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A Causal Investigation of Aggregate Output Fluctuations in India

This article is an attempt to understand the causal factors behind fluctuations in aggregate output. We find an absence of bidirectional causality between the gross domestic product residual and the gross domestic capital formation residual as well as between the GDP residual and the residual of the combined expenditures of the central and state governments, while the causality between the balance of trade residual and GDP residual is weakly unidirectional.

SASIDARAN G

An economy is seldom free from aggregate fluctuations[1] [Romar 2001]. Given the ubiquitous nature of fluctuations in modern economies, one of the central goals of macroeconomists is to identify the causal factors responsible for such aggregate fluctuations.

India's growth pattern is characterised by aggregate fluctuations. In an attempt to identify the plausible factors that could have been instrumental in causing those fluctuations over the years, this paper addresses the issue of causality in India with regard to the variations in aggregate output for the period 1970-71 to 2004-05 in a time-series framework.

The set of variables considered for the study are basically components of aggregate demand. The variables considered are gross domestic product (GDP) at factor cost (measured in constant prices), gross domestic capital formation (GDCF), balance of trade (BOT) and the combined expenditures of the central and state governments.

The widespread use of these aggregate demand components in business cycle research can be offered as an explanation for the choice of those variables for our study here. Some of these variables were extensively considered for study by Prescott (1986) and the following discussion borrows heavily from their study.

We follow Lucas (1977) in defining business cycles as the recurrent fluctuations of output about trend and the co-movements among other aggregate time-series. Initially, we start by forming cycles for different sets of time-series data. We define a cycle as the recurrent fluctuation of output around a fitted trend. In other words, we calculate the residuals for different sets of data which is nothing but the difference between the actual data and the detrended data. We make use of the Hodrick-Prescott filter to detrend the actual time-series data. After detrending the actual time-series data, we find residuals for each of the variables. We then check for the stationarity of the residuals that we formulated using the Augmented Dickey-Fuller test (1979). If one of the residuals was non-stationary we take differences to render that series stationary.

The next step is to check for causality. We use the Granger (1969) technique to examine the direction of causality between the GDP residual and other residuals. We also try to analyse the cross-correlation between the GDP residual and each of the other residuals.

Literature Review

Early analysts of business cycles believed that each cyclical phase of the economy carries within it the seed that generates the next cyclical phase. A boom generates the next recession; that recession generates the next boom; and the economy is caught forever in a self-sustaining cycle. In contrast, the modern theories of business cycles attribute cyclical fluctuations to the cumulative effects of shocks and disturbances that recurrently buffet the economy. In other words, without shocks there are no cycles. The evolution of thought about business cycles from an emphasis on self-sustaining behaviour towards one in which random shocks take centre stage is a significant development in macroeconomics [Chatterjee 2000].

Economic fluctuations thus arise when an economy is perturbed by shocks which then propagate through the economy. There are different schools of thought attributing different hypotheses concerning such shocks and propagation mechanisms to the fluctuations, which continue to remain the major area of conflict between them. The aftermath of the Great Depression in the 1930s and Keynes' *General Theory* marked the dawn of the debate over the source and propagation of economic fluctuations.

The theories of fluctuations are generally divided into two influential schools of thought, the Classicals and the Keynesians. The classical school emphasises "the optimisation of private economic players, the adjustment of relative prices to equate supply and demand and the efficiency of unfettered markets". The Keynesian school believes in appreciating the possibility of market failure on a grand scale in conjunction with analysing the intricacies of general equilibrium to account for economic fluctuations [Mankiw 1989].

A manifestation of the classical view of economic fluctuations is the real business cycle theory, which has gained much attention since the 1980s. The proponents of the real business cycle theory hold persistent real (supply-side) shocks as the predominant factor which generates fluctuations in output and employment. The real business cycle theory rests on the fundamental principle that the only forces that can plausibly cause economic fluctuations are those forces which disturb the Walrasian equilibrium.[2] This extends the

Walrasian paradigm and provides a unified explanation for economic fluctuations.

It is also observed that this division of theories of fluctuations into ones focusing on real shocks impinging on a Walrasian economy and ones focusing on nominal disturbances affecting an economy which is non-Walrasian (the New Keynesian school of thought) is oversimplified in the sense that it omits the possibility of real non-Walrasian theories[3] [Romar 2001]. In an attempt to keep many features of the real business cycle approach intact and also include non-Walrasian ingredients, real business cycle style models have been developed, which focus on general equilibrium.[4]

Most studies on business cycles have their origins in the seminal contribution of Burns and Mitchell (1946). Their contribution was influential because it provided a comprehensive catalogue of the empirical features of business cycles in the US and also for developing methods to measure business cycles. One of the central issues that they faced was to identify a methodology to isolate the cyclical component of an aggregate economic time-series and that still remains a critical issue for most of the researchers. A variety of detrending and smoothing techniques have been employed by many macroeconomists replacing the method adopted by Burns and Mitchell because of the complexities involved in it [Baxter and King 1995].

Methodology

Hodrick-Prescott filter: The detrending procedure that is used is known as the Hodrick-Prescott filter. Fluctuations are by definition deviations from some slowly varying path. We call this a slowly varying path a "trend". This trend is defined by the computational procedure used to fit the smooth curve through the data. The key facts of the business cycle are not sensitive to the detrending procedure if the trend curve is smooth.

The curve fitting method is to select the trend path $\{T_t\}$ which minimises the sum of the squared deviations from a given series $\{Y_t\}$ subject to the constraint that the sum of the squared second differences not be too large.

This is

$$\min_{\{T_t\}^{T}_{t=1}} \sum_{t=1}^{T} (Y_t - T_t)^2$$

subject to

$$\sum_{t=2}^{T-1} [(T_{t+1}-T_t) - (T_t-T_{t-1})]^2 \leq \mu$$

The smaller is μ, the smoother is the trend path. If $\mu = 0$, the least squares linear time trend results. For all series, μ is picked so that the Lagrange multiplier of the constraint is 100. This produces the right degree of smoothness in the fitted trend when the observed data is annual. μ is known as the smoothing parameter. Thus, the sequence $\{T_t\}$ minimises

$$\sum_{t=1}^{T} [(Y_t-T_t)^2 + 100 \sum_{t=2}^{T-1} [(T_{t+1}-T_t)-(T_t-T_{t-1})]^2$$

The first-order conditions of this minimisation problem are linear in Y_t and T_t, so for every series, $T = AY$, where A is the same $T \times T$ matrix. The deviations from the trend, also by definition, are

$Y_t^d = Y_t - T_t$ for t = 1,2,….,T.

An alternative interpretation of the procedure is that it is a high pass linear filter. We filter Y using a high pass band filter. Thus the trend component of the variables is not assumed to follow a simple linear path; a smooth but non-linear trend is removed from the data and the actual fluctuations are compared. This process of filtering or detrending is known as the Hodrick-Prescott filter [Prescott 1986].

Granger causality: The Granger (1969) approach to the question of whether x causes y is to see how much of the current y can be explained by the past values of x and then to see whether adding lagged values of x can improve the explanation. Y is said to be Granger caused by x if x helps in the prediction of y, or equivalently if the coefficients on the lagged x's are statistically significant.[5]

Consider the following equation

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + ... + \alpha_n Y_{t-n} + \beta_1 X_{t-1} + ... + \beta_n X_{t-n} + u_t$$

The null hypothesis that is tested is that all the lag coefficients of the independent variable in the regression upto the assumed maximum lag are zero which is $\beta_1 = \beta_2 = \ldots = \beta_n = 0$ using the standard F-test of joint significance. Usually, if the p value of the test is larger than 0.05, we do not reject the null hypothesis leading to the conclusion that there is no causal relationship, that is, X does not Granger cause Y. If the p value is less than 0.05, the hypothesis gets rejected implying the existence of causal relationship, that is X Granger causes Y. Note that we have taken four period lags in the above equation to compute the results. In practice, the choice of the lag length is arbitrary and varying the lag length may lead to different test results.[6] The number of lags is generally more to ensure non-autocorrelated residuals [Chandra 2002].

Empirical Results

We have used the Hodrick-Prescott filter (H-P filter) to detrend the annual time series data. The original data has been taken from the *Handbook of Statistics of Indian Economy*, of the Reserve Bank of India. The observations are taken for the period – 1970-71 to 2004-05.

We set out the empirical results one by one and try to offer a suitable explanation explaining the results that we formulated using EViews 4.0. (The figures and tables are annexed to this paper.)

Figure 1 gives us the detrended GDP at factor cost series. Figure 2 gives us the detrended GDCF series. Figure 3 gives us the detrended BOT series. Figure 4 gives us the detrended series for the deflated combined expenditures of the central and state governments (The original series was in nominal terms, which was converted to real terms by deflating the original series with an implicit price deflator.) As it can be seen, all the graphs comprise of three different time paths, each representing the original series, the fitted trend line using H-P filter and the residual or the cycle series (which is the difference between the actual series and the trend series).

We have used the H-P filter to detrend the actual time series for all the variables we have considered for the study. Now, we make a 2×2 comparison of the GDP cycle with the other cycles to observe the behaviour of the cycles.

Figure 5 gives us the comparison between the GDP cycle and the GDCF cycle. Figure 6 compares the GDP cycle and the BOT cycle. Figure 7 compares the GDP cycle and the Deflated Expenditure cycle. It is clear from the figures that compared cycles

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have varying amplitudes and they do not move in the same direction (excepting a few phases). One can see from Figure 5 that both the cycles have almost the same amplitudes only in certain specific years (1978, 1990 and 2003) and the rest of the years are marked by amplitudes of varying levels. Figures 6 and 7 also clearly indicate that the compared cycles hardly move in the same direction. Thus this preliminary comparison of the different cycles (GDCF, BOT and the deflated expenditure cycles) with the GDP cycle reveals the absence of any significant influence of those cycles on the GDP cycle (which we verify in detail below).

At this juncture, it would be appropriate to present the cross-correlation results of the GDP cycle with other variables of interest. Table 1 gives us the cross-correlation results of the GDP cycle with the other cycles with one lag and one lead. The highlighted values indicate that they are not significantly correlated with the GDP cycle.

As we have already mentioned, to check for the direction of causality between the GDP cycle and the other cycles, we use the Granger's causality test. It is to be noted that the standard Granger procedure will be inapplicable if the cycles are cointegrated. To ensure that the cycles are not cointegrated, we have to check for the stationarity of the residuals.

We use the Augmented Dickey-Fuller (ADF) Unit Root test for each of the residual. Here the null hypothesis we test is that "there is a unit root in the augmented model". If the calculated ADF statistic is less than its critical value, then *X* is said to be stationary or integrated to the order zero and the null hypothesis gets rejected in favour of stationarity. If this is not the case, then the ADF test is performed on the first difference of *X*. This determines whether the variables used by us are stationary or not. We present the results below.

Table 2 gives us the ADF unit root test result on GDP residual. The GDP residual series is stationary because the calculated ADF test statistic is less than its critical value at 1 per cent level of significance. Table 3 gives us the ADF unit root test result on the GDCF residual. We can see from the table that the calculated ADF test statistic is less than its critical value at 1 per cent level of significance and hence the GDCF residual series is stationary. Table 4 gives us the ADF unit root test result on BOT residual. The residual series shows stationarity as the calculated ADF test statistic is less than its critical value at 1 per cent level of significance. Table 5 gives us the result for the ADF unit root test on expenditure residual. Here the residual series shows non-stationarity as the calculated ADF test statistic is greater than its critical value at 1 per cent level of significance. So we take the first difference (I(1)) and see whether the residual series is rendered stationary. Table 6 gives us the results of the ADF test after taking the first difference. We can see that one difference is sufficient to make the series stationary as the table indicates the ADF test statistic to be lesser than its critical value at 1 per cent level of significance. So the residual series on expenditures is stationary at I(1).

Now that we have shown that the residuals are stationary,[7] we can proceed to apply the Granger's causality test to investigate the direction of causality. We take four-period lags here for our analysis and it should also be noted that varying the lag length might lead to different results. We present below the results for the Granger's causality test.

Table 7 gives us the Granger causality test for GDP residual and the GDCF residual. The table clearly shows that we accept the null hypothesis because the probability value (p value) is larger than 0.05 at 5 per cent level of significance. The acceptance of the null hypothesis reveals that there is no causality in both directions between GDCF residual and the GDP residual.

This result implies that the fluctuations in the GDCF cycle have no significant role to play in causing fluctuations in the aggregate output of the economy. An absence of causality is significant in the sense that it is contrary to the conventional economic wisdom that fluctuations in the capital formation of an economy play an instrumental role in the fluctuations of GDP. It is also to be noted that the absence of causality is bidirectional meaning that the fluctuations in GDP too do not have a role in the fluctuations in capital formation of our economy.

Table 8 reveals the Granger test results for GDP residual and the BOT residual. Here, there are two interesting aspects to be noted. One, we can conclude that there is no causality between GDP residual and BOT residual as the probability value is greater than 0.05 at 5 per cent level of significance. Two, considering the causality between BOT residual and GDP residual, we can see that the probability value is nearly 0.1. This means that there is a unidirectional causality that cannot be ignored at 10 per cent level of significance even though the null hypothesis gets accepted at the 5 per cent level. So we can conclude that there is a weak one-directional causality that exists between BOT residual and GDP residual.

The existence of a weak unidirectional causality implies that the fluctuations in the BOT residuals Granger cause fluctuations in the GDP residual and not the other way round. Given the extent of significance of the external sector to our economy, this result is quite intuitive as it reinforces the fact that volatility in the external sector will have a profound impact in terms of fluctuations in the aggregate output of our economy.

Table 9 gives us the Granger test for GDP residual and the expenditure residual. Here the absence of a bidirectional causality is very evident as the probability values are greater than 0.05 in both the cases and hence we accept the null hypothesis at 5 per cent level of significance.

This result implying that the fluctuations in the expenditure residual do not have any significant role in causing fluctuations in the aggregate output conflicts the mainstream economists' view that government spending is a burden which destabilises the economy thereby causing considerable damage to the aggregate output of the economy. It is to be noted that this result also shows the absence of a bidirectional causality meaning that the fluctuations in the GDP too do not influence the fluctuations of total expenditures of the economy.

Conclusions

The purpose of this paper, was to document some significant features of aggregate economic fluctuations, also referred to as business cycles. Given that in a developing economy like India, fluctuations in the aggregate output have been an integral part of the growth process, throwing some light on the issues of causality relating to fluctuations proves extremely insightful.

There is not much of empirical literature existing on the aggregate fluctuations in India. We have made an attempt in this paper to empirically investigate the causality issues relating to the aggregate fluctuations in India. By doing so, we have found some very interesting results. Our finding that the fluctuations in the capital

Annexure

Figure 1: Detrended GDP Series

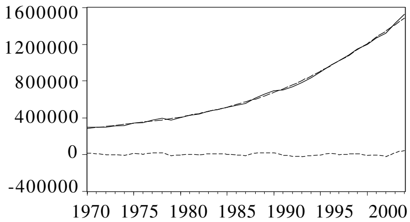

Figure 2: Detrended GDCF Series

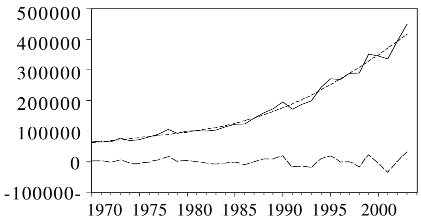

Figure 3: Detrended BOT Series

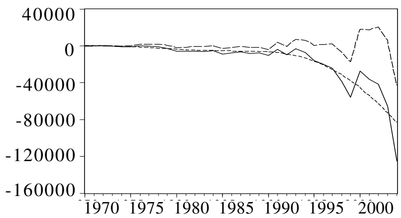

Figure 4: Detrended Deflated Expenditure Series

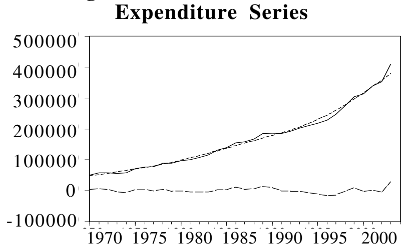

Figure 5: Comparison of GDP and GDCF Cycles

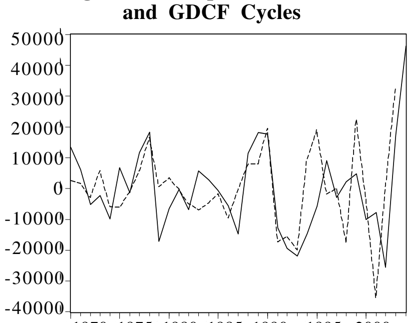

Figure 6: Comparison of GDP and BOT Cycles

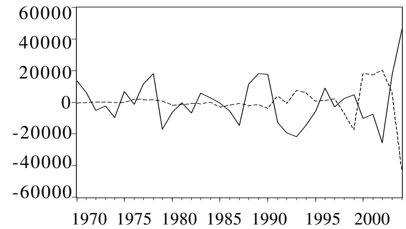

FIgure 7: Comparison of GDP and Deflated Expenditure Cycles

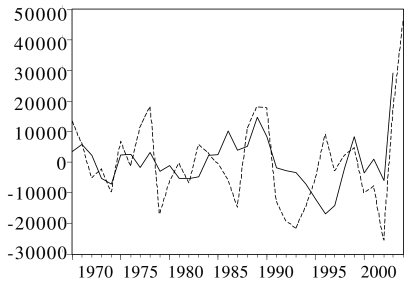

Table 1: Cross-correlation of GDP Cycle

Variable X	X(t-1)	X(t)	X(t+1)
GDCF cycle	0.2983	0.5064	-0.0132
BOT cycle	0.0139	-0.6420	-0.2742
EXP cycle	0.0276	0.4679	-0.0197

Table 2: Augmented Dickey-Fuller Unit Root Test on GDP Residual

ADF Test Statistic	-3.869118	1 Per Cent Critical Value*	-3.6422
		5 Per Cent Critical Value	-2.9527
		10 Per Cent Critical Value	-2.6148

Note: *MacKinnon critical values for rejection of hypothesis of a unit root.

Table 3: Augmented Dickey-Fuller Unit Root Test on GDCF Residual

ADF Test Statistic	-5.712339	1 Per Cent Critical Value*	-3.6496
		5 Per Cent Critical Value	-2.9558
		10 Per Cent Critical Value	-2.6164

Note: *MacKinnon critical values for rejection of hypothesis of a unit root.

Table 4: Augmented Dickey-Fuller Unit Root Test on BOT Residual

ADF Test Statistic	-4.215308	1 Per Cent Critical Value*	-3.6422
		5 Per Cent Critical Value	-2.9527
		10 Per Cent Critical Value	-2.6148

Note: *MacKinnon critical values for rejection of hypothesis of a unit root.

Table 5: Augmented Dickey-Fuller Unit Root Test on Expenditure Residual

ADF Test Statistic	-3.451313	1 Per Cent Critical Value	-2.6395
		5 Per Cent Critical Value	-1.9521
		10 Per Cent Critical Value	-1.6214
ADF Test Statistic	-2.236325	1 Per Cent Critical Value*	-2.6369
		5 Per Cent Critical Value	-1.9517
		10 Per Cent Critical Value	-1.6213

Note: *MacKinnon critical values for rejection of hypothesis of a unit root.

Table 6: Augmented Dickey-Fuller Unit Root Test on D (Exp Residual)

ADF Test Statistic	-3.451313	1 Per Cent Critical Value*	-2.6395
		5 Per Cent Critical Value	-1.9521
		10 Per Cent Critical Value	-1.6214

Note: *MacKinnon critical values for rejection of hypothesis of a unit root.

Table 7: Granger Causality Test for GDP Residual and GDCF Residual

Pairwise Granger Causality Tests
Sample: Relevant Annual Data for the Period 1970-71 to 2003-04
Lags: 4

Null Hypothesis:	Obs	F-Statistic	Probability
CAPRESIDUAL does not Granger Cause GDPRESIDUAL	30	1.70551	0.18640
GDPRESIDUAL does not Granger Cause CAPRESIDUAL		0.47018	0.75700

Table 8 : Granger Causality Test for GDP Residual and BOT Residual

Pairwise Granger Causality Tests
Sample: Relevant Annual Data for the Period 1970-71 to 2004-05
Lags: 4

Null Hypothesis:	Obs	F-Statistic	Probability
GDPRESIDUAL does not Granger Cause TRRESIDUAL	31	0.41824	0.79369
TRRESIDUAL does not Granger Cause GDPRESIDUAL		2.28345	0.0.9271

Table 9: Granger Causality Test for GDP Residual and Expenditure Residual

Pairwise Granger Causality Tests
Sample: Relevant Annual Data for the Period 1970-71 to 2003-04
Lags: 4

Null Hypothesis:	Obs	F-Statistic	Probability
GDPRESIDUAL does not Granger Cause DEFLEXRESID	30	0.26613	0.89641
DEFLEXRESID does not Granger Cause GDPRESIDUAL		0.47535	0.75336

formation as well as in the total expenditures of the government do not play a significant role in contributing to the fluctuations in the aggregate output of our economy is noteworthy. This empirical investigation leaves us with a better understanding of the nature of business cycles in India and ergo throws open the window for further research in this area. EPW

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Notes

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1 By fluctuations, we mean variations in aggregate output. We use the terms business cycles and aggregate fluctuations interchangeably.

2 A Walrasian equilibrium is the set of all quantities and relative prices that equate supply and demand simultaneously in all markets, in an economy characterised by the absence of externalities, asymmetric information or other market imperfections.

3 An example of a real non-Walrasian theory could be an economy which departs from a baseline Walrasian model, taking into account the presence of asymmetric information, externalities, but in which the fluctuations might be due to supply-side shocks (technology shocks).

4 These models are often referred to as dynamic stochastic general equilibrium models which are evaluated by calibration.

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

6 It is observed that Granger's causality test is sensitive to the number of lags used [Gujarati 1995].

7 This rules out the possibility of cointegration among the residuals.

References

Baxter, M and R King (1995): 'Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series', Working Paper No 5022, National Bureau of Economic Research.

Burns, A F and W C Mitchell (1946) 'Measuring Business Cycles', National Bureau of Economic Research, New York.

Chandra, R (2002): 'Export Growth and Economic Growth: An Investigation of Causality in India', *The Indian Economic Journal*, 49 (3), pp 64-72.

Chatterjee, S (2000): 'From Cycles to Shocks: Progress in Business Cycle Theory', *Business Review*, Federal Reserve Bank of Philadelphia.

Granger, C W J (1969): 'Investigating Causal Relationships by Econometric Models and Cross-Spectral Methods', *Econometrica*, Vol 37, No 3, pp 424-38.

Gujarati, N D (1995): 'Basic Econometrics', Third Edition, Tata McGraw Hill publishers.

Hodrick, R and E Prescott (1997): 'Postwar US Business Cycles: An Empirical Investigation', Journal of Money, Credit and Banking, 29 (1), pp 1-16.

Lucas, R (1977): 'Understanding Business Cycles', presented at the Carnegie-Rochester Conference Series on Public Policy.

Mankiw, G (1989), 'Real Business Cycles: A New Keynesian Perspective', *Journal of Economic Perspectives 3*, summer, pp 79-90.

Prescott, E (1986): 'Theory Ahead of Business-Cycle Measurement', Federal Reserve Bank of Minneapolis Quarterly Review, fall, pp 9-22.

Romar, D (2001): 'Advanced Macroeconomics', Second Edition, McGraw Hill publishers.

Snowdon, B and H Vane (1997): 'A Macroeconomics Reader', Routledge publishers, London.

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