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Revisiting the Samuelson's Accelerator Model for the Indian Economy

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Abstract:

The aim of this paper is to develop a modified version of the Samuelson (1939) Accelerator Model to study the Indian Economy in the post liberalization period (1992-1993 to 2018-2019). The crisis which has emerged in the Indian economy has gained tremendous acceptance by now. Several papers have tried to investigate the major factors which are gradually leading to the propagation of this crisis. The objective of this research paper is to examine the macroeconomic variables responsible for this crisis. The theory of accelerator has been introduced owing to the fact that consumption has been a major contributor in keeping the economy afloat over the past decade since the GFC.

Econometric analysis has been carried out to estimate the parameters of the model using the standard OLS technique and to examine if the interactions between consumption and investment can explain the time path of GDP for which the data has been collected from the Handbook of Statistics on the Indian Economy. The model seems to give robust results as I go on to conclude that the accelerator principle is highly relevant to our economy and therefore echoing that are the need of the hour is to boost consumption to put the grappling economy back on the growth trajectory.

JEL Classification: E21, C01, C51, E2, P44, Y4

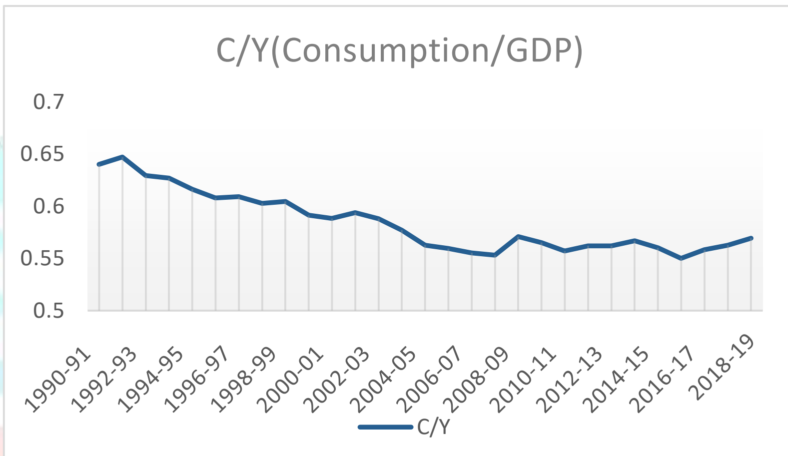
Keywords: Multiplier-Accelerator, Samuelson, Difference equation, growth, consumption, investment

I.INTRODUCTION

The Indian Economy has portrayed continued cross currents that has often made it difficult to disentangle the individual effects on the vulnerable variables. The paradigm shift to the LPG policies since 1991 has paved new ways towards a better India. However, this venture, nonetheless has not been a smooth transition as its benefits are constantly threatened by obnoxious developments in the global economy and owing to a hoard of internal issues as well. The past fiscal year has witnessed very low growth figures that has highlighted the fear of the Indian economy moving into a downward spiral with meagre signs of recovery.

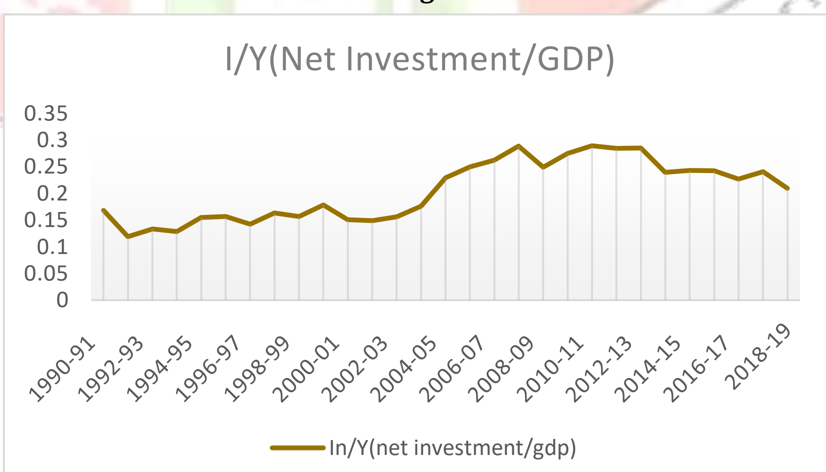
Several reports have tried to investigate the underlying reasons triggering this and have also tried to identify the fundamental macroeconomic variables which has been adversely affected. Global rating agency Moody's has said that India's growth has been decelerating due to a confluence of factors leading to stalling of investment and muting of consumption. Although, at the face value, the root causes of sputtering of consumption and investment might seem to be different, the fairly similar pattern of movement exhibited by both of these macroeconomic variables does indicate an underlying relationship between these two variables, at least in the context of the Indian economy in the post liberalization period. The following figures illustrates the fluctuations in consumption and net investment as a proportion of GDP (at constant price) over time.

Figure 1



Source: Handbook of Statistics on the Indian Economy

Figure 2



Source: Handbook of Statistics on the Indian Economy

The above observations makes it imperative to analyze the relationship between consumption and net investment in explaining the growth figures plaguing the economy. Thus, in this paper I try to empirically investigate the strength of this relationship using a modified version of Samuelson (1939) Model of interaction between multiplier and accelerator.

In light of the above background, the remaining paper is segregated into the following sections. Section II deals with the Literature Review, Section III incorporates the Theoretic framework, Section IV presents the Econometric analysis performed and Section V renders the Conclusion of the paper.

II. LITERATURE REVIEW

Although several works of literature exist on various extensions of the basic framework of the Samuelson's Accelerator Model, only a handful of papers have empirically tested the model.

B.S Mahalingam (1989) tried to empirically estimate the standard macroeconomic models in the context of the Indian economy for the period 1965-1983. She obtained the estimate for the MPC to be 0.591 and the accelerator coefficient to be 2.573.

Michaelides, Panayotis G and Belegri-Roboli (2009) analyzed the Hick's Accelerator Model for the economy of Greece for the period 1963-2007. The model was found to be a good fit with the correlation coefficient between actual and estimated GDP obtained to be as high as 0.99.

A similar study was also conducted Fischer G. (1952) for the US economy for 1947-1950. His results suggested a kind of accelerator phenomenon in the US economy but warned that the estimates must be interpreted with caution owing to the statistical fallicies involved in the estimation process.

Bohner H, Gelles G, Heim J (2010) considered the problem of unification of continuous and the discrete accelerator models. To accomplish this, they employed the theory of dynamic equations time scales which not only unified the discrete and continuous cases, but also enhanced the analysis of "in between" cases.

III. THE THEORETIC FRAMEWORK

The model analyzed statistically in this paper is a modified version of system of National Income equations as compared to that presented in Samuelson (1939). I assume that consumption in the current period is a function of the income in the recent past which in this analysis is one year i.e we have,

$$C_t = \beta + \gamma Y_{t-1};\ \beta > 0, 0 < \gamma < 1 - - - (1)$$

Where C is the aggregate real consumption, Y is aggregate real income and $0 < \gamma < 1$, is the marginal propensity to consume.

Net investment is defined in terms of the familiar accelerator principle, i.e aggregate real induced investment in the current period is a function of changes in aggregate real consumption in the recent past. So we have,

$$I_t = \alpha(C_t - C_{t-1});\ \alpha > 0 - - - (2)$$

Where α is the accelerator coefficient. Thus, what the accelerator coefficient shows is that a small change in consumption will cause a manifold increase in induced investment.

The government expenditure in this model has been considered to be growing over time at a continuous growth rate g given by:

$$G_t = G_0(1+g)^t; g > 0 - - - (3)$$

Here as compared to the Samuelson's framework where government expenditure had been considered to be autonomous, equation (3) shows a government expenditure varying overtime. This is essentially true for a developing country like India where government expenditure is considered to be the fundamental stimulus driving the entire economy and thus it is very unlikely that it will remain constant overtime and this is also evidence from the dataset in the Appendix 2.

Finally, a definitional equation completes the system:

$$Y_t = C_t + I_t + G_t - - - (4)$$

Thus equations (1),(2),(3),(4) constitutes the set of equations defining the model. By plugging the values of equations (1),(2),(3) in equation (4) we get a second order difference equation with constant coefficients and a variable term given as:

$$Y_{t+2} - \gamma(1+\alpha)Y_{t+1} + \alpha\gamma Y_t = \beta + G_0(1+g)^{t+2} - - - (5)$$

By solving equation (5) we get the time path of GDP and the nature of the time path depends on the precise values of the characteristic roots (b_1, b_2) and coefficients which we shall obtain in the context of the Indian Economy in the next section.

The time path of GDP is given as:

$$Y_t = A_1 {b_1}^t + A_2 {b_2}^t + \frac{\beta}{1-\gamma} + \frac{G_0(1+g)^{t+2}}{(1+g)^2 - \gamma - \gamma(1+\alpha)g} --- (6)$$

where A_1 and A_2 are two arbitrary constants which are to be determined from the initial conditions.

The derivation of equation (6) has been provided in the Appendix 1.

IV. ECONOMETRIC ANALYSIS

In this section we try to estimate the parameters of the model developed in the previous section namely β, γ, α, g. The period of study is the post liberalization period in the Indian Economy from 1992-1993 to 2018-2019. The data used in all the regression analysis has been provided in the Appendix 2. All the parameters are estimated using the standard OLS technique.

The presence of first order autocorrelation is checked using the DW Test. The test statistic for the test is given by:

$$d = \frac{\sum_{t=2}^{n}(e_t - e_{t-1})^2}{\sum_{t=1}^{n} {e_t}^2}$$

Here, we test: $H_0: \rho = 0$ against $H_1: \rho > 0$ where ρ is the autocorrelation coefficient. At 5% level of significance, the critical value corresponding to 27 observations and 1 regressor has been obtained from:

Savin and White for model with intercept ($d_L = 1.328$) and from Farebrother for model without intercept ($d_L = 1.26$). If $d < d_L$ then we conclude that positive autocorrelation is present in the data in both the cases.

If the d statistic detects autocorrelation, then it has been removed from the data using the Cochrane Orcutt Iterative Procedure where the estimate for ρ has been obtained as

$$\hat{\rho} = \frac{\sum e_t \,.\, e_{t-1}}{\sum {e_t}^2}$$

We use this estimate to regress $(Y_t - \hat{\rho}Y_{t-1})$ on $(X_t - \hat{\rho}X_{t-1})$, where X and Y are the independent and dependent variables respectively. New residuals are obtained and from which a new estimate of ρ is calculated. The iterative process terminates when the absolute difference between two successive estimates of ρ is less than 0.05.

Heteroskedasticity is verified using the White's Test where the independent variable and the square of the independent variable are considered as the regressors in all the following cases. The regression equation to be estimated is given as:

$${e_t}^2 = \delta_1 + \delta_2 X_t + \delta_3 {X_t}^2 + \varepsilon_t$$

And we consider the test statistic as nR^2 which follows a chi square distribution with 2 degrees of freedom under the null hypothesis. If the value of the test statistic exceeds the critical value at 5% level of significance, then we reject the null hypothesis of homoscedasticity.

Case 1:

In the first case we try to estimate the regression equation:

$$C_t = \beta + \gamma Y_{t-1} + u_t \,;\, t = 1,2,..,27$$

The results as obtained from Excel are as follows:

Regression Analysis						
OVERALL FIT						
Multiple R	0.998951		AIC	348.2244		
R Square	0.997903		AICc	349.2679		
Adjusted F	0.99782		SBC	350.8161		
Standard E	609.7242					
Observatio	27		Rho	0.230899		
ANOVA				Alpha	0.05	
	df	*SS*	*MS*	*F*	*p-value*	*sig*
Regressior	1	4.42E+09	4.42E+09	11899.53	5.22E-35	yes
Residual	25	9294090	371763.6			
Total	26	4.43E+09				
	coeff	*std err*	*t stat*	*p-value*	*lower*	*upper*
Intercept	1762.956	338.5844	5.206843	2.18E-05	1065.628	2460.283
Y_t-1	0.580458	0.005321	109.085	5.22E-35	0.569498	0.591417

And the true estimate of the intercept is obtained as $\hat{\beta} = \frac{\beta_{calc.}}{1-\hat{\rho}} = 2292.23$

Positive autocorrelation was present in the data as $d(= 0.694) < d_L(= 1.328)$ which has been removed using the CO-IP. The p-values of the coefficient and the intercept term are significant and the high value of R square implies that the model is a very good fit to the available data.

Thus, the estimated equation is given as:

$$\widehat{C_t} = 2292.23 + 0.58Y_{t-1} - - - (7)$$

The high value of the intercept term as evident from the results clearly indicates that consumption depends significantly on several other factors which have not been incorporated in this framework.

Case 2:

In the second case, we try to estimate the regression equation:

$$I_t = \alpha(C_t - C_{t-1}) + v_t\,; t = 1,2,..,27 \; and \; d1 = C_t - C_{t-1}$$

Here, it is important to note that we are estimated a model without intercept because it has been analytically obtained that the intercept term turns out to be insignificant and further by dropping the intercept term, the model becomes a better fit to the data and thus the final results obtained can be summarized as follows:

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.962005					
R Square	0.925454					
Adjusted F	0.886993					
Standard E	4003.184		Rho hat=	0.258915		
Observatio	27					
ANOVA						
	df	*SS*	*MS*	*F*	*ignificance F*	
Regressior	1	5.17E+09	5.17E+09	322.7798	8.35E-16	
Residual	26	4.17E+08	16025482			
Total	27	5.59E+09				
	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
d1*	5.889881	0.327834	17.96607	3.53E-16	5.21601	6.563753

Positive autocorrelation was present in the data as indicated by the d-statistic i.e, $d(=1.06) < d_L(=1.26)$ and has been removed by the CO-IP. From the White's Test it has been inferred that we accept the null hypothesis of homoscedasticity at 5% level of significance.

The p-value indicates that the coefficient is highly significant and we obtain the accelerator coefficient as 5.89 which can be interpreted as if the consumption demand rises by 1 billion then the induced investment will increase by 5.89 billion. Further, the high value of R square implies that the model is good fit to the given data. The estimated equation is given by:

$$\widehat{I_t} = 5.89(C_t - C_{t-1}) - - - (8)$$

Case 3:

In the third case, we try to analyze the variations in the government expenditure in the Indian economy across the period of study for which we consider the linearize equation (3) using natural log and we try to estimate the regression equation:

$$lnG_t = lnG_0 + \ln(1+\text{g}).\text{t} + w_t; t = 1,2,..,28$$

And the results obtained are as follows:

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.993651					
R Square	0.987341					
Adjusted F	0.986873		growth rate of G=		0.06	
Standard E	0.056627					
Observatio	29					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regressior	1	6.752953	6.752953	2105.941	3.68984E-27	
Residual	27	0.086579	0.003207			
Total	28	6.839532				
	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	7.882742	0.021587	365.1662	2.08E-51	7.838450083	7.927035
Time	0.057676	0.001257	45.89054	3.69E-27	0.055097696	0.060255

The p-values clearly that the slope coefficient is significant and we obtain the continuous rate of growth as 0.06 which implies that on an average the government expenditure has increased at a rate of 6% per fiscal year. Further, the DW Test has also confirmed that the model does not suffer from autocorrelation. Thus, we obtain the estimated equation as:

$$\widehat{lnG_t} = 7.88 + 0.057t - - - (9)$$

Results:

Thus the estimates of the parameters of the model are obtained as:

$$\hat{\beta} = 2292.23 \quad \hat{\gamma} = 0.58 \quad \hat{\alpha} = 5.89 \quad \hat{g} = 0.06$$

Using these estimates we obtain the roots of the characteristic equation of the reduced form of equation (5) as:

$$b_1, b_2 = 2.757, 1.239 \; i.e \; 1 < b_2 < b_1$$

And we also observe that: $\alpha\gamma = 3.416 > 1$
Thus we can infer that GDP in the Indian context exhibits a diverging time path which is also non- oscillatory and non-fluctuating.

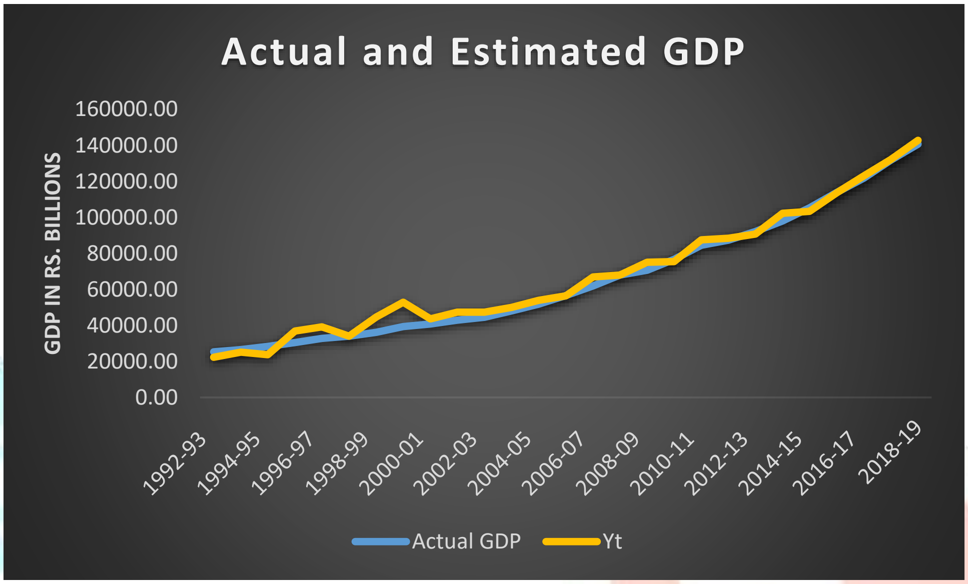
Now to get the definite solution of equation (5) we need to definitize the arbitrary constants A_1 and A_2 using the initial conditions i.e at $t = 0$ and $t = 1$. Plugging these two values of t in equation (5) gives us a system of simultaneous equations which can be solved to obtain the definite values $A_1{}^*$and $A_2{}^*$. The expressions for these two arbitrary constants has been worked out in the Appendix.

This gives us the definite solution of our model as:

$$Y_t = A_1{}^* b_1{}^t + A_2{}^* b_2{}^t + \frac{\beta}{1-\gamma} + \frac{G_0(1+g)^{t+2}}{(1+g)^2 - \gamma - \gamma(1+\alpha)g} - - - (10)$$

Finally we plot the estimated and actual GDP figures and observe that the modified version of the Samuelson's (1939) Accelerator Model developed in this paper is a good fit to the available data as is clearly evitable from the graphical representation below:

Figure 3



Source: Handbook of Statistics on the Indian Economy

V. CONCLUSION

In this paper a modified version of the Samuelson's Accelerator Model has been implemented to study the Indian Economy grappling with unprecedented growth figures. Through this paper I have made an attempt to investigate the fundamental macroeconomic variables that have been signaling that our economy is being dragged into a state of recession. The proposed Methodology yields satisfactory results when fitted to the GDP data of the Indian economy over the period 1992-1993 to 2018-2019.

Most of the results are in tandem with our intuitions except for in Case 2 of the previous section whereby it is observed that the proposed model becomes a better fit to the given data when the intercept term is dropped (as indicated by higher value of R square). This fairly implies that all other factors affecting private investment which has been considered as the autonomous component of investment in this case is insignificant in the case of the Indian Economy. The economic rationale that can be provided for this seemingly paradoxical results can be that investment in our country is predominantly on capital goods which are in turn used in the production of finished consumption goods. This implies that when the economy is characterized by dearth of demand, then investors lose confidence fearing that their investments might not yield profitable returns and consequently amplifying the crisis situation as is evident in the contemporary scenario.

The results of the paper suggest that modified version of the Samuelson's original framework with its simplicity of structure and conformity with the theory is an appropriate tool for forecasting future trends of GDP and policy framing purposes to remap India's growth trajectory at the aggregate level.

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Appendix 1

Finding the solution of the second order difference equation in Section III:

Equation (5) gives us: $Y_{t+2} - \gamma(1+\alpha)Y_{t+1} + \alpha\gamma Y_t = \beta + G_0(1+g)^{t+2}$

To obtain the complementary function consider the reduced equation $Y_{t+2} - \gamma(1+\alpha)Y_{t+1} + \alpha\gamma Y_t = 0$

Let Ab^t be the trial solution and by putting this in the reduced equation, we obtain the characteristic equation as:

$$b^2 - \gamma(1+\alpha)b + \alpha\gamma = 0$$

This gives us the characteristic roots as:

$$b_1, b_2 = \frac{\gamma(1+\alpha) \pm \sqrt{\{\gamma(1+\alpha)\}^2 - 4\alpha\gamma}}{2}$$

Thus, we obtain the complementary function as:

$$Y_C = A_1 {b_1}^t + A_2 {b_2}^t - - - (A1)$$

Where A_1 and A_2 are two arbitrary constants which are to be determined from the initial conditions.

For the particular integral since the RHS of equation (5) depends on t, we consider the particular integral to be of the form:

$$Y_P = B_0 + B_1(1+g)^{t+2}$$

Putting this in (5) and by comparing the coefficients, we obtain the particular integral as:

$$Y_P = \frac{\beta}{1-\gamma} + \frac{G_0(1+g)^{t+2}}{(1+g)^2 - \gamma - \gamma(1+\alpha)g} - - - (A2)$$

From (A1) and (A2) we obtain the general solution as:

$$Y_t = Y_C + Y_P$$

$$Y_t = A_1 {b_1}^t + A_2 {b_2}^t + \frac{\beta}{1-\gamma} + \frac{G_0(1+g)^{t+2}}{(1+g)^2 - \gamma - \gamma(1+\alpha)g} - - - (A3)$$

Now to get the definite solution of equation (5) we need to definitize the arbitrary constants A_1 and A_2 using the initial conditions i.e at $t = 0$ and $t = 1$. Plugging these two values of t in equation (5) gives us a system of simultaneous equations as follows:

$$A_1 + A_2 = Y_0 - \theta_2 - - - (A4)$$

$$A_1 b_1 + A_2 b_2 = Y_1 - \theta_3 - - - (A5)$$

$$\theta_2 = \frac{\beta}{1-\gamma} + \frac{G_0(1+g)^2}{(1+g)^2 - \gamma - \gamma(1+\alpha)g}$$

$$\theta_3 = \frac{\beta}{1-\gamma} + \frac{G_0(1+g)^3}{(1+g)^2 - \gamma - \gamma(1+\alpha)g}$$

This gives us the definite solution of our model as:

$$Y_t = A_1{}^* b_1{}^t + A_2{}^* b_2{}^t + \frac{\beta}{1-\gamma} + \frac{G_0(1+g)^{t+2}}{(1+g)^2 - \gamma - \gamma(1+\alpha)g} - - - (A6)$$

Appendix 2

This Appendix provides for the datasets which has been used and computed through the analysis presented in this paper.

TABLE 1 presents the data used in obtaining the Regression results and

TABLE 2 shows the data on Actual and Estimated GDP for the period 1992-1993 to 2018-2019.

<u>TABLE 1</u>

Base Year 2011-12 (Constant Prices)		(All figures in Billions)					
Year	Private Consumption Exp	Govt Exp	Gross Fixed Capital Formation	Export of Goods	Import of Goods	GDP	Net Capital Formation
1990-91	15232.63	3018.72	5011.22	1570.76	1677.76	23793.50	4006.63
1991-92	15561.24	3013.65	4732.24	1722.54	1678.01	24044.97	2862.42
1992-93	15962.53	3117.68	5158.06	1806.82	2032.54	25363.19	3385.91
1993-94	16656.41	3302.73	5110.33	2055.79	2424.16	26568.15	3418.90
1994-95	17465.93	3348.43	5593.68	2323.96	2972.07	28337.30	4393.88
1995-96	18529.24	3609.73	6503.65	3053.58	3807.99	30483.70	4772.98
1996-97	19969.64	3777.25	6701.80	3245.65	3715.07	32785.09	4665.30
1997-98	20566.66	4202.28	7297.31	3170.07	4205.48	34112.81	5565.43
1998-99	21903.74	4714.64	8005.97	3610.22	5082.15	36222.49	5674.17
1999-00	23235.35	5269.86	8640.50	4260.03	5437.51	39288.04	7004.09
2000-01	24034.55	5342.36	8520.06	5033.38	5687.08	40849.75	6167.98
2001-02	25465.30	5468.09	9823.86	5250.31	5854.53	42869.46	6374.83
2002-03	26196.27	5457.95	9781.05	6357.33	6556.87	44544.60	6956.35
2003-04	27748.49	5609.46	10814.64	6966.50	7467.23	48083.22	8452.69
2004-05	29183.39	5832.48	13408.18	8859.75	9124.60	51857.17	11892.78
2005-06	31706.79	6350.53	15579.38	11169.81	12098.09	56672.05	14160.31
2006-07	34394.28	6590.27	17732.03	13443.48	14696.82	61922.13	16248.11
2007-08	37613.27	7221.03	20605.11	14240.15	16194.85	67991.33	19645.69
2008-09	40325.57	7970.25	21327.78	16318.84	19873.28	70636.86	17602.72
2009-10	43303.91	9076.54	22962.79	15554.23	19448.76	76626.69	21085.55
2010-11	47064.18	9600.40	25487.62	18605.41	22484.46	84488.54	24455.14
2011-12	49104.47	9683.75	29977.33	21439.31	27155.54	87363.29	24858.33
2012-13	51790.91	9742.63	31457.93	22898.36	31084.28	92130.17	26286.35
2013-14	55573.29	9798.25	31949.24	24682.69	31918.11	98013.70	23476.26
2014-15	59023.86	10738.94	33021.73	25121.76	32359.65	105369.84	25605.11
2015-16	62623.73	11097.25	35184.46	23786.87	30449.17	113810.02	27593.92
2016-17	68066.24	13400.86	36020.41	24860.07	31330.81	121898.54	27650.66
2017-18	74174.89	13785.63	41365.72	26073.10	30835.60	131798.57	31767.28
2018-19	80166.74	15060.35	45484.52	29339.69	35579.01	140775.86	29458.11

TABLE 2

Year	Actual GDP	Yp	Yc	Yt
1992-93	25363.19	17247.31	4983.66	22230.97
1993-94	26568.15	17954.33	7175.27	25129.60
1994-95	28337.30	18703.77	5077.24	23781.01
1995-96	30483.70	19498.18	17400.96	36899.15
1996-97	32785.09	20340.25	18836.20	39176.45
1997-98	34112.81	21232.85	12731.30	33964.15
1998-99	36222.49	22179.00	22455.05	44634.05
1999-00	39288.04	23181.92	29661.32	52843.24
2000-01	40849.75	24245.02	19425.43	43670.45
2001-02	42869.46	25371.90	22022.33	47394.23
2002-03	44544.60	26566.40	20813.40	47379.80
2003-04	48083.22	27832.56	22261.24	50093.80
2004-05	51857.17	29174.70	24694.99	53869.69
2005-06	56672.05	30597.36	25856.79	56454.15
2006-07	61922.13	32105.39	34780.12	66885.51
2007-08	67991.33	33703.89	34241.67	67945.56
2008-09	70636.86	35398.31	39733.09	75131.39
2009-10	76626.69	37194.38	38335.64	75530.02
2010-11	84488.54	39098.23	48373.79	87472.01
2011-12	87363.29	41116.30	47334.75	88451.06
2012-13	92130.17	43255.46	47467.72	90723.18
2013-14	98013.70	45522.97	56850.48	102373.46
2014-15	105369.84	47926.53	55372.16	103298.70
2015-16	113810.02	50474.31	63271.06	113745.36
2016-17	121898.54	53174.95	69838.60	123013.55
2017-18	131798.57	56037.62	76123.45	132161.08
2018-19	140775.86	59072.06	83763.64	142835.70