that $\Delta S/S$ Granger causes $\Delta YNA_{fc}/YNA_{fc}$ can be rejected. **Therefore, there is a uni-directional causality from $\Delta S/S$ to $\Delta YNA_{fc}/YNA_{fc}$.**

➢ Final Summary - Wald's F-Test

Causality Test Results		
Sr. No.	***Variables***	***Causal Relationship***
1.	$\Delta S/S$ - $\Delta Y/Y$	$\Delta S/S \rightarrow \Delta Y/Y$
2.	$\Delta S/S$ - $\Delta Y_{fc}/Y_{fc}$	$\Delta S/S \rightarrow \Delta Y_{fc}/Y_{fc}$
3.	$\Delta S/S$ - $\Delta YNA_{fc}/YNA_{fc}$	$\Delta S/S \rightarrow \Delta YNA_{fc}/YNA_{fc}$

The summary of Granger test results for Wald's F-test reveals that in the Indian case, the growth rate of saving Granger-causes growth rate of income uni-directionally for all the three pairs of growth rate of saving and economic growth rate - $\Delta S/S$ and $\Delta Y/Y$, $\Delta S/S$ and $\Delta Y_{fc}/Y_{fc}$, and $\Delta S/S$ and $\Delta YNA_{fc}/YNA_{fc}$.

3.6 Conclusions

In the first phase, this chapter examined the saving rate and the growth rate relationship in the post-planned period in India and came to the conclusion that India's economic growth rate has not kept pace with the saving rates.

In response to it, this chapter explored various reasons for this kind of saving and income behaviour which is widely termed as the high saving-low growth puzzle. The high saving-low growth riddle has been explained by the following factors:

i. Low investment multiplier
ii. Low overall productivity
iii. Estimation problems
iii. Low investment demand
iv. Low capacity utilisation
v. Structural factors

The main objective of this chapter has been to find out the growth-saving causality in India. In the second phase, the study examined the nature of causal relationship between savings and growth to arrive at the answers to several important questions:

- Is it growth that causes saving?
- Does saving cause growth?
- Is the causal relationship between saving and growth bi-directional?
- Whether there exists a causal relationship between saving and growth at all?

The study examined the causal relationship between Gross Domestic Saving [S] and Income [defined alternatively as nominal national income (Y), nominal national income at factor cost (Y_{fc}) and non-agricultural income at factor cost (YNA_{fc})], using the cointegration approach to Granger causality test.

This empirical analysis involved the following steps:

1. Augmented Dickey-Fuller [ADF] test - Unit Root Test for stationarity.
2. Cointegrating Regression for the residuals.
3. Augmented Engle-Granger [AEG] test - Cointegration test for stationarity of residuals.

4. Error Correction Mechanism [ECM]

5. Granger Causality Test -

   a. Vector Error Correction Model [VECM]

   b. Wald's F-test

Based on the empirical results, the study concludes the following:

i. The Gross domestic saving and income share a uni-directional causal relationship from income to saving in the long-run, meaning thereby that income causes gross domestic saving for all the income variables.

ii. Three alternative measures of National Income [Y, Y_{fc}, YNA_{fc}] were used in the study with Gross Domestic Saving [S], but the causal relationship shared between these variables did not change. The marginal propensity to save [MPS] was found to be nearly the same for all the income measures around 0.3.

iii. On the other hand, saving defined as growth rate of gross domestic saving [$\Delta S/S$] and income defined as growth rate of income [$\Delta Y/Y$, $\Delta Y_{fc}/Y_{fc}$, $\Delta YNA_{fc}/\Delta YNA_{fc}$] share a uni-directional causal relationship from growth rate of saving to growth rate of income. This implies that growth rate of saving causes growth rate of income [or economic growth] for all the income variables but the reverse is not true.

iv. In the short-run, Gross Domestic Saving [S] and National Income [Y, Y_{fc}, YNA_{fc}] share a bi-directional causal relationship, meaning thereby that saving causes income and income causes saving.

iv. From the above results on the causality between saving and growth, the conclusion is made that in India growth rate of saving is not economic growth led.

How well these results compare with other empirical studies?

To answer this, the study carried out a vast survey of literature on the empirical work on causality between growth rates of saving and economic growth and concluded that:

i. Income class of a country plays an important role in determining the direction of causality. The empirical results for high income countries confirmed causality from economic growth to growth rate of savings. In case of upper-middle income countries, causality was found to be bi-directional between economic growth and growth rate of savings. Most of the low-middle income countries experienced causality from economic growth to growth rate of savings. For the low-income countries, the results were mixed on the causal relationship between economic growth and growth rate of savings.

ii. In the country specific studies, *growth to saving causality* was found for the following countries - Pakistan, Mexico and Philippines, whereas *saving to growth causality* was observed in the case of Sri Lanka, Congo and Singapore.

iii. India's results seem to be more towards the capital fundamentalist view which identifies and interprets the strong connection between saving and growth variables as a causal chain running from saving to growth. Also, the results are in consistency with Lewis [1955], who stressed upon the role of savings in initiating economic growth in poor countries.

iv. Saving is not economic growth led in the Indian case. Therefore, to enhance the savings in India, it is not economic growth which is more important. To enhace the savings further, there is a need to focus on framing of saving incentive policies by the government.

If not economic growth then what are the factors which influence the Indian saving growth? This is a very pertinent question has been explored in the next chapter.

Notes

1. Paradoxically, Muhleisen [1997] found household saving for the post-liberalisation period to be underestimated due to non-inclusion of some preferred assets like jewellery and gold. This view gets support from Athukorala and Sen [1995] argument that the decline in the household investment in physical capital and hence in the household saving rate, particularly in the three years following the reform process, is largely the result of an underestimation of GDCF. Thus, agreeing to household physical saving being an underestimate, in the nineties. Although they fail to provide any convincing evidence, they do support the existence of an upward bias in the household financial saving estimates during the same period. In this context, Balakrishnan [1996] observed that in the year 1992-93 the saving rate declined despite an improvement in the growth rate. Thus, contradicting the argument that saving rate is related to the rate of growth.

2. The Chelliah Committee Report identified the following errors in estimation of saving and capital formation statistics:

   [i] Despite being an organised segment, the private corporate sector estimates are subject to errors.

   [ii] The estimates for the household sector carry errors as they are worked out on the basis of the available data from various censuses, sample surveys, research studies and assumed relationships.

   [iii] The estimates of Kutcha construction are weak as it is based on obsolete data / information from distant NSS results.

3. A covariance stationary time-series has a constant unconditional mean and an auto-covariance that is only a function of time displacement.

4. These assumptions include zero mean, constant variance [i.e., homeoscedasticity] and no autocorrelation.

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