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Study of the Quantity Theory of Money

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STUDY OF THE QUANTITY THEORY OF MONEY

By

Jerome Howard Jr.

B.A. Northeastern Illinois University, 2014

A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
Master of Arts

Department of Economics
in the Graduate School
Southern Illinois University Carbondale
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RESEARCH PAPER APPROVAL

THE STUDY OF THE QUANTITY THEORY OF MONEY

By

Jerome Howard

A Research Paper Submitted in Partial

Fulfillment of the Requirements

for the Degree of

Master of Arts

in the field of Economics

Approved by:

Dr. Subhash C. Sharma, Chair

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Graduate School

Southern Illinois University Carbondale

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TITLE: STUDY OF THE QUANTITY THEORY OF MONEY

MAJOR PROFESSOR: Dr. Scott Gilbert

This paper examines the classical theory of the relationship between the money supply, inflation, and output. The purpose of the paper is to determine empirically if the quantity theory of money holds true. Using regression analysis, one can observe if the theory is accurate. Taking data over time and from three separate countries, I used the ordinary least squares method to determine the correctness of the quantity theory of money. I used a large amount of other statistically methods to determine the preciseness of the theory.

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INTRODUCTION

Money, inflation, and output, better known as GDP, are connected. They depend on each other. If one changes, the others are bound to change. One of the main theorems in macroeconomics is the theory behind the relationship of Money, inflation, and output. The theory behind this relationship is called the quantity theory of money. In this theory, the product of money supply and velocity of money of a country is equal to the product of the inflation and output of the country. Velocity is how fast the money changes users. It deals with the fact that money changes hands. This equation is the basis of my paper. The goal of this paper is to test the accuracy of the quantity theory of money. Using data and statistics, I will test the statistical significance of the quantity theory of money. Once the model is tested, there should be evidence if the theory holds empirically.

LITERATURE REVIEW

The quantity theory of money has been examined many times in journals and publications. The theory goes back to the 1800's. David Ricardo first demonstrated the quantity of money in 1811¹. The first point about the quantity theory of money is that a change in the money supply induces a change in inflation. There was also a paper about the quantity theory of money from Wesley C. Mitchell. That paper about relationship of money explains that money supply alone doesn't determine the amount of inflation and output in the economy. When combined with the velocity of money, a relationship can be determined. The money supply and velocity being equivalent to the price level and output. That relationship determines the model.

When you have a growth in the money supply, a change occurs in the quantity of inflation and the growth of the country's output. One paper by Robert E. Lucas Jr. describes this relationship between money supply and inflation. In the paper, he uses time-series data to analyze short-term and long-term relationships between the inflation, as measured by the country's Consumer Price Index, and the M1 stock, which includes the currency in the circulation and deposits². In the short-run, the data did not fit the model of the quantity theory of money. In the long-run, the data was a better predictor of the model for the quantity theory. In the paper, he doesn't mention output, but includes treasury bills.

The quantity theory of money has a historical context. In the 1550, Prussia and Poland had issues with their money supply. Because the country produced too many coins, so as a result prices went up. There was an influx of coins coming into the Prussia that spelled disaster for the

¹ Wesley C. Mitchell, "Quantity Theory on the Value of Money," *The Journal of Political Economy*, retrieved online, <http://www.jstor.org/stable/1817857>

² Robert E. Lucas Jr., "Two Illustrations of the Quantity Theory of Money," *The American Economic Review*, retrieved online, <http://www.jstor.org/stable/1805778>

economy. The King of Prussia at that time had to close a mint to lower the amount of money in circulation³. This incident demonstrates the intuition behind the quantity theory of money. It shows the relationship between money and inflation.

In the journal *the Quarterly Journal of Economics*, Francis A. Walker writes about the quantity theory of Money. He relates it to supply and demand, one of the fundamental cornerstones of economic theory. He connected the use of money and the transfer of it across agents. He implies the use of Velocity of money.⁴ He goes on to debate the validity of a claim by a Sarah Hardy of the inaccuracy of the quantity theory of money. Through Logic and reason, he demonstrates the error in her line of thinking.

J. Lawrence Laughlin wrote an article about the quantity theory of Money. In the article, he talks about the importance of prices and how they are determined with respect to the quantity theory of money. He goes on to say that purchasing power and input costs are major determinants of prices in a market.⁵ Laughlin goes on to say that the total volume of goods has a forbearance on the market. He defines the word 'money' to include currency in circulation, checks, and bank notes. He goes on to say that money has a broad definition. The quantity theory of money should be adjusted for allow for inconsistencies.

In *Cost-Induced Inflation and the Quantity Theory of Money*, Miles Fleming speaks about the role of each of the factors in the theory. He explains that the “Rising prices, with unchanged output, mean higher money expenditure, and therefore involve an expanded demand for money balances to carry out this expenditure.”⁶ The real interest rate changes. The velocity increases to accommodate for the change in money. The money supply can changed, but not in this particular example. The article mentions the “Pigou Effect” which is the, “circumstances lower the real value of the privately held public debt

³ Oliver Volckart, “Early Beginnings of the Quantity Theory of Money,” *The Economic History Review*, retrieved online, <http://www.jstor.org/stable/2599810>

⁴ Francis A. Walker, “The Quantity-Theory of Money,” *The Quarterly Journal of Economics*, retrieved online, <http://www.jstor.org/stable/1886009>

⁵ J Lawrence Laughlin, “The Quantity-theory of Money,” *Journal of Political Economy*, retrieved online, <http://www.jstor.org/stable/1822087>

⁶ Miles Fleming, “Cost-Induced Inflation and the Quantity Theory of Money,” *The Economic Journal*, retrieved online, <http://www.jstor.org/stable/2228916>

including currency.”⁷ The Pigou Effect “will reduce expenditure in real terms, but probably only after a considerable rise in prices has significantly reduced the real value of the privately held public debt, and thus induced the holders of it to increase their real saving.” The article states that the quantity of Money is a “perfect stabilizer of prices.”⁸ “The assertion that the quantity of money is the cause of inflation leads to the prescription of monetary policy as the only way to control inflation.”⁹

The article *Some International Evidence on the Quantity Theory of Money* sheds light on the equation governing this principle. It states the quantity theory of money in growth form using natural logarithms. It states that the growth in Money supply plus the growth of the velocity is equal to the growth of the inflation level plus the growth of the level of output.¹⁰ The article uses complex statistics to test the framework of the theory. The statistics show that there is validity to the money theorem.

Kanhaya L. Gupta and Bakhtiar Moazzami demonstrate the quantity theory of money in an empirical context. In the paper, the author test the validity of the quantity theory by using a sample of a half dozen countries: Canada, France, W. Germany, Italy, the United Kingdom, and the United States. The data is time-series, just like my paper. It expands over decades: 1953 to 1987. It uses natural logarithms for most of the variables. It states that the theory of the quantity theory of money still holds up under inspection.¹¹ Money is connected to the income and the interest rate of the countries involved. The article show statistical significance about the theory.

Leon Walras had an understanding about the quantity theory of money. In an article about Walras’ ideas about the quantity theory of money, Renato Cirillo discussed the importance of Walras’ ideas about money. Walras was an early proponent about the relationship between the overall money supply and the price level. “Walras was convinced that the price level had to be controlled at all costs

⁷ Miles Fleming, “Cost-Induced Inflation and the Quantity Theory of Money”

⁸ Miles Fleming, “Cost-Induced Inflation and the Quantity Theory of Money”

⁹ Miles Fleming, “Cost-Induced Inflation and the Quantity Theory of Money”

¹⁰ Nigel W. Duck, “Some International Evidence on the Quantity Theory of Money,” *Journal of Money, Credit and Banking*, retrieved online, <http://www.jstor.org/stable/2077816>

¹¹ Kanhaya L. Gupta and Bakhtiar Moazzami, “On Some Predictions of the Quantity Theory of Money,” *Southern Economic Journal*, retrieved online, <http://www.jstor.org/stable/1060336>

and, according to him, this could only be done by strictly controlling the money supply.”¹² He believed all money should be back one hundred percent by gold reserves. Walras “opted for a strong monetary policy, but he was unwilling to make the central bank the agency entrusted with the implementation of such measures”¹³ “But he perceived that equilibrium could not be guaranteed in the absence of responsible control of the money stock.”¹⁴

The classical economic theorist David Ricardo had specific ideas about money and its role in society. He was one of the early advocates of the quantity theory of money. In the article *Ricardo's Theory of Money Matters*, Maria Cristina Marcuzzo and Annalisa Rosselli mention the work completed by David Ricardo. He advocated the relationship between money, prices and labor. He advocated the use of regulation of money.¹⁵

¹² Renato Cirillo, “Leon Walras’ Theory of Money,” *The American Journal of Economics and Sociology*, retrieved online, <http://www.jstor.org/stable/3486926>

¹³ Renato Cirillo, “Leon Walras’ Theory of Money”

¹⁴ Renato Cirillo, “Leon Walras’ Theory of Money”

¹⁵ Maria Cristina Marcuzzo, and Annalisa Rosselli “Ricardo’s Theory of Money Matters,” *Revue Economique*, retrieved online, <http://www.jstor.org/stable/3502260>

METHODS AND DATA

Basic Regression Analysis

For this project, I did an Ordinary least squares regression of money supply, which was the dependent variable, on velocity, inflation, and the output of the countries of Mexico, Canada, and the United States of America. The data was time series. I used the first year as 1985 and the last year as 2014. Some of the equations have 2015 included in the data. The equation was not in a linear format, so I had to use logarithms to linearize the equations for each country. Once I had the correct format, I regressed the money supply on the independent variables. I applied the equation:

$$\log(\text{MoneySupply}) = c1 + c2 * \log(\text{velocity}) + c3 * \log(\text{inflation}) + c4 * \log(\text{Output})$$

The equation for the quantity theory of money is nonlinear. I had to linearize it to be of any use. I linearized it so that it could be standardized. I moved the velocity variable to the other side to isolate the money supply variable.

I started my empirical research on Canada. The results are in table 1.

For the United States, I completed a basic regression analysis with time series. The results can be seen in Table 1. The intercept is negative. The coefficient for velocity is well expected to be negative. The coefficients for inflation and output are positive. This relationship is shown to mean that when inflation and output increase, the money supply increases as well. Some of the variables are statistically significant for the model. The p-values for velocity and output are all well below even the .05 level. There is apparently no joint statistical significance in the U.S. regression model. This could be due to a number of reasons. This data set could be under suspicion. Maybe the combination of the independent variables did not model well.

Table 1 for OLS Regression of Money Supply, Inflation and Output

p-values	USA	Mexico	Canada
C ₂	-.2798695808607084***	-1.0000***	-1.0000***
C ₃	.053593869876367860	1.0000***	1.0000***
C ₄	1.150944062396776***	1.0000***	1.0000***
Adjusted R ²	.8655861023591251	1.0000	1.00000
N	30	30	30

***=significance at .01 percent **= significance at .05 percent *=significance at .10 percent.

Nonlinear regression

To see if the model would have a better fit, I used a non-linear regression on the logs of the variables. I started with a quadratic model of the log of the variable in the theory equation. I also used a cubic equation to see if that was a better fit.

The quadratic regression of Canada for the model of the quantity theory of money is in the table below. The coefficient for the velocity is negative. The coefficients for inflation and GDP are positive. The statistical significance varies. For the intercept and the output, there is statistical significance at the 95th confidence interval and the other intervals. For the velocity, there is no statistical significance. Also, there is no statistical significance for inflation in this regression model. Compared to the simple regression of Canada, the quadratic is a worse fit.

Table 2

Dependent Variable: LOG(CANADA_MONEY_SUPPLY)
 Method: Least Squares (Gauss-Newton / Marquardt steps)
 Date: 04/13/16 Time: 18:53
 Sample (adjusted): 1985 2014
 Included observations: 30 after adjustments

$$\text{LOG(CANADA_MONEY_SUPPLY)} = C(1) + C(2) * \text{LOG(CANADA_VELOCITY)} \\ + C(3) * \text{LOG(CANADA_VELOCITY)}^2 + C(4) * \text{LOG(CANADA_GDP)} + C(5) \\ * \text{LOG(CANADA_GDP)}^2$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1650.307	382.0459	4.319657	0.0002
C(2)	-0.039452	0.059044	-0.668190	0.5101
C(3)	-0.008914	0.015808	-0.563864	0.5779
C(4)	-119.0795	27.35781	-4.352670	0.0002
C(5)	2.181733	0.489729	4.454979	0.0002
R-squared	0.986300	Mean dependent var		26.21880
Adjusted R-squared	0.984108	S.D. dependent var		0.651655
S.E. of regression	0.082149	Akaike info criterion		-2.009560
Sum squared resid	0.168710	Schwarz criterion		-1.776027
Log likelihood	35.14340	Hannan-Quinn criter.		-1.934851
F-statistic	449.9670	Durbin-Watson stat		0.933367
Prob(F-statistic)	0.000000			

Table 3

Dependent Variable: LOG(CANADA_MONEY_SUPPLY)
 Method: Least Squares (Gauss-Newton / Marquardt steps)
 Date: 04/13/16 Time: 20:02
 Sample (adjusted): 1985 2014
 Included observations: 30 after adjustments

$$\text{LOG(CANADA_MONEY_SUPPLY)} = C(1) + C(2) * \text{LOG(CANADA_INFLATION_C} \\ \text{PI)} + \text{LOG(CANADA_INFLATION_CPI)}^2$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	25.61353	0.338836	75.59279	0.0000
C(2)	-0.602212	0.336004	-1.792275	0.0839
R-squared	-3.232825	Mean dependent var		26.21880
Adjusted R-squared	-3.383997	S.D. dependent var		0.651655
S.E. of regression	1.364434	Akaike info criterion		3.523697
Sum squared resid	52.12706	Schwarz criterion		3.617110
Log likelihood	-50.85546	Hannan-Quinn criter.		3.553581
Durbin-Watson stat	0.890501			

Mexico's quadratic regression is represented in the table below. From the table, there is the

presence of statistical significance. The p-values for the several independent variables are very small. The values are highly statistically significant. This demonstrates a strong relationship between the dependent variables and the independent ones. The coefficients are higher in this regression model as compared to the non-quadratic one. The R-squared is less in the quadratic model as compared to the standard model. This means that the money supply is better explained in the standard log model as compared to the quadratic model.

Table 4 Quadratic regression of Money Supply, Inflation, and Output

Dependent Variable: LOG(MEXICO_MONEY_SUPPLY)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 04/13/16 Time: 18:57
Sample (adjusted): 1985 2014
Included observations: 30 after adjustments
LOG(MEXICO_MONEY_SUPPLY)=C(1)+C(2)*LOG(MEX_VELOCITY)+C(3)
*LOG(MEX_VELOCITY)^2+C(4)*LOG(MEXICO_INFLATION)
+LOG(MEXICO_INFLATION)^2

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	30.38947	0.940931	32.29725	0.0000
C(2)	1.566679	0.451452	3.470314	0.0018
C(3)	-0.167878	0.022464	-7.473192	0.0000
C(4)	-5.435382	0.528203	-10.29032	0.0000
R-squared	0.848398	Mean dependent var		26.45904
Adjusted R-squared	0.830905	S.D. dependent var		1.860116
S.E. of regression	0.764901	Akaike info criterion		2.425425
Sum squared resid	15.21191	Schwarz criterion		2.612252
Log likelihood	-32.38138	Hannan-Quinn criter.		2.485193
F-statistic	48.50045	Durbin-Watson stat		1.627586
Prob(F-statistic)	0.000000			

Table 5

Dependent Variable: LOG(MEXICO_MONEY_SUPPLY)
 Method: Least Squares (Gauss-Newton / Marquardt steps)
 Date: 04/13/16 Time: 19:46
 Sample (adjusted): 1985 2014
 Included observations: 30 after adjustments
 LOG(MEXICO_MONEY_SUPPLY)=C(1)+C(2)*LOG(MEXICO_GDP)+C(3)
 *LOG(MEXICO_GDP)^2

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-7282.759	1282.077	-5.680440	0.0000
C(2)	482.1820	85.86607	5.615513	0.0000
C(3)	-7.950095	1.437627	-5.530011	0.0000
R-squared	0.960683	Mean dependent var		26.45904
Adjusted R-squared	0.957770	S.D. dependent var		1.860116
S.E. of regression	0.382251	Akaike info criterion		1.009163
Sum squared resid	3.945137	Schwarz criterion		1.149283
Log likelihood	-12.13745	Hannan-Quinn criter.		1.053989
F-statistic	329.8600	Durbin-Watson stat		0.639514
Prob(F-statistic)	0.000000			

The result for a quadratic regression of the U.S. are stated below. The p-values for velocity and output for this equation are statistically significant. Therefore, there is a strong relationship between the dependent variable, the United States' money supply, and the independent variables the velocity of money and GDP. There is no statistical significance for the inflation in the quadratic model. The R-squared statistic is greater in the simple regression. The Adjusted R-squared statistic is greater in the quadratic regression. This could mean that for the quadratic equation, the money supply is accounted for in the independent variables.

Table 6 Quadratic Regression for the Money supply, Inflation, and Output

Dependent Variable: LOG(USA_MONEY_SUPPLY)
 Method: Least Squares (Gauss-Newton / Marquardt steps)
 Date: 04/13/16 Time: 19:05
 Sample (adjusted): 1985 2014
 Included observations: 30 after adjustments
 LOG(USA_MONEY_SUPPLY)=C(1)+C(2)*LOG(USA_VELOCITY)+C(3)
 *LOG(USA_VELOCITY)^2+C(4)*LOG(USA_INFLATION)+C(5)
 *LOG(USA_INFLATION)^2+C(6)*LOG(USA_GDP)+C(7)
 *LOG(USA_GDP)^2

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1020.572	630.5410	1.618565	0.1192
C(2)	-0.550610	0.697157	-0.789794	0.4377
C(3)	0.056788	0.123098	0.461328	0.6489
C(4)	0.100181	0.183862	0.544867	0.5911
C(5)	-0.094712	0.147538	-0.641949	0.5273
C(6)	-67.12370	41.98987	-1.598569	0.1236
C(7)	1.135487	0.698556	1.625477	0.1177
R-squared	0.897625	Mean dependent var		27.85801
Adjusted R-squared	0.870919	S.D. dependent var		0.383978
S.E. of regression	0.137955	Akaike info criterion		-0.922816
Sum squared resid	0.437726	Schwarz criterion		-0.595869
Log likelihood	20.84223	Hannan-Quinn criter.		-0.818223
F-statistic	33.61082	Durbin-Watson stat		0.527637
Prob(F-statistic)	0.000000			

I also used a cubic regression model for all three countries. I started with Canada; the results are listed below. The only statistically significant variable is the output in the cubic regression equation. The other variables have p-values that are too high. The R-squared and adjusted R-squared are lower than the standard regression model. This shows that the regular model for the country of Canada is a better predictor than the cubic one.

Table 7 Cubic Regression for the country of Canada

Dependent Variable: LOG(CANADA_MONEY_SUPPLY)

Method: Least Squares (Gauss-Newton / Marquardt steps)

Date: 04/13/16 Time: 18:04

Sample (adjusted): 1985 2014

Included observations: 30 after adjustments

$$\text{LOG(CANADA_MONEY_SUPPLY)} = \text{C(1)} + \text{C(2)} * \text{LOG(CANADA_VELOCITY)} \\ + \text{C(3)} * \text{LOG(CANADA_VELOCITY)}^2 + \text{C(4)} * \text{LOG(CANADA_VELOCITY)}^3 \\ + \text{C(5)} * \text{LOG(CANADA_GDP)} + \text{C(6)} * \text{LOG(CANADA_GDP)}^2 + \text{C(6)} \\ * \text{LOG(CANADA_GDP)}^3$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	988.5897	344.0527	2.873367	0.0084
C(2)	0.042380	0.186123	0.227699	0.8218
C(3)	-0.064801	0.121571	-0.533031	0.5989
C(4)	0.009515	0.020523	0.463606	0.6471
C(5)	-53.38953	18.60158	-2.870161	0.0084
C(6)	0.023437	0.007775	3.014271	0.0060
R-squared	0.986455	Mean dependent var		26.21880
Adjusted R-squared	0.983634	S.D. dependent var		0.651655
S.E. of regression	0.083367	Akaike info criterion		-1.954280
Sum squared resid	0.166800	Schwarz criterion		-1.674041
Log likelihood	35.31420	Hannan-Quinn criter.		-1.864629
F-statistic	349.5873	Durbin-Watson stat		1.009733
Prob(F-statistic)	0.000000			

Table 8

Dependent Variable: LOG(CANADA_MONEY_SUPPLY)

Method: Least Squares (Gauss-Newton / Marquardt steps)

Date: 04/13/16 Time: 20:10

Sample (adjusted): 1985 2014

Included observations: 30 after adjustments

$$\text{LOG(CANADA_MONEY_SUPPLY)} = \text{C(1)} + \text{C(2)} * \text{LOG(CANADA_INFLATION_CPI)} \\ + \text{C(3)} * \text{LOG(CANADA_INFLATION_CPI)}^2 + \text{C(4)} * \text{LOG(CANADA_INFLATION_CPI)}^3$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	26.79155	0.218892	122.3962	0.0000
C(2)	-0.325277	0.349069	-0.931841	0.3600
C(3)	-0.380325	0.118818	-3.200899	0.0036
C(4)	0.042983	0.142217	0.302238	0.7649
R-squared	0.406732	Mean dependent var		26.21880
Adjusted R-squared	0.338278	S.D. dependent var		0.651655
S.E. of regression	0.530097	Akaike info criterion		1.692052
Sum squared resid	7.306070	Schwarz criterion		1.878878
Log likelihood	-21.38078	Hannan-Quinn criter.		1.751819
F-statistic	5.941684	Durbin-Watson stat		0.479669
Prob(F-statistic)	0.003160			

The next country I did was Mexico. I performed the following analysis on Mexico. The money supply, velocity, inflation measure, and output were cubed. The results are stated below. In the following table, it can be shown that independent variables are statistically significant. There is a strong relationship between each of the explanatory variables and the dependent one. The r-squared and adjusted r-squared variable are less in the cubic equation when compared to the standard one.

Table 9 Cubic Regression of Money Supply, Inflation, and Output for Mexico

Dependent Variable: LOG(MEXICO_MONEY_SUPPLY)^3
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 03/18/16 Time: 18:32
Sample (adjusted): 1985 2014
Included observations: 30 after adjustments
LOG(MEXICO_MONEY_SUPPLY)^3=C(1)+ C(2)*LOG(MEX_VELOCITY)^3
+C(3)*LOG(MEXICO_INFLATION)^3+C(4)*LOG(MEXICO_GDP)^3

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-87376.44	3369.042	-25.93510	0.0000
C(2)	-4.408668	0.261502	-16.85904	0.0000
C(3)	26.20013	3.681701	7.116312	0.0000
C(4)	4.009015	0.124134	32.29593	0.0000
R-squared	0.996436	Mean dependent var		18783.42
Adjusted R-squared	0.996025	S.D. dependent var		3690.018
S.E. of regression	232.6447	Akaike info criterion		13.86047
Sum squared resid	1407212.	Schwarz criterion		14.04729
Log likelihood	-203.9070	Hannan-Quinn criter.		13.92023
F-statistic	2423.243	Durbin-Watson stat		1.519138
Prob(F-statistic)	0.000000			

The cubic regression equation for the United States is stated below. In this specific equation, velocity and output are statistically significant, where inflation is not. This could be due to the reason that there are variations in the data used to create the model. The coefficients are much larger in this model than in the standard one. The R-squared and adjusted r-squared are

smaller in the cubic model than in the standard model. The fit is better in the standard model than in the cubic model.

Table 10: Cubic Regression of Money Supply, Inflation, and Output

Table 6 test for Cubic Regression

Dependent Variable: LOG(USA_MONEY_SUPPLY)^3

Method: Least Squares (Gauss-Newton / Marquardt steps)

Date: 03/18/16 Time: 18:24

Sample (adjusted): 1985 2014

Included observations: 30 after adjustments

LOG(USA_MONEY_SUPPLY)^3=C(1)+C(2)*LOG(USA_VELOCITY)^3+C(3)

*LOG(USA_INFLATION)^3+C(4)*LOG(USA_GDP)^3

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-5547.502	3425.181	-1.619623	0.1174
C(2)	-24.98042	8.239245	-3.031882	0.0054
C(3)	91.80660	137.4830	0.667767	0.5102
C(4)	1.020209	0.122231	8.346580	0.0000
R-squared	0.862194	Mean dependent var		21631.67
Adjusted R-squared	0.846293	S.D. dependent var		900.7390
S.E. of regression	353.1388	Akaike info criterion		14.69517
Sum squared resid	3242383.	Schwarz criterion		14.88199
Log likelihood	-216.4275	Hannan-Quinn criter.		14.75493
F-statistic	54.22364	Durbin-Watson stat		0.387705
Prob(F-statistic)	0.000000			

In summary, the standard regression model better explained the data than the cubic and quadratic equations. I only included some variables for the regression because the data has the problem of multicollinearity.

Heteroscedasticity

To measure heteroscedasticity, several items are required. To confirm if heteroscedasticity has occurred, a person has to perform the White test. The test involves squaring the residuals and carrying out a regression via OLS with the squared residuals on the explanatory variables and its squared value.

In this model, RESID2 is the squared residuals of the Canada data set. The other variables are the independent variables and their squared quantities. The White test deals with

joint significance of the explanatory variables. The table shows the following results of a regression of the RESID2 variable against the explanatory variables and their squares. As can be seen, the F-statistic is 7.01239. The p-value for the F-statistic is 0.000246. The equation is heteroscedastic. The equation could be modified to estimate for the robust command. The robust command requires the use of the Huber-white command in E-views. The results are listed below. As shown below, the f-statistic is above the .05 level, therefore it is not heteroscedastic.

Table 11
Test for Heteroskedasticity of Canada

Dependent Variable: RESID2

Method: Least Squares (Gauss-Newton / Marquardt steps)

Date: 04/01/16 Time: 18:19

Sample (adjusted): 1985 2014

Included observations: 30 after adjustments

RESID2=C(1)+ C(2)*LOG(CANADA_VELOCITY)+C(3)*LOG(CANADA_VELO
CITY)^2+C(4)*LOG(CANADA_INFLATION_CPI)+C(5)
*LOG(CANADA_INFLATION_CPI)^2+C(6)*LOG(CANADA_GDP)+C(7)
*LOG(CANADA_GDP)^2

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-5.94E+08	9.83E+08	-0.603820	0.5519
C(2)	-928960.3	400312.3	-2.320589	0.0295
C(3)	14627.92	53231.14	0.274800	0.7859
C(4)	763222.9	386194.8	1.976264	0.0602
C(5)	-179639.4	71027.48	-2.529153	0.0187
C(6)	44788657	70870539	0.631978	0.5336
C(7)	-840019.9	1276430.	-0.658101	0.5170
R-squared	0.646573	Mean dependent var		190246.8
Adjusted R-squared	0.554374	S.D. dependent var		235825.6
S.E. of regression	157425.9	Akaike info criterion		26.97226
Sum squared resid	5.70E+11	Schwarz criterion		27.29921
Log likelihood	-397.5839	Hannan-Quinn criter.		27.07685
F-statistic	7.012839	Durbin-Watson stat		2.023894
Prob(F-statistic)	0.000246			

Table 12 adjustment of heteroskedasticity for Canada

Dependent Variable: LOG(CANADA_MONEY_SUPPLY)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 04/01/16 Time: 20:18
Sample (adjusted): 1985 2014
Included observations: 30 after adjustments
White heteroskedasticity-consistent standard errors & covariance
LOG(CANADA_MONEY_SUPPLY)=C(1)+C(2)*LOG(CANADA_VELOCITY)
+C(3)*LOG(CANADA_INFLATION_CPI)+C(4)*LOG(CANADA_GDP)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.79E-09	4.59E-10	3.899506	0.0006
C(2)	-1.000000	7.65E-12	-1.31E+11	0.0000
C(3)	1.000000	7.87E-12	1.27E+11	0.0000
C(4)	1.000000	1.60E-11	6.24E+10	0.0000
R-squared	1.000000	Mean dependent var		26.21880
Adjusted R-squared	1.000000	S.D. dependent var		0.651655
S.E. of regression	3.98E-12	Akaike info criterion		-49.53891
Sum squared resid	4.11E-22	Schwarz criterion		-49.35208
Log likelihood	747.0836	Hannan-Quinn criter.		-49.47914
F-statistic	2.59E+23	Durbin-Watson stat		0.301793
Prob(F-statistic)	0.000000	Wald F-statistic		4.94E+23
Prob(Wald F-statistic)	0.000000			

The same can be done for the country of Mexico's equation. In this case, the equation is not heteroskedastic, because the f-statistic is above the confidence intervals. Therefore, there would be no need to use the White heteroscedasticity-consistent standard errors command.

Table 13 Test for heteroskedasticity of Mexico

Dependent Variable: RESID2
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 04/01/16 Time: 19:56
Sample (adjusted): 1985 2014
Included observations: 30 after adjustments
RESID2= C(1)+C(2)*LOG(MEX_VELOCITY)+C(3)*LOG(MEX_VELOCITY)^2
+C(4)*LOG(MEXICO_INFLATION)+C(5)*LOG(MEXICO_INFLATION)^2
+C(6)*LOG(MEXICO_GDP)+C(7)*LOG(MEXICO_GDP)^2

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	4.25E+08	1.63E+09	0.261202	0.7963
C(2)	86148.48	731597.2	0.117754	0.9073
C(3)	-7931.179	34417.77	-0.230438	0.8198
C(4)	54581.17	856040.6	0.063760	0.9497
C(5)	1553.126	105407.5	0.014734	0.9884
C(6)	-28713218	1.09E+08	-0.263909	0.7942
C(7)	484509.4	1818104.	0.266492	0.7922
R-squared	0.069423	Mean dependent var		190246.8
Adjusted R-squared	-0.173336	S.D. dependent var		235825.6
S.E. of regression	255447.9	Akaike info criterion		27.94039
Sum squared resid	1.50E+12	Schwarz criterion		28.26733
Log likelihood	-412.1058	Hannan-Quinn criter.		28.04498
F-statistic	0.285974	Durbin-Watson stat		1.408185
Prob(F-statistic)	0.937632			

The U.S. model can be tested. The United States' White test can verify the existence of heteroscedasticity. The results of the White test are shown below. The results of the White test show that there is statistical significance of heteroscedasticity. The f-statistic is below any of the confidence interval. This confirms that there is heteroscedasticity for this equation. The equation for the United States can be written as the following:

Table 14 test for Heteroskedasticity of USA

Dependent Variable: RESID2

Method: Least Squares (Gauss-Newton / Marquardt steps)

Date: 03/18/16 Time: 18:43

Sample (adjusted): 1985 2014

Included observations: 30 after adjustments

$$\text{RESID2} = \text{C}(1) + \text{C}(2) * \text{LOG}(\text{USA_VELOCITY}) + \text{C}(3) * \text{LOG}(\text{USA_VELOCITY})^2 + \text{C}(4) * \text{LOG}(\text{USA_INFLATION}) + \text{C}(5) * \text{LOG}(\text{USA_INFLATION})^2 + \text{C}(6) * \text{LOG}(\text{USA_GDP}) + \text{C}(7) * \text{LOG}(\text{USA_GDP})^2$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-5.67E+08	8.58E+08	-0.661112	0.5151
C(2)	128115.6	948417.7	0.135084	0.8937
C(3)	-51147.66	167463.0	-0.305427	0.7628
C(4)	-499797.7	250128.0	-1.998168	0.0577
C(5)	137583.5	200711.5	0.685479	0.4999
C(6)	38072398	57123044	0.666498	0.5117
C(7)	-638295.0	950316.5	-0.671666	0.5085
R-squared	0.497702	Mean dependent var		190246.8
Adjusted R-squared	0.366668	S.D. dependent var		235825.6
S.E. of regression	187675.1	Akaike info criterion		27.32378
Sum squared resid	8.10E+11	Schwarz criterion		27.65072
Log likelihood	-402.8566	Hannan-Quinn criter.		27.42837
F-statistic	3.798264	Durbin-Watson stat		1.707654
Prob(F-statistic)	0.008927			

Table 15 Correction for Standard errors of USA

Dependent Variable: LOG(USA_MONEY_SUPPLY)

Method: Least Squares (Gauss-Newton / Marquardt steps)

Date: 04/08/16 Time: 09:31

Sample (adjusted): 1985 2014

Included observations: 30 after adjustments

White heteroskedasticity-consistent standard errors & covariance

$$\text{LOG}(\text{USA_MONEY_SUPPLY}) = \text{C}(1) + \text{C}(2) * \text{LOG}(\text{USA_VELOCITY}) + \text{C}(3) * \text{LOG}(\text{USA_INFLATION}) + \text{C}(4) * \text{LOG}(\text{USA_GDP})$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-5.991830	3.304305	-1.813341	0.0813
C(2)	-0.279870	0.103090	-2.714798	0.0116
C(3)	0.053594	0.089615	0.598045	0.5550
C(4)	1.150944	0.108391	10.61849	0.0000
R-squared	0.879491	Mean dependent var		27.85801
Adjusted R-squared	0.865586	S.D. dependent var		0.383978
S.E. of regression	0.140776	Akaike info criterion		-0.959730
Sum squared resid	0.515264	Schwarz criterion		-0.772904
Log likelihood	18.39595	Hannan-Quinn criter.		-0.899963
F-statistic	63.25050	Durbin-Watson stat		0.501485
Prob(F-statistic)	0.000000	Wald F-statistic		60.62557
Prob(Wald F-statistic)	0.000000			

The first and third entries have statistical significance. The second does not. The adjusted values still have a low amount. This can be due to the result that the standard errors have been adjusted.

Multicollinearity

The issue of multicollinearity is a dilemma that arises when dealing with a data set. Multicollinearity is a problem that can dilute the results of a regression analysis. Therefore a person needs to check for multicollinearity when dealing with regression analysis.

To check to see if the data is collinear, one must regress the independent variables on each other. Once this is done, looking at the results is next. If the coefficient for the regressor is very high, multicollinearity is highly likely.

The following tables have a regression of an independent variable on another one. I regressed the GDP of Canada, Mexico, and the United States on the inflation measure of the respective countries.

The first country I estimated was Canada. The results show a huge coefficient difference between the two statistical measures. Therefore, one can interpret there to be multicollinearity. Canada's output goes along the same path as its inflation. But there is more to the data than just this test.

Table 16 Test for Multicollinearity of Canada

Dependent Variable: CANADA_GDP
 Method: Least Squares (Gauss-Newton / Marquardt steps)
 Date: 04/13/16 Time: 19:17
 Sample (adjusted): 1985 2014
 Included observations: 30 after adjustments
 CANADA_GDP = C(1) +
 C(2)*CANADA_INFLATION_CPI

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.61E+12	9.44E+10	17.09208	0.0000
C(2)	-1.14E+11	3.41E+10	-3.355649	0.0023
R-squared	0.285193	Mean dependent var	1.34E+12	
Adjusted R-squared	0.259665	S.D. dependent var	2.94E+11	
S.E. of regression	2.53E+11	Akaike info criterion	55.41432	
Sum squared resid	1.79E+24	Schwarz criterion	55.50773	
Log likelihood	-829.2147	Hannan-Quinn criter.	55.44420	
F-statistic	11.17144	Durbin-Watson stat	0.343860	
Prob(F-statistic)	0.002369			

The next country that I test multicollinearity for was Mexico. The result are found in the table below. I used the same format as I did for Canada: regressing GDP on inflation. The coefficient is very low, $-1.14 * 10^{11}$. This shows that there is multicollinearity for the variables. The variables follow the same trajectory along the years. This issue has to be accounted for.

Table 17 Test for Multicollinearity of Mexico

Dependent Variable: MEXICO_GDP
 Method: Least Squares (Gauss-Newton / Marquardt steps)
 Date: 04/13/16 Time: 19:19
 Sample (adjusted): 1985 2014
 Included observations: 30 after adjustments
 MEXICO_GDP = C(1) + C(2)*MEXICO_INFLATION

	Coefficien			
	t	Std. Error	t-Statistic	Prob.
C(1)	1.10E+13	3.86E+11	28.36817	0.0000
C(2)	-4.93E+10	9.72E+09	-5.067349	0.0000
R-squared	0.479057	Mean dependent var	9.79E+1	2
Adjusted R-squared	0.460452	S.D. dependent var	2.31E+1	2
S.E. of regression	1.70E+12	Akaike info criterion	59.22149	
Sum squared resid	8.06E+25	Schwarz criterion	59.31490	
Log likelihood	-886.3224	Hannan-Quinn criter.	59.25138	
F-statistic	25.74871	Durbin-Watson stat	0.435314	
Prob(F-statistic)	0.000023			

The last country I tested for was the United States. The result of the test for multicollinearity are found below. The coefficient of the United States' inflation is extremely low. The results demonstrate evidence for multicollinearity. This shows is that the data for both inflation and GDP follow the similar trends. The results have to be accounted for.

Table 18 test for Multicollinearity of USA

Dependent Variable: USA_GDP

Method: Least Squares (Gauss-Newton / Marquardt steps)

Date: 04/13/16 Time: 19:23

Sample (adjusted): 1985 2014

Included observations: 30 after adjustments

USA_GDP = C(1) + C(2)*USA_INFLATION

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.43E+13	1.20E+12	11.89904	0.0000
C(2)	-9.37E+11	4.66E+11	-2.012428	0.0539
R-squared	0.181782	Mean dependent var		1.21E+13
Adjusted R-squared	0.152560	S.D. dependent var		2.76E+12
S.E. of regression	2.54E+12	Akaike info criterion		60.03221
Sum squared resid	1.81E+26	Schwarz criterion		60.12562
Log likelihood	-898.4832	Hannan-Quinn criter.		60.06209
F-statistic	6.220716	Durbin-Watson stat		0.080237
Prob(F-statistic)	0.018802			

All this data says that the variables of inflation and output are very collinear. There is a hint of intuition behind this. Changes in GDP affect the changes in the price level. During periods of high GDP, people consume more. The high consumption affects the level of prices in the economy. During periods of low GDP, prices goes down because people are spending less. So the data says that the two variables are collinear, but the fact is that this is expected given the situation. Collinearity might exists definitely but, the reason behind this give us a cause not to reject the model. Therefore, the model still holds.

Serial Correlation

The data I collected is time-series; therefore, I can test for serial correlation. Serial correlation is the similarity of values of the residuals across time. The issue of serial correction

can interfere with the correctness of t-statistics and standard errors, because the classical theory assumes that errors are independent of each other. A good economist must account for serial correlation when undertaking regression analysis.

To understand serial correlation, many tools can be used. A graph can be used to see if the residuals correspond to each other over time. You can observe the Durbin-Watson statistic and check for statistical significance of serial correlation. The following graph displays the residuals of Canada over time. The graph displays that there is serial correlation.

Fortunately, there is a way to solve this problem: use the corrected standard errors to improve the outcome. Using the Newey-West standard errors can fix the problem of serial correlation. The new statistics for Canada are found below.

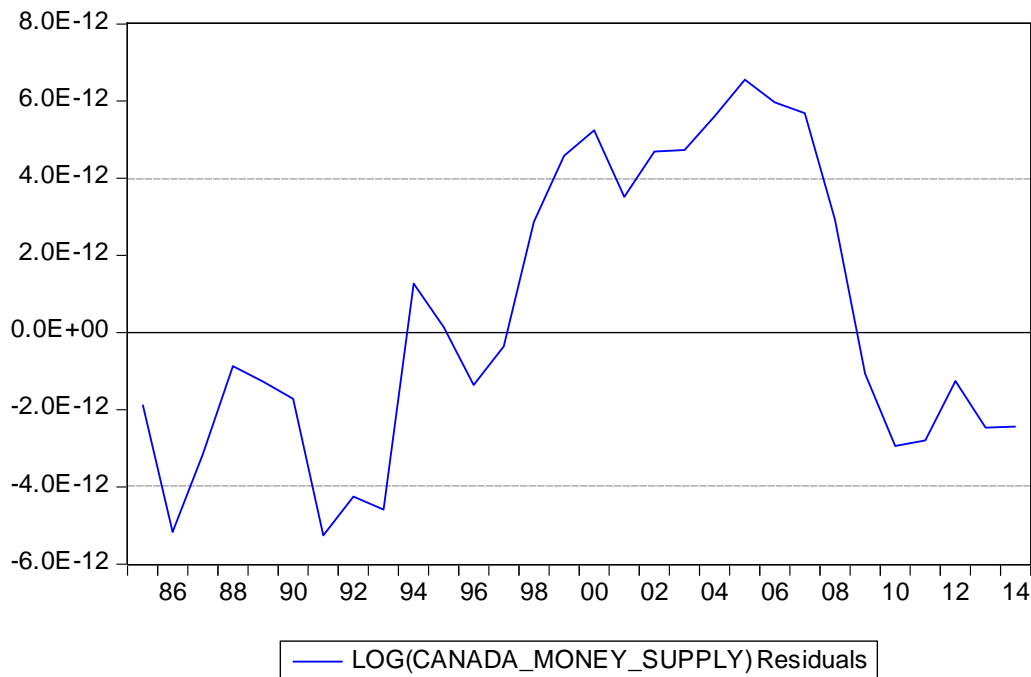


Figure 1 Serial Correlation of Canada

Table 19 Adjustment for Serial Correlation of Canada

Dependent Variable: LOG(CANADA_MONEY_SUPPLY)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 04/02/16 Time: 15:00
Sample (adjusted): 1985 2014
Included observations: 30 after adjustments
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed
bandwidth = 4.0000)
LOG(CANADA_MONEY_SUPPLY)=C(1)+C(2)*LOG(CANADA_VELOCITY)
+C(3)*LOG(CANADA_INFLATION_CPI)+C(4)*LOG(CANADA_GDP)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.79E-09	8.14E-10	2.200907	0.0368
C(2)	-1.000000	1.35E-11	-7.42E+10	0.0000
C(3)	1.000000	1.37E-11	7.30E+10	0.0000
C(4)	1.000000	2.84E-11	3.52E+10	0.0000
R-squared	1.000000	Mean dependent var		26.21880
Adjusted R-squared	1.000000	S.D. dependent var		0.651655
S.E. of regression	3.98E-12	Akaike info criterion		-49.53891
Sum squared resid	4.11E-22	Schwarz criterion		-49.35208
Log likelihood	747.0836	Hannan-Quinn criter.		-49.47914
F-statistic	2.59E+23	Durbin-Watson stat		0.301793
Prob(F-statistic)	0.000000	Wald F-statistic		1.95E+23
Prob(Wald F-statistic)	0.000000			

For Mexico, the issue of serial correlation also occurs. The following graph demonstrates the issue of serial correlation. The graph demonstrates there is serial correlation. The errors of the equation are related to each other. This is a problem because one of the assumptions of the classical model is that errors are independent of each other. To account for this problem, one can use the Newey-West standard error to compensate for the data. The following table corrects the shortcomings.

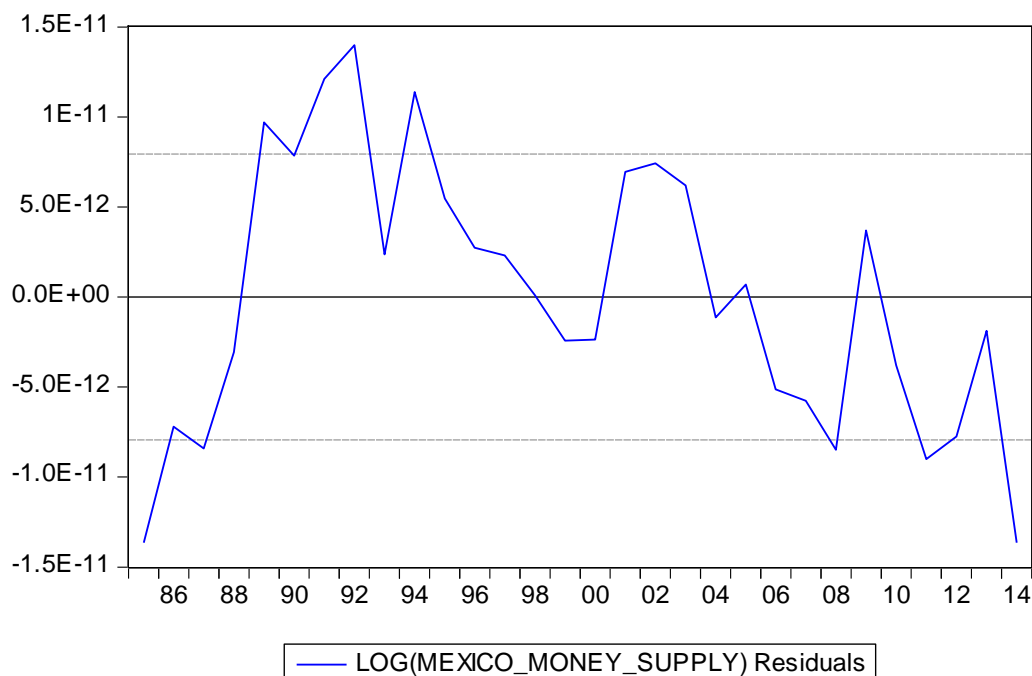


Figure 2 Serial Correlation of Mexico

Table 20 Adjustment for Serial Correlation of Mexico

Dependent Variable: LOG(MEXICO_MONEY_SUPPLY)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 04/02/16 Time: 15:14
Sample (adjusted): 1985 2014
Included observations: 30 after adjustments
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed
bandwidth = 4.0000)

$$\text{LOG(MEXICO_MONEY_SUPPLY)} = C(1) + C(2) * \text{LOG(MEX_VELOCITY)} + C(3) * \text{LOG(MEXICO_INFLATION)} + C(4) * \text{LOG(MEXICO_GDP)}$$

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-3.30E-09	1.45E-09	-2.280779	0.0310
C(2)	-1.000000	4.97E-12	-2.01E+11	0.0000
C(3)	1.000000	5.57E-12	1.80E+11	0.0000
C(4)	1.000000	4.76E-11	2.10E+10	0.0000

R-squared	1.000000	Mean dependent var	26.45904
Adjusted R-squared	1.000000	S.D. dependent var	1.860116
S.E. of regression	7.94E-12	Akaike info criterion	-48.15662
Sum squared resid	1.64E-21	Schwarz criterion	-47.96979
Log likelihood	726.3493	Hannan-Quinn criter.	-48.09685
F-statistic	5.30E+23	Durbin-Watson stat	0.685019
Prob(F-statistic)	0.000000	Wald F-statistic	2.45E+23
Prob(Wald F-statistic)	0.000000		

The issue with the United States is similar. There is a need to check for serial correlation with the dependent variable. To determine if serial correlation exists, plot the residuals over time on a graph. The following graph demonstrates this result.

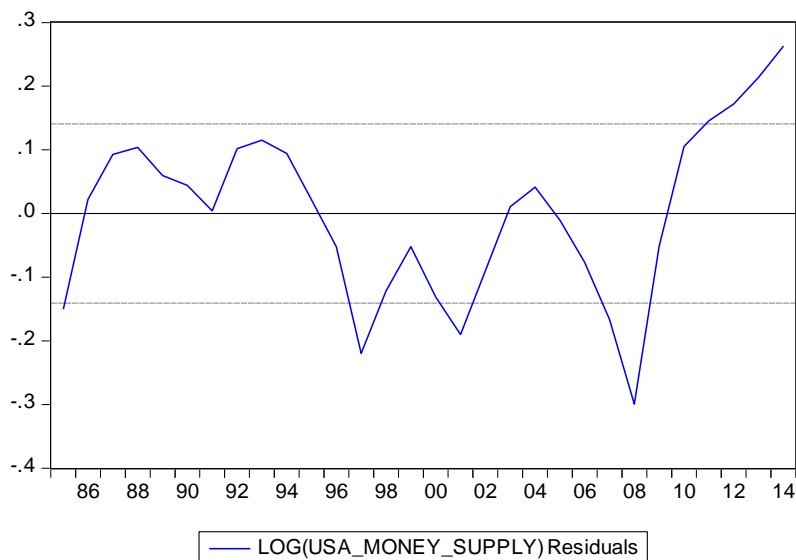


Figure 3 Serial Correlation for USA

As can be seen, the residuals vary over time. There is evidence of serial correlation. There has to be adjustment in order to correct the data. Using the Newey-West standard error can correct for this issue. The following table is a correction of the standard errors. The statistics changed. This gives a better approximation of the model.

Table 21 Adjustment for Serial Correlation of USA

Dependent Variable: LOG(USA_MONEY_SUPPLY)
 Method: Least Squares (Gauss-Newton / Marquardt steps)
 Date: 04/02/16 Time: 15:26
 Sample (adjusted): 1985 2014
 Included observations: 30 after adjustments
 HAC standard errors & covariance (Bartlett kernel, Newey-West fixed
 bandwidth = 4.0000)
 LOG(USA_MONEY_SUPPLY)=C(1)+C(2)*LOG(USA_VELOCITY)+C(3)
 *LOG(USA_INFLATION)+C(4)*LOG(USA_GDP)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-5.991830	3.990909	-1.501370	0.1453
C(2)	-0.279870	0.111765	-2.504089	0.0189
C(3)	0.053594	0.099957	0.536169	0.5964
C(4)	1.150944	0.135233	8.510797	0.0000
R-squared	0.879491	Mean dependent var		27.85801
Adjusted R-squared	0.865586	S.D. dependent var		0.383978
S.E. of regression	0.140776	Akaike info criterion		-0.959730
Sum squared resid	0.515264	Schwarz criterion		-0.772904
Log likelihood	18.39595	Hannan-Quinn criter.		-0.899963
F-statistic	63.25050	Durbin-Watson stat		0.501485
Prob(F-statistic)	0.000000	Wald F-statistic		37.16218
Prob(Wald F-statistic)	0.000000			

Granger Causality

Because the topic is based on time-series data, the topic of Granger causality should be addressed. The topic of Granger causality deals with how connected two variables are over time. The issue is whether the data signifies if one variable “Granger causes” another variable. Does the changes in one variable over time affect another variable? The Granger causality is tested using a joint significance f-test.

Money Supply and GDP are not Granger causal. Money Supply and inflation are not related by Granger Causality. Velocity and the money supply are not Granger caused by each other. If the values were different, I would have a different outcome.

Table 22 Granger Causality results for Canada

Pairwise Granger Causality Tests

Date: 04/02/16 Time: 17:15

Sample: 1985 2015

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
CANADA_MONEY_SUPPLY does not Granger Cause CANADA_GDP	28	0.13253	0.8765
CANADA_GDP does not Granger Cause CANADA_MONEY_SUPPLY		2.14201	0.1403
CANADA_MONEY_SUPPLY does not Granger Cause CANADA_INFLATION_CPI	28	0.32930	0.7228
CANADA_INFLATION_CPI does not Granger Cause CANADA_MONEY_SUPPLY		0.37451	0.6917
CANADA_VELOCITY does not Granger Cause CANADA_MONEY_SUPPLY	28	0.42669	0.6577
CANADA_MONEY_SUPPLY does not Granger Cause CANADA_VELOCITY		0.17292	0.8423

I did a Granger causality test for Mexico and received the following results. The money supply in Mexico does not Granger cause the GDP of this country.. The money supply does not Granger cause the inflation in Mexico. The inflation does not Granger Cause the money supply. The money supply in Mexico does not Granger cause velocity. The Mexican velocity of money does not Granger cause the Mexican money supply.

Table 23 Granger Causality Tests for Mexico

Pairwise Granger Causality Tests

Date: 04/02/16 Time: 17:21

Sample: 1985 2015

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
MEXICO_MONEY_SUPPLY does not Granger Cause MEXICO_GDP	28	3.28832	0.0555
MEXICO_GDP does not Granger Cause MEXICO_MONEY_SUPPLY		0.27653	0.7609
MEXICO_MONEY_SUPPLY does not Granger Cause MEXICO_INFLATION	28	1.27476	0.2985
MEXICO_INFLATION does not Granger Cause MEXICO_MONEY_SUPPLY		0.09573	0.9091
MEXICO_MONEY_SUPPLY does not Granger Cause MEX_VELOCITY	28	0.01461	0.9855
MEX_VELOCITY does not Granger Cause MEXICO_MONEY_SUPPLY		0.23111	0.7955

The situation for the United States is listed below. The United States velocity does not Granger cause the money supply, but the money supply does Granger cause the USA's velocity.

The inflation in America does not Granger Cause the money supply, nor does the money supply cause the inflation. The GDP of the United states does not Granger cause the money supply, and the money supply does not Granger cause the U.S.' GDP.

Table 24 Granger Causality results for USA

Pairwise Granger Causality Tests

Date: 04/02/16 Time: 17:34

Sample: 1985 2015

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
USA_VELOCITY does not Granger Cause USA_MONEY_SUPPLY	28	0.12850	0.8800
USA_MONEY_SUPPLY does not Granger Cause USA_VELOCITY		5.47432	0.0114
USA_INFLATION does not Granger Cause USA_MONEY_SUPPLY	28	0.04063	0.9603
USA_MONEY_SUPPLY does not Granger Cause USA_INFLATION		2.17080	0.1369
USA_GDP does not Granger Cause USA_MONEY_SUPPLY	28	0.39772	0.6764
USA_MONEY_SUPPLY does not Granger Cause USA_GDP		1.86868	0.1770

Forecasting

Because of the subject matter, the time series data can be forecasted. The three countries have data that can be used to predict future trends. Since money supply is the dependent variable, I will only predict future money supply amounts.

The money supply of Canada can be forecasted using the data from past periods. I created a Vector Autoregressive model to simulate the future money supply. The following is an equation for the forecast of future money supply for Canada:

Equation 1 the VAR of Canada Money Supply

$$\text{CANADA_MONEY_SUPPLY} = 4.06366118408\text{e-}13 \cdot \text{CANADA_MONEY_SUPPLY}(-1) - 2.88154382765\text{e-}13 \cdot \text{CANADA_MONEY_SUPPLY}(-2) + 0.000229568317703 + 1 \cdot \text{CANADA_MONEY_SUPPLY}$$

The results of this equation show that the future money supply is dependent on past values of the Canadian money supply. The lags of Canadian money supply give the expected value of the future money supply.

For Mexico, the same thing can be done. Taking the past values of the Mexican money supply can create an expectation of the future money supply. The following equation shows a Vector Autoregressive model.

Equation 2 VAR for Mexico

$$\text{MEXICO_MONEY_SUPPLY} = -7.36826972214\text{e-}13 * \text{MEXICO_MONEY_SUPPLY}(-1) + 3.28794179212\text{e-}13 * \text{MEXICO_MONEY_SUPPLY}(-2) - 0.000918765028345 + 1 * \text{MEXICO_MONEY_SUPPLY}$$

The U.S. money supply can be forecasted by a similar equation. Taking the lags from two previous periods, one can create a Vector Autoregressive model for the money supply.

Equation 3 VAR for USA

$$\text{USA_MONEY_SUPPLY} = 1.54383887743\text{e-}13 * \text{USA_MONEY_SUPPLY}(-1) - 1.48440333928\text{e-}13 * \text{USA_MONEY_SUPPLY}(-2) + 0.0148492415228 + 1 * \text{USA_MONEY_SUPPLY}$$

The equation up above show that the United States money supply can be forecasted by using past years' value and creating an equation for the expected future value. In this equation, I used two past values to predict a future value.

Thus, the money supply can be forecasted to allow an estimate of the future.

RESULTS

I collected much data for this paper. I did a regression for Mexico, Canada, and the United States separately. I collected the Money supply, inflation level and output of those respective country over the period 1985 to 2014. I used a compact disc from the International Monetary Fund to get the money supply for each country. I went to ycharts.com and the World Bank website to get inflation measures over time. I had to use a different measure for Canada because one value was negative and didn't adjust for my calculation of velocity. I got the output for each country from the World Bank website. I used the quantity theory of money formula to estimate the relationship between the variables. Once I had the data from the countries and the time periods, I calculated the velocity for each year and individual country. I had to linearize the equations to get results.

The velocity coefficient for the Canada equation is negative as is expected to be. The velocity was originally on the other side of the equation, so it is reasonable that it would be on negative. The coefficients for inflation and Gross Domestic Product are positive. The variables for the velocity, inflation, and output are all less than .05. These results imply that they are all statistically significant at the five percent confidence interval. Thus, for this specific equation, the velocity, inflation and output for Canada are related to one another. There is evidence for joint statistical significance as seen in table 1. The f-value is well below the .01 confidence interval.

For Mexico, I also did a regression analysis over time. The results can be seen in table 1. Again, the velocity coefficient is negative. The intercept is negative also. The reason behind this is the variation in the data I used. The coefficients for output and inflation are positive. This could imply that as the inflation rate and output increase, the money supply increases. The p-

value for the all the variables are very small. This shows that there is statistical significance between the velocity and the money supply, the inflation and the money supply, and the Gross Domestic Product and the money supply. There is joint statistical significance here as well. The p-value for the f-statistic is very small, showing a high incidence of statistical significance.

Once I had the velocity for each period, I could start the statistical calculations. I entered my data into Eviews and received a variety of data that measured a plethora of econometric phenomena. Some of the results were not what I expected. Some of the output was understandable. Most of the regression models dealing with the relationship between the money supply, velocity, inflation, and output were statistically significant. In the model, the regression models confirm to the theory of the quantity of money. Because I used three countries, I had a lot of data to sort through. The amount of years in the data set made this project data-intensive. In future studies, one could extend the amount of countries used in the data set. Including more years for analysis would also be a better indicator of economic theory.

CONCLUSION

The quantity theory of money has been tested. I have used a variety of statistical measures to determine if the theory holds up empirically. There have been a few exceptions to the data, but the quantity theory of money still holds. The theory that the money supply of a country is tied to its inflation level and level of output still carries heavy weight. There were a few instances where the theory was lacking, but overall the data I computed showed that the quantity theory of money is a good representation of the way the money supply is connected to the output and inflation in a country.

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