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Monetary Policy Implications of Cash, Other Money Supplies, and Cryptocurrencies in Singapore: A Growing Cashless Society.

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ABSTRACT

The country of Singapore has been a growing cashless society for years. Analyzing their money supplies relative to their gross domestic product and their consumer price index can give insight into how the central bank of Singapore are able to maintain control over their monetary policy. Using data from 1974 to the present, I tested the effect of physical cash and other money supplies on the economic and inflationary growth of this country. With this in mind, I expected to see a positive correlation between these money supplies, GDP, and inflation. However, what I found in my regression analysis was the opposite regarding cash. There found to be no significant impact of physical cash on gross domestic product or inflation; therefore, money supply zero, or physical money, does not contribute significant effects on the economic well-being or inflation of the country of Singapore. With the basis of my theories grounded in the quantity theory of money, it is surprising to find that my results for money supply zero defies this theory. As for the other money supplies, these being money supply two and three, there was found to be a significant impact on both gross domestic product and the consumer price index. This followed what I believed to be true in my hypothesis.

I. INTRODUCTION

Monetary policy is used by central banks around the world to manipulate and control the markets. Cash is the basis for most of what economists would use to implement monetary policy. However, there is a world-wide trend commencing of societies going cashless. My research will delve into whether or not cash has an impact on the monetary system of a particular country; I have chosen to use Singapore, as they have an almost complete cashless society, and I will compare it to other findings for other countries as well.

My research will contribute to furthering the understanding of monetary policy and the true impact of cash on a small scale of macroeconomics. It will possibly add to already previously discovered knowledge of the correlation between cash and macroeconomic factors or shed light on alternative ways to influence monetary policy.

I will also be looking slightly at the monetary policy implications of the rise in the usage of cryptocurrencies that are replacing physical monies. With the trend of going cashless in many societies rising there will be a significant shift from physical cash to cryptocurrencies like Bitcoin. The impact of this shift on the central bank of Singapore is merely speculation and I will not be using data since this trend is new within the past five years and would have little statistical significance.

I will be comparing my research to others' findings in other progressive cashless societies to uncover any patterns that may be arising out of macro factors in countries with little to no cash. This, along with others' research, could be used to begin the process of going cashless in larger societies like the United States.

II. BACKGROUND

Starting my research for monetary policy in a cashless society brought various sources and scholarly articles to not only increase my knowledge on the topic, but also help me move towards a solid hypothesis.

Storti and Grauwe outline two questions in their article: the first being whether going cashless will cause price indeterminacy or inflation and the other being what the central banks' role becomes if there is no cash in circulation (Storti & Grauwe, 2001). The paper concluded that in a cashless society there will be inflation and an inability to fluctuate prices manually. The central banks' authority with monetary policy decreases significantly without cash in circulation because they are no longer able to manage price stability using traditional monetary tools. My research will be based on this theory and extending it to the country of Singapore to make sure that the theory holds up in real life with actual numerical data.

Yaqub, Bello, Adenuga, and Ogundeji centered their article on the country of Nigeria which has recently introduced policies to go cashless and based transactions electronically (Yaqub, Bello, Adenuga, & Ogundeji, 2013). It attempts to illuminate the benefits and also the challenges Nigeria will face with transitioning to a cashless society. What it concluded with regards to monetary policy is that the cashless society was initiated to increase the effectiveness of Nigeria's central bank's monetary tools since having so much cash in circulation was hindering the central bank's ability to control inflation and prices. Although there was evidence that the central bank could lose control if they failed to maintain their grasp on fiscal policy. This paper has given me insight into the argument that in countries with excessive amounts of cash causing rapid inflation, going cashless could benefit them. With this in mind, I will make sure to add this to my research and determine if Singapore has overly excessive amounts of cash in

circulation and therefore might be able to control monetary policy better without the usage of physical money.

Bordo and Levin from the Hoover Institution touch on the significance of central banks developing their own form of cryptocurrency in order to maintain the level of control in monetary policy that cash allowed for (Bordo & Levin, 2017). The findings were that the usage of cryptocurrencies by central banks would allow for a safe, stable, and costless alternative to physical cash. Central banks, particularly in the United States, could use these electronic monies to continue with the monetary policy initiatives laid out for them including price stability. Although I comprehend the argument behind the usage of electronic monies by the central bank, however, I do not understand how these substitutes would be safe. The usage of electronic cash like Bitcoin has no real life backing behind it and there is room for error with these types of nonexistent monies. There is also risk of privacy and hacking that the journal article failed to look at; if hackers were able to access a central bank's bitcoin reserve it could put an entire country at risk. Before this would actually be able to work there would have to be a backing by either the country's government or another entity like the FDIC. If there was a way that allowed for central banks around the world to substitute in cryptocurrencies for physical cash as this trend increases then monetary policy would be unaffected, however, until then central banks like the central bank of Singapore will be unable to fully influence the markets.

Arnone and Bandiera attempt to identify the effects on the central banks' ability to implement monetary policy with cash going electronic (Arnone & Bandiera, 2004). The findings were that the increase in the usage of electronic money would have little to no effect on the monetary policy goals enforced by the central bank. Central banks will still be able to manipulate short term interest rates and therefore maintain a grip on monetary policy; they will begin this

process, however, by using an intervention band and interfering once it goes past this band limit. This argument coincides with the argument made by "Cashless Policy in Nigeria" in that it expresses doubts of the central banks' authority being diminished without cash in circulation. This paper has added to the possibility that going cashless would not actually impact central banks, however, where this paper falters is it does not discuss the velocity of money and the impact this theory has on this type of situation. The drastic increase in the velocity of money would have an effect on the central bank and their role as an influencer of economic activity.

Adding on to the article above with regards to the electronic money movement, Palley's article argues that it will impact the central banks' ability to control and influence monetary policy (Palley, 2001). This article states that since central banks get most of their control from the leveraging of liabilities, with electronic money the demand for these liabilities will decrease among the financial system and take away any power the central bank has over price stability through open market operations. It covers ways of possibly asserting the central banks' control over inflation and interests rates, but ultimately the central banks will lose their authority to influence markets. This article raised intellectual points for my thesis especially when explaining the process of banks and their liabilities to the country's central bank. I knew the overall premise of the process, but the paper went into more depth and added to my background knowledge that I will use to defend my thesis.

Dalebrant, in her thesis written at Berkley University, delves in Sweden's cashless society and the way that it affects the Riksbank (Dalebrant, 2016). The author argues that the movement towards no cash will not have a negative effect on the Riksbank's ability to conduct monetary policy. The data used, although with the little data there was, the author's money supplies for

Sweden were found to have no significant effect on GDP or inflation. I am going to use this paper to compare to my own findings with Singapore since both countries are advanced cashless societies. My data will be more extensive over a longer period of time and therefore I expect to find differing data from this particular thesis.

Yi Wen wrote a short essay for the Federal Reserve of St. Louis about the quantity theory of money (citation). He extrapolates that the quantity theory of money holds that an increase in the money supply will increase the average price level through the equation:

$$P = V + M - Y$$

However, the quantity theory of money also assumes the money growth will remain constant which will cause no effect on the output (Y) and therefore not cause any effect on the gross domestic product. If the growth of money does not hold this assumption will fluctuate making the equation:

$$Y = V + M - P$$

This illustrates my hypothesis that an increase in cash or other money supplies will cause an increase in total output and increase the gross domestic product. This helps to further my thesis by assisting in explaining the signage of my data; I am using the quantity theory of money to justify why the increase in the money supply also increases the CPI and GDP.

Hock-Han Tee and Hway-Boon Ong, professors at Multimedia University in Malaysia, conducted a study of five different European Union countries including Austria, Belgium, France, Germany, and Portugal all of which are going cashless (Ong, 2016). They were searching for a short-run and long-run effect of adopting a cashless policy in these countries.

They found that in each country going cashless did not have an effect on gross domestic production in the short-run, however, did have an effect in the long-run. Therefore, these countries adopting this type of policy will not be able to see the effect on their economy until very long after it is implemented. Applying this to my research, it may be hard for the effect of the money supply zero to be seen on gross domestic product and inflation since my data only reaches back to 1974. This could prepare a refutation to any reason as to why my data may show my independent variables have no significant impact on my two dependent variables

III. MODEL DEVELOPMENT

Equations

+

CPI

Null and Alternative Hypothesis

GDP

CPI

Variables and signs

The quantity theory of money states that the money supply multiplied by the velocity of money is proportional to average price level multiplied by the total transactions in the economy.

$$M \times V = P \times Y$$

This direct relationship assumes that as the money supply increases inflation will also increase causing wages to increase and in turn cause higher consumption and investment from individuals (Investopedia, 2017). This increase in consumption and other factors causes a proportional increase in the gross domestic product.

Based off of the quantity theory of money we can assume the following for the money supplies in relation to GDP and CPI:

GDP

: This is the auto-regressive term for the GDP equation to correct for multiplicative serial correlation. I expect this term to be positive.

M0: As the supply of cash in circulation increases there will be an increase in gross domestic product.

M2: As the usage of short-term money deposits and short term money market funds increases the gross domestic product will increase as well.

M3: As the usage of long-term money deposits and long term money market funds increases the gross domestic product will increase as well.

CPI

: This is the auto-regressive term for the CPI equation to correct for multiplicative serial correlation. I expect this term to be positive.

M0: As the cash in circulation increases there will be an increase in the rate of inflation indicated by the consumer price index.

M2: As the usage of short-term money deposits and short term money market funds increase there will be an increase in the rate of inflation indicated by the consumer price index.

M3: As the usage of long-term money deposits and long term money market funds increase there will be an increase in the rate of inflation indicated by the consumer price index.

IV. DESCRIPTION OF DATA

Data Dictionary

- GDP
    - The total value of all goods and services produced in a country within a year (Investopedia, 2017).
    - Collected annually from the World Bank from 1974 through 2016.
- CPI
    - Price index that measures changes in the price of a consumer basket of goods (Investopedia, 2017).
    - Collected annually from IEconomics from 1974 through 2016.
- M0
    - Money supply indicating all coins and notes (Financial Times, 2017).

- Collected annually from IEconomics from 1974 through 2016.

- M2
  - Money supply including all of M1 and all short term money deposits, and short term money market funds (IEconomics, 2017). For the purpose of my thesis, I will subtract M1 from M2 in order to get the accurate account of strictly M2.
  - Collected annually from IEconomnics from 1974 through 2016.

- M3
  - Money supply including all of M2 and all long term money deposits, and long term money market funds (IEconomics, 2017). For the purpose of my thesis, I will subtract M2 from M3 in order to get the accurate account of strictly M3.
  - Collected annually from IEconomnics from 1974 through 2016.

IEconomics is a branch off website from the original Trading Economics site. It is used for more precise and easily accessed graphs and data. This is the site I got all of my money supply data from and also to gain access to data for Singapore's CPI. I compared information for GDP from both IEconomics and Trading Economics with the World Bank's information in order to make sure both sites were credible, however, the World Bank does not publish information regarding the money supplies for Singapore so I was unable to check those variables. Since the information for GDP matched the World Bank's information I do trust the data from both sites; I would have liked to get all of the data from the World Bank data website, but the World Bank does not publish the money supply data for this country. I would have also liked to have had quarterly data for all of my variables, however, although I had quarterly data from IEconomics

and Trading Economics, the World Bank only published annual data for the GDP and therefore I had to stick with annual for all variables.

METHODOLOGY

For my regression, I will be running Ordinary Least Squares which is the standard regression analysis. OLS is a regression estimation technique that attempts to minimize the sum of the squared residuals when estimating the beta coefficients (Studenmund, 2016). Along with OLS I will also be using an auto-regression term to correct for multiplicative serial correlation. I discovered my equation had serial correlation through conducting a Durbin Watson test. I am using this regression technique and this auto-regressive term instead of using Generalized Least Squares because it is the easiest way for my equation to be estimated without serial correlation due to the nature of my serial correlation.

Before running a regression, I conducted a correlation matrix on SPSS50 to check for multicollinearity since I suspected this would be an issue with my data. Multicollinearity is when one variable is a linear dependent on another variable; in my case, since money supplies build on each other linear dependency will most certainly be the case even though I attempted to correct for this by taking the differences of the money supplies for my variables (Studenmund, 2016). The correlation between M0 and (M1-M0) where high between each other, however, were not highly correlated with the other variables of (M2-M1) and (M3-M2). Nor were (M2-M1) and (M3-M2) highly correlated with each other. The correlation coefficients for M0 and (M1-M0) were 0.927. The general rule of thumb being above 0.8 there is sever multicollinearity, these two variables are almost identical. I have since decided to leave out the variable (M1-M0) and leave in the variable M0, even though there still are traces of multicollinearity, due to the nature of my

thesis and the need for having cash in circulation within my equations. Below is my correlation matrix:

Correlations

		Real GDP (2016 $)	GDP auto-regressive	M0	M2-M1	M3-M2	Auto-regressive CPI	CPI
Real GDP (2016 $)	Pearson Correlation	1	.992**	.966**	.983**	.109	.872**	.952**
GDP auto-regressive	Pearson Correlation	.992**	1	.976**	.986**	.123	.881**	.958**
M0	Pearson Correlation	.966**	.976**	1	.980**	.094	.880**	.949**
M2-M1	Pearson Correlation	.983**	.986**	.980**	1	-.006	.860**	.940**
M3-M2	Pearson Correlation	.109	.123	.094	-.006	1	.282	.256
Auto-regressive CPI	Pearson Correlation	.872**	.881**	.880**	.860**	.282	1	.949**
CPI	Pearson Correlation	.952**	.958**	.949**	.940**	.256	.949**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Since my data is a time series there is also the issue of having multiplicative serial correlation. I conducted a Durbin-Watson test and found that the d-statistic came out to be less than my lower d-statistic limit and therefore I rejected the null of serial correlation. My d-statistic was 0.849 for my gross domestic product equation and 0.652 for my consumer price index equation. My d-lower limit was 1.29 for forty values and four independent variables. Since both

DW statistics were below this lower limit there is evidence of serial correlation. To solve for this issue I will be using an auto-regressive term: my dependent variable, real gross domestic product and consumer price index. I will be going with an AR(2) term as it seems to fit my time series the best; I had to run my data through eviews instead of the conventional excel in order to include this type of auto-regressive term. As the PAC reached closer to 0 there was a better fit, however, past three AR terms the complexity of my equation reached to great. Therefore compromising for two AR terms seemed to be in the greatest interest of my regression. An auto-regressive term will create a dynamic time series model which will explain the current GDP and CPI values without the error terms being correlated with each other (Studenmund, 2016). Below is the correlogram that eviews produced for me:

Date: 11/14/17 Time: 11:24
Sample: 1974 2016
Included observations: 43

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*******	. |*******	1	0.907	0.907	27.241	0
. |******|	. *| . |	2	0.804	-0.107	49.397	0
. |***** |	. *| . |	3	0.684	-0.15	66.027	0
. |**** |	. *| . |	4	0.561	-0.078	77.66	0
. |*** |	. *| . |	5	0.436	-0.087	84.96	0
. |**. |	. | . |	6	0.323	-0.015	89.122	0
. |**. |	. | . |	7	0.215	-0.056	91.046	0
. |*. |	. |*. |	8	0.138	0.081	91.873	0
. | . |	. | . |	9	0.068	-0.046	92.085	0
. | . |	. | . |	10	0.007	-0.053	92.088	0
. | . |	. | . |	11	-0.035	0.031	92.149	0
. *| . |	. *| . |	12	-0.079	-0.091	92.478	0
. *| . |	. | . |	13	-0.115	-0.021	93.222	0
. *| . |	. | . |	14	-0.139	0.01	94.386	0
. *| . |	. *| . |	15	-0.172	-0.094	96.274	0
. **| . |	. *| . |	16	-0.207	-0.07	99.203	0

V. RESULTS

Real Gross Domestic Product:

Dependent Variable: REAL_GDP__2016_$_
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 11/14/17 Time: 13:15
Sample: 1974 2016
Included observations: 43
Convergence achieved after 13 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.41E+10	1.12E+10	1.253542	0.2179
M0	-2800478.	1662408.	-1.684592	0.1005
M2_M1	1042287.	146340.1	7.122363	0.0000
M3_M2	1410299.	400480.8	3.521514	0.0012
AR(2)	0.106097	0.161624	0.656442	0.5156
SIGMASQ	1.83E+20	4.69E+19	3.906256	0.0004

R-squared	0.980730	Mean dependent var	1.20E+11
Adjusted R-squared	0.978126	S.D. dependent var	9.87E+10
S.E. of regression	1.46E+10	Akaike info criterion	49.77471
Sum squared resid	7.88E+21	Schwarz criterion	50.02046
Log likelihood	-1064.156	Hannan-Quinn criter.	49.86534
F-statistic	376.6152	Durbin-Watson stat	0.849763
Prob(F-statistic)	0.000000		

Inverted AR Roots	.33	-.33

The critical t-value for thirty-eight degrees freedom for a five percent confidence level is 1.686; I made the assumption that the auto-regressive term will count once.

The variable money supply zero is statistically insignificant, although there is a possibility that a larger sample size could make this variable significant as it is extremely close to being significant. The t-statistic for money supply zero is 1.685 which is less than the critical t-value of 1.686. I failed to reject the null that money supply zero effects the real gross domestic product of Singapore. For every one dollar increase in money supply zero there is a $2,800,478

decrease in the real gross domestic product of Singapore. This could also be in part due to the increase in usage of bitcoin and other cryptocurrencies since there is an alternative now to physical cash. GDP does not necessary have to decrease as physical cash decreases due to these various alternatives.

The variable money supply two (with money supply one subtracted out) is statistically significant at the five percent confidence level. The t-statistic for money supply two is 7.122 which is greater than the t-critical value of 1.686. I reject the null that money supply two does have an effect on the real gross domestic product of Singapore. For every one dollar increase in the money supply two there is a $1,042,287 increase in the gross domestic product of Singapore.

The variable money supply three (with money supply two subtracted out) is statistically significant at the five percent confidence level. The t-statistic for money supply three is 3.522 which is greater than the t-critical value of 1.686. I reject the null that money supply three does have an effect on the real gross domestic product of Singapore. For every one dollar increase in the money supply three there is a $1,410,299 increase in the gross domestic product of Singapore.

Consumer Price Index:

Dependent Variable: CPI
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 11/14/17 Time: 13:28
Sample: 1974 2016
Included observations: 43
Convergence achieved after 16 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	48.49265	3.169133	15.30155	0.0000
M0	0.000257	0.000211	1.216272	0.2316
M2_M1	0.000109	2.22E-05	4.903630	0.0000
M3_M2	0.000221	0.000116	1.909754	0.0639
AR(2)	0.883618	0.125121	7.062118	0.0000
SIGMASQ	5.571839	1.220984	4.563400	0.0001

R-squared	0.979657	Mean dependent var	69.21279
Adjusted R-squared	0.976908	S.D. dependent var	16.74561
S.E. of regression	2.544677	Akaike info criterion	4.905262
Sum squared resid	239.5891	Schwarz criterion	5.151011
Log likelihood	-99.46313	Hannan-Quinn criter.	4.995886
F-statistic	356.3606	Durbin-Watson stat	0.652363
Prob(F-statistic)	0.000000		

Inverted AR Roots	.94	-.94

The critical t-value for thirty-eight degrees freedom for a five percent confidence level is 1.686;I made the assumption that the auto-regressive term will count once.

The variable money supply zero is statistically insignificant at the five percent confidence level. The t-statistic for money supply zero is 1.216 which is less than the critical t-value of 1.686. I failed to reject the null that money supply zero effects the consumer price index of Singapore and therefore money supply zero will not have an effect on inflation. For every one dollar increase in money supply zero there is a 0.000257 point increase in the consumer price index of Singapore. With this in mind, central banks will not be forced to alternate their

monetary policy with regards to inflation. The dependency on physical money may transfer over to other methods like bitcoin that allow for the same targets to be achieved.

The variable money supply two (with money supply one subtracted out) is statistically significant at the five percent confidence level. The t-statistic for money supply two is 4.903 which is greater than the t-critical value of 1.686. I reject the null that money supply two does have an effect on the consumer price index of Singapore and therefore money supply two will have an effect on inflation. For every one dollar increase in money supply two there is a 0.000109 point increase in the consumer price index of Singapore.

The variable money supply three (with money supply two subtracted out) is statistically significant at the five percent confidence level. The t-statistic for money supply three is 1.910 which is greater than the t-critical value of 1.686. I reject the null that money supply three does have an effect on the consumer price index of Singapore and therefore money supply three will have an effect on inflation. For every one dollar increase in money supply three there is a 0.000221 point increase in the consumer price index of Singapore.

VI. CONCLUSION AND DISCUSSION

I found that my original hypothesis held mostly true until reaching money supply zero, or strictly physical money. Unlike what I originally thought, money supply zero is not significant in its influence of gross domestic product. I found my inflation data to not support the quantity theory of money in that as money increases there is not seen to be an increase in the consumer price index that is significant. This is also true for my hypothesis for the increase in gross domestic product as money increases; only, however, if the growth of money is not kept constant and allowed to fluctuate making the equation $Y = V + M - P$ as stated in the background portion

of this paper. Specifically for my data it is interesting that my data goes against this theory, although this could be because I do not have enough data points or there could be other issues with my data. It could also be the fact that I am only looking at the short-run and not the long-run. As seen with other data, GDP and inflation are not usually effected in the short-run, but can be seen in the long-run. Only looking at my data, however, it disproves this major influential theory.

My data and results could be used for other countries who are seeking to revert to a cashless system. With countries like Switzerland and Singapore leading the way, this could help others looking at this type of system with worry about whether or not it will affect their gross domestic product negatively. Countries converting to a system with no physical cash would still be able to influence their gross domestic product and their inflation rate within their country. Physical cash is not the only influencer of both of these concepts therefore countries with no cash can still control these systems.

By taking a slight look at the effect of bitcoin and other cryptocurrencies on monetary policy I hope that others will start to do more research on the topic of these types of currencies and applying them directly to central banks. Seeing the lack of significance with the physical cash on both gross domestic product and inflation gives the impression that the rise in cryptocurrencies and the subsequent decrease in cash may not have that large of an impact on the economy nor on central banks' roles within the economy. With more data there will be a better understanding of the true impact these types of currencies will have on a central bank's ability to regulate and maintain monetary policy, however, for now there is only speculation of the effects.

Going forward, I hope that this data can contribute to a larger scaled research project that could actually disprove or find true the quantity theory of money. I would also like to use this theory and research on other countries developing into cashless societies since as seen with Switzerland the quantity theory of money failed as well. It would be interesting to see if this holds true with not only Switzerland and Singapore, but also other countries. Adding more data as time goes on would also be an improving feature for future research as these countries continue their decline on their dependence of cash.

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