Keynesian Theory of Consumption. Theoretical and Practical Aspects

Kirill Breido, Ilona V. Tregub

The Finance University Under The Government Of The Russian Federation
International Finance Faculty, Moscow, Russia

E-mail: ilonavl_fa@mail.ru, Fax: (495) 366 56 33

THEORETICAL ASPECTS

Recall that real GDP can be decomposed into four component parts: aggregate expenditures on consumption, investment, government, and net exports. The income-expenditure model considers the relationship between these expenditures and current real national income. Aggregate expenditures on investment, I, government, G, and net exports, NX, are typically regarded as autonomous or independent of current income. The exception is aggregate expenditures on consumption. Keynes argues that aggregate consumption expenditures are determined primarily by current real national income. He suggests that aggregate consumption expenditures can be summarized by the equation

$$aggregate\ consumption = C + mpc(Y)$$

where C denotes autonomous consumption expenditure and Y is the level of current real income, which is equivalent to the value of current real GDP. The marginal propensity to consume (*mpc*), which multiplies Y, is the fraction of a change in real income that is currently consumed. In most economies, the *mpc* is quite high, ranging anywhere from .60 to .95. Note that as the level of Y increases, so too does the level of aggregate consumption.

Total aggregate expenditure, AE, can be written as the equation

$$AE = A + mpc(Y)$$

where A denotes total autonomous expenditure, or the sum C + I + G + NX. Different levels of autonomous expenditure, A, and real national income, Y, correspond to different levels of aggregate expenditure, AE.

Equilibrium real GDP in the income-expenditure model is found by setting current real national income, Y, equal to current aggregate expenditure, AE. Algebraically, the equilibrium condition that Y = AE implies that

$$Y = A + mpc(Y) \rightarrow (1 = mpc) * Y = A \rightarrow Y^* = m(A)$$

where $m = \frac{1}{(1-mpc)}$

In words, the equilibrium level of real GDP, Y*, is equal to the level of autonomous expenditure, A, multiplied by m, the Keynesian multiplier. Because the mpc is the fraction of a change in real national income that is consumed, it always takes on values between 0 and 1. Consequently, the Keynesian multiplier, m, is always greater than 1, implying that equilibrium real GDP, Y*, is always a multiple of autonomous aggregate expenditure, A, which explains why m is referred to as the Keynesian multiplier.

PRACTICAL ASPECTS

DATA

As soon as we analyze and test the Keynesian economic consumption, we should find out some specific data, i.e. real consumer expenditures, adjusted to inflation (mlns of current US$), which we will denote y_t, and real disposable income, also adjusted to inflation (mlns of current US$), which we will denote as x_t. But we also need long-term time series of economic data of a particular country. Let us observe and test the simplest example - economy of the USA.

We will take quarterly data from the 3 quarter of 1961 to 2 quarter of 1996. We will leave the corresponding data for the 3 quarter of 1996 for model forecasting.

So, we should collect appropriate numbers to estimate the model. The data has been collected at http://www.economicswebinstitute.org, Economics Web Institute, and http://www.wwnorton.com/college/econ/macro/, Hall and Taylor "Macroeconomics" page. (Appendix, Table 1.)

MODEL TESTING

Model Specification

Here is the mathematical interpretation for our economic model - the Keynesian Consumrtion function.

$$\begin{cases} Y_t = \beta_0 + \beta_1 X_t + u_t \\ E_{u(t)} = 0 \\ \sigma_{u(t)} = const \end{cases}$$

It includes all the variables needed: Y_t – real consumer expenditures, adjusted to inflation (mlns of current US$) in the US economy, X_t – real disposable income, also adjusted to inflation (mlns of current US$) in the US economy, β_0 – Autonomous consumption, β_1 – the marginal propensity to consume, plus the disturbance term for different "noises".

Steps explanation and results interpretation

We need to put into the rows of Regression, Data Analysis the corresponding data of endogenous and exogenous variables from the 3 quarter of 1961 to 2 quarter of 1996.

The results of the regression statistics.

Summary Output Table 2

Regression Statistics	
Multiple R	0,96
R Square	0,93
Adjusted R Square	0,92
Standard Error	39,45
Observations	60

The results of variance analysis

ANOVA Table 3

	df	*SS*	*MS*	*F*
Regression	1	13474644	13474644	8655,73
Residual	58	90290	1557	
Total	59	13564934		

Table 4

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-500	47,616	-10,498	0,000	-595,194	-404,568
X Variable 1	1,031	0,011	93,036	0,000	1,009	1,054

Specification of estimated econometric model

$$\begin{cases} Y_t = -499.88 + 1.03 * X_t + u_t \\ \qquad (47.62) \quad (0.01) \quad (39.46) \\ R^2 = 0.99 \ F_{emp} = 8656 \ F_{crit} = 4 \ t_{crit} = 2 \end{cases}$$

Where β_0 = -499.88 with standard error of 47.62, β_1 = 1.03 with standard error of 0.01; the standard error of disturbance term with its standard error 39.46. In this case we can interpret our results as that autonomous consumption equals to nearly -500 mln dollars. How is it possible? Particularly, it means that autonomous savings equals to 500 mln US dollars. Our *mpc* equals to 1.03, which is hardly possible as it will represent 103% spending of disposable income. However, our R^2 shows that the model is right in 99% cases, which is critically good. Our F_{emp} is much higher than F_{crit}, which gives us an impression of R^2 being formed not under the influence of random factors.

TESTS

R^2

The value of our R^2 shows that the model is right in 99% cases, which is extremely good. Moreover, mathematically it means that about all sample results of y_i (US households' private consumption) can be well calculated and explained by our x_i (US households' disposal income) data.

F-test

The calculated level of significance is less than significance level, which equals to 5% mistake possibility, states that R^2 is not formed under the influence of random factors.

Besides that we need to calculate F_{crit} as our F_{emp} should be within the interval (F_{crit};+∞). Otherwise, we could not trust our t-stat as it will be overestimated and it will be hard for us to determine the significant for the model coefficients. In our case F_{crit} =fраспобр(0.05;1;58)=4, where 1 is the number of degrees of freedom, it equals to the number of the equation regressors m=1, and 58 is the number of degrees of freedom, it equals to n-(m+1). F=8656 is within the interval (4;+∞). So, we can trust our R^2, i.e. it is not formed under the influence of random factors.

t-test

T-test itself shows which coefficients are significant and which are not, that is $|t| \leq t_{crit}$. For this purpose we need to calculate t_{crit}. t_{crit}= 3.57. In our case all absolute values of t-stat are more than t_{crit}, therefore, all the regression coefficients are significant.

Goldfield-Quandt test

GQ test is considered to be a checking mechanism for homoscedasticity of random disturbances (the 2nd assumption of Gauss-Markov theorem).

$Var(\varepsilon_1) = Var(\varepsilon_2) = \cdots = Var(\varepsilon_n) = \sigma^2$

So, we need, first of all, sort the initial data in ascending order of the sums of *x's* absolute values. Then, divide ordered data into two arrays so as $(m+1)<k<n/2$, where k – number of observations in the first array, m- number of factors. Examine these 2 arrays with Regression Analysis. Calculate GQ statistics. $GQ = RSS_1/RSS_2$. Then we need to compute F_{crit}, where $\nu_1 = \nu_2 = k-(m+1)$, k – number of observations in the first array, m – number of regressors. fраспобр(α;ν_1;ν_2). Finally, we need to check the following inequalities: $\begin{cases} GQ \leq F_{crit} \\ 1/GQ \leq F_{crit} \end{cases}$.

If that is right, we can talk about homoscedasticity of random disturbances, otherwise about heteroscedasticity.

In our case the 1st array contains k=30 observations, while the second – n-k=30. $F_{crit\ GQ}$ is calculated by function fраспобр(α;ν_1;ν_2), where α=0.05, $\nu_1=\nu_2=k-(m+1)=28$, where k – number of observations in the 1st array, m – number of factors.

Goldfield-Quandt test Table 5

RSS_1=	51776,73967
RSS_2=	34886,07265
GQ=	1,484166481
1/GQ=	0,67377886
$F_{crit\ GQ}$=	1,882079434

Thus, both inequalities are valid. Assumption about homoscedasticity of random disturbances is adequate.

Durbin-Watson test

The DW test examines the possibility of autocorrelation (3rd assumption of the Gauss-Markov theorem), i.e. $Cov(\varepsilon_i, \varepsilon_j) = 0 \ \ if \ \ j = i - 1$.

DW itself is calculated as $DW = \sum_{t=2}^{n}(\varepsilon_t - \varepsilon_{t-1})^2 / \sum_{t=1}^{n}\varepsilon_t^2$. However, we also need to find corresponding values of d_L and d_U with the help of Durbin-Watson statistical table, according to n=60 – total number of observations, k=1 – total number of factors.

There are 3 possible results: there is autocorrelation of the residuals ($d \in \{(0; d_L); (4 - d_U; 4)\}$), there is no autocorrelation of the residuals ($d \in \{(0; d_L); (4 - d_U; 4)\}$), we can not say anything certain about it ($d \in \{(d_L; d_U); (4 - d_U; 4 - d_L)\}$).

Autocorrelation normally occurs only in regression analysis using time-series data. The disturbance term in a regression equation picks up the influence of those variables affecting the dependent variable that has not been included in the regression equation. That's why, the OLS method is not appropriate here, otherwise we need to "fix" the specification.

If there exists residuals' autocorrelation, we need to include lagging factor so as to avoid the influence of residuals to their next ones. That means that our model will include factors Y_{t-1} and $X_{i(t-1)}$ and corresponding coefficients.

In our case, d=0.93, while d_L=1.549 and d_U=1.616. So, it lies in the interval$(0; d_L)$, which means positive autocorrelation of the model's residuals. This can be "corrected", by changing the model through including the lagging data for each of the factors (Table 13, Appendix) so as the function will take the following form.

$$\begin{cases} \quad\quad Y_t = 0.18 * X_t + 0.8241 * Y_{t-1} + u_t \\ \quad\quad\quad\quad (0.07) \quad\quad (0.067) \quad\quad (20.9) \\ R^2 = 0.998 \ \ F_{emp} = 15524 \ \ F_{crit} = 3.16 \ \ t_{crit} = 2 \end{cases}$$

Where β_1 =0.18 with standard error of 0.07; β_2 =0.824 with standard error of 0.067 the standard error of disturbance term is 20.9. In this case we exclude autonomous consumption from our model as in fact it was autonomous savings, while we need autonomous consumption as it has been stated by Keynes. Our *mpc* equals to 0.18, which is possible as it will represent 18% spending of disposable income by the US households. Moreover, our R^2 shows that the model is right in 99.8% cases, which is critically good. Our F_{emp} is much higher than F_{crit}, which gives us an impression of R^2 being formed not under the influence of random factors.

Summary output Table 6

Regression Statistics	
Multiple R	0,999083319
R Square	0,998167479
Adjusted R Square	0,99810318
Standard Error	20,88314498
Observations	60

Table 7

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	13540076	6770038	15524	0,000000
Residual	57	24858	436		
Total	59	13564934			

Table 8

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-57,18	44,06	-1,30	0,20	-145,41	31,05
X Variable 1	0,18	0,07	2,62	0,01	0,04	0,32
X Variable 2	0,82	0,07	12,25	0,00	0,69	0,96

From the constructed tables above we can conclude that coefficient β_0 is insignificant (its t stat value is lower than t_{crit}; its p-value is more than 0.05). So, we should not include it in our model specification.

Table 9

RSS_1=	12136,7
RSS_2=	9401,51
GQ=	1,29093
1/GQ=	0,77464
$F_{crit\ GQ}$=	1,86081

As we see, R^2 is still quite OK, as it is 99.8% (Table 7) and besides Our F_{emp} is much higher than F_{crit}, which gives us an impression of R^2 being formed not under the influence of random factors (Table 8). T-stat for β_0 signs that this coefficient must be excluded from the model as its absolute value is not more than t_{crit} (Table 9). GQ test justifies the 2nd Gauss-Markov assumption about residuals' homoscedasticity (Table 11).

Moreover, we will have d=1.63, while d_L=1.549 and d_U=1.616. So, it lies in the interval$(d_U; 4 - d_U)$, which means that there is no autocorrelation of the model's residuals.

ADEQUACY CHECKING

Now let us check whether our model is adequate, that is whether it is possible to predict the future correctly using our model. For this purpose we need to check whether real data of consumption expenditures by the US households for the last period – 3rd quarter of 1996, which we have not analyzed during the previous steps. But, first of all, we need to calculate upper and lower boundaries of our confidence interval for the last period. We need to calculate them using following formula: $\hat{Y}_t +/- t_{crit} * st.error$. Then we need to check: $y_{n+1} \in \{(\hat{y}_n - st.error *$ $tcrit;(yn+st.\ error*tcrit)$, where standard error = 20.88. It a very important notion that we will use new specification and data from Appendix, Table 12 to estimate the lower/higher boundaries of the confidence interval.

Table 10

Lower 95%	*Upper 95%*	*Empirical*	*Empirical>Lower 95%*	*Empirical<Higher 95%*
4739,118486	4822,754039	4694,27	False	True

So, our empirical data for the 3 quarter of 1996 data does not lie between upper and lower boundaries predicted by our model. That means that using this model, we can not forecast the future correctly and accurately.

PREDICTING

Now we can firmly say that it is hardly possible to state that our model is good for predictions. One of the main reasons for this, from my point of view, is our imperfect model specification. The case is that we have excluded from our model coefficient β_0, which is critically important as it shows the amount of autonomous consumption explained and included in the consumption theory by Keynes.

So, we objected one of the main fundamental economic principles and washed out the predicting ability of our model in sake of autocorrelation avoidance.

CONCLUSION

Analyzing everything written above we can conclude that our model accepts 2nd and 3rd Gauss-Markov assumptions about residuals'' homoscedasticity and zero autocorrelation, correspondently. Moreover, we have finally determined the Marginal Propensity to Consume for the US households, which equals to 18% of their disposable income.

Nevertheless, we rejected the autonomous consumption (coefficient β_0) and, consequently, this factor is omitted. More than that, we found out that we cannot predict the future correctly. That is why, from macroeconomic point of view, our model is incorrect.

So, our model is of a not satisfactory explanatory ability of real time-series data, such as households' private consumption in the USA predicting and cannot be used for general data analysis of consumption functions.

APPENDIX

Table 1

Year and Quarter	Consumer Exp. (Real)	Disp. Income (Real)
1981,3	3058,8	3477,1
1981,4	3035,3	3472,6
1982,1	3054,0	3453,0
1982,2	3062,1	3499,0
1982,3	3080,1	3485,2
1982,4	3129,7	3494,9
1983,1	3156,5	3508,2
1983,2	3220,0	3543,7
1983,3	3267,1	3597,2
1983,4	3318,6	3670,3
1984,1	3354,0	3758,2
1984,2	3397,5	3824,7
1984,3	3418,4	3888,5
1984,4	3460,6	3896,4
1985,1	3511,2	3902,6
1985,2	3540,8	3977,0
1985,3	3602,1	3958,7
1985,4	3612,1	3996,0
1986,1	3644,0	4052,3
1986,2	3683,0	4089,3
1986,3	3742,8	4106,8
1986,4	3764,8	4099,5
1987,1	3765,7	4138,7
1987,2	3814,0	4097,8
1987,3	3852,9	4157,8
1987,4	3856,5	4222,0
1988,1	3924,2	4289,7
1988,2	3952,2	4298,6
1988,3	3985,1	4329,9
1988,4	4029,1	4354,3
1989,1	4032,8	4403,4
1989,2	4047,4	4384,6
1989,3	4083,2	4404,0
1989,4	4095,0	4422,6
1990,1	4128,9	4475,5
1990,2	4134,7	4494,3
1990,3	4148,5	4499,7
1990,4	4116,4	4468,8
1991,1	4084,5	4452,7

1991,2	4110,0	4492,6
1991,3	4119,5	4494,2
1991,4	4109,1	4506,3
1992,1	4173,8	4565,6
1992,2	4196,4	4599,8
1992,3	4226,7	4600,6
1992,4	4282,3	4688,7
1993,1	4289,7	4603,0
1993,2	4318,8	4658,0
1993,3	4359,5	4674,8
1993,4	4390,0	4731,7
1994,1	4420,5	4666,5
1994,2	4458,7	4776,0
1994,3	4489,4	4810,2
1994,4	4524,0	4859,9
1995,1	4534,8	4903,8
1995,2	4569,9	4907,1
1995,3	4597,3	4959,5
1995,4	4609,4	5012,9
1996,1	4649,1	5037,6
1996,2	4687,6	5054,5
1996,3	4694,3	5114,6

Table 12

Year and Quarter	Consumer Exp. (Real)	Disp. Income (Real)	Consumer Exp. (Real) (t-1)
1981,3	3058,8	3477,1	3045,8
1981,4	3035,3	3472,6	3058,8
1982,1	3054,0	3453,0	3035,3
1982,2	3062,1	3499,0	3054,0
1982,3	3080,1	3485,2	3062,1
1982,4	3129,7	3494,9	3080,1
1983,1	3156,5	3508,2	3129,7
1983,2	3220,0	3543,7	3156,5
1983,3	3267,1	3597,2	3220,0
1983,4	3318,6	3670,3	3267,1
1984,1	3354,0	3758,2	3318,6
1984,2	3397,5	3824,7	3354,0
1984,3	3418,4	3888,5	3397,5
1984,4	3460,6	3896,4	3418,4
1985,1	3511,2	3902,6	3460,6
1985,2	3540,8	3977,0	3511,2
1985,3	3602,1	3958,7	3540,8
1985,4	3612,1	3996,0	3602,1
1986,1	3644,0	4052,3	3612,1
1986,2	3683,0	4089,3	3644,0
1986,3	3742,8	4106,8	3683,0
1986,4	3764,8	4099,5	3742,8
1987,1	3765,7	4138,7	3764,8
1987,2	3814,0	4097,8	3765,7
1987,3	3852,9	4157,8	3814,0
1987,4	3856,5	4222,0	3852,9
1988,1	3924,2	4289,7	3856,5
1988,2	3952,2	4298,6	3924,2
1988,3	3985,1	4329,9	3952,2
1988,4	4029,1	4354,3	3985,1
1989,1	4032,8	4403,4	4029,1
1989,2	4047,4	4384,6	4032,8
1989,3	4083,2	4404,0	4047,4
1989,4	4095,0	4422,6	4083,2
1990,1	4128,9	4475,5	4095,0
1990,2	4134,7	4494,3	4128,9
1990,3	4148,5	4499,7	4134,7
1990,4	4116,4	4468,8	4148,5
1991,1	4084,5	4452,7	4116,4
1991,2	4110,0	4492,6	4084,5
1991,3	4119,5	4494,2	4110,0

1991,4	4109,1	4506,3	4119,5
1992,1	4173,8	4565,6	4109,1
1992,2	4196,4	4599,8	4173,8
1992,3	4226,7	4600,6	4196,4
1992,4	4282,3	4688,7	4226,7
1993,1	4289,7	4603,0	4282,3
1993,2	4318,8	4658,0	4289,7
1993,3	4359,5	4674,8	4318,8
1993,4	4390,0	4731,7	4359,5
1994,1	4420,5	4666,5	4390,0
1994,2	4458,7	4776,0	4420,5
1994,3	4489,4	4810,2	4458,7
1994,4	4524,0	4859,9	4489,4
1995,1	4534,8	4903,8	4524,0
1995,2	4569,9	4907,1	4534,8
1995,3	4597,3	4959,5	4569,9
1995,4	4609,4	5012,9	4597,3
1996,1	4649,1	5037,6	4609,4
1996,2	4687,6	5054,5	4649,1