Berkeley
UNIVERSITY OF CALIFORNIA

The Monetary Policy Effects of Sweden's Transition Towards a Cashless Society: An Econometric Analysis

Therése Dalebrant
Honors Thesis in Economics
Advisor: Professor Steven Wood

University of California, Berkeley
Department of Economics
May 2016

Contents

Abstract: Sweden is predicted to become one of the world's first cashless societies. This will affect the Swedish economy in many ways, including the role of the Swedish central bank. The benefits to society are predicted to outweigh the costs, due to increased efficiency in the payment system and reduced transaction costs. Moreover, the ability of the Riksbank to carry out monetary policy will not be negatively affected. In contrast, the power of the Riksbank to control the economy may increase at the zero lower bound with less cash in circulation.

I would like to sincerely thank my advisor Professor Steven Wood for his guidance, support, and time spent helping me throughout this research process. His help has been extremely valuable both in terms of completing my thesis and for my own personal development as a student. I would also like to thank Professor Roger Craine for his guidance when setting up my econometric model and for his professional insights regarding monetary policy.

I. Introduction

Sweden is likely to become one of the first cashless societies in the world. Thus, in this paper, I raise the question of how the central bank of Sweden, the Riksbank, will be affected by this transition. More specifically, will their ability to conduct monetary policy change without cash in circulation?

Historically, economists have believed that the growth of the money supply was positively related to the nominal growth of GDP. This idea was represented by the quantity theory of money, which became the foundation for monetary policy decisions. However, most central banks today have adjusted the way they conduct monetary policy by targeting the short-term interest rate rather than the money supply. Because of this, I hypothesize that Sweden's transition towards a cashless society will not decrease the efficiency for the Riksbank to conduct monetary policy.

In turn, I will prove this by showing that the quantity theory of money does not hold through regression analysis, and thus conclude that a transition towards a cashless society will not affect the ability of the Riksbank to conduct monetary policy. In contrast, I introduce the idea that monetary policy may in fact become more efficient in a cashless society operating at the zero lower bound for nominal interest rates.

II. The Riksbank and the Swedish Payment System

Sweden is home to the world's oldest central bank, formally known as "The Riksbank", founded in 1668. The Riksbank was the first regular issuer of bank notes as well as the first central bank to introduce a price stability target in 1930 after abandoning the gold standard. This

strategy turned out to be highly efficient as it helped Sweden recover from the Great Depression faster in comparison to other countries.

More recently, the Riksbank has been in the forefront of the negative interest rate movement together with Japan, the European Central Bank, Denmark, and Switzerland. This novel unorthodox approach of cutting policy rates to negative territory in order to fight sluggish growth and reach inflation targets has received a lot of attention across the globe. As a result, economists follow Sweden's experiment of operating below the zero lower bound closely as it is regarded as a new era of monetary policy.

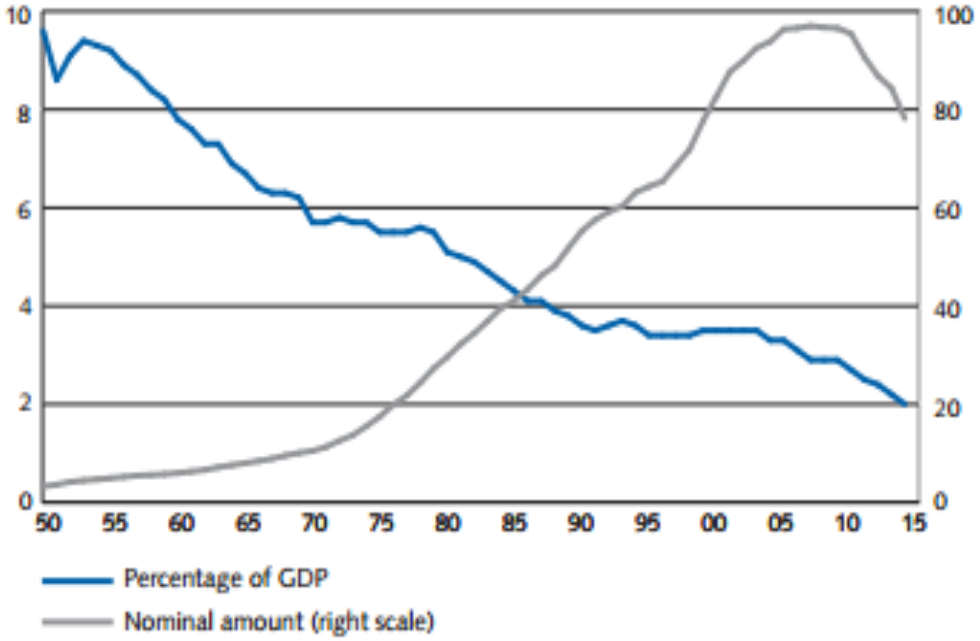
Needless to say, The Riksbank has been leading the way in terms of monetary policy for almost 400 years, and is now on the verge of writing economic history once again as Sweden is predicted to become the first country in the world to transition towards a cashless society. While Sweden's first coin was minted in 995, economists estimate that Sweden's very last coin will be minted by 2045. This is because electronic payment methods, such as debit cards and payment apps have increased rapidly in Sweden over the last two decades.

Today, the Swedish payment system consists of two major payment methods: cash payments and card payments. Cash payments are carried out by immediately transferring the value of a purchase from the buyer to the seller whereas banks function as an intermediary to transfer the value of the purchase from buyer to seller for card payments. The most important difference between the two methods is that cash has its own value in contrast to cards that function as an instrument to initiate a payment. The most common payment methods in Sweden are cash and debit card payments. Checks are rarely used after a 15kr ($1.80) fee was implemented in 1990.

According to the Riksbank, approximately one quarter of all payments at points of sale in Sweden are made in cash. However, given the relatively small size of cash payments, they represent only 10% of total payments. Moreover, as a percentage of GDP, the total value of coins and banknotes in circulation illustrate a long-term declining trend, as seen in chart 1.

Chart 1

Value of Banknotes and Coins in Circulation, 1950-2014
(Annual average, bank's holdings excluded)
Percentage as a proportion of GDP and SEK billion



Source: The Riksbank

As the proportion of non-cash payments has been rising in Sweden, the total cash in circulation has fallen significantly during the last two decades. In 1950, the value of notes and coins in circulation was around 10% of GDP whereas this number was only 2.6% in 2011. In comparison, by the end of 2010, the value of notes and coins in circulation in terms of Euros was

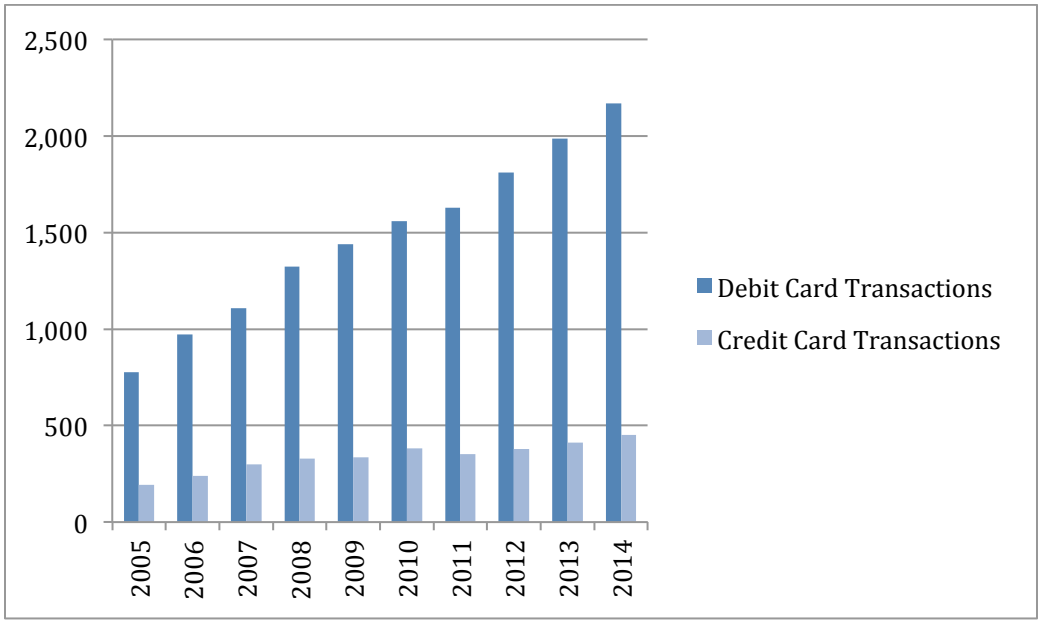
9.4% of the total GDP of the Euro region. Moreover, the Swedish researcher Niklas Arvidsson, states that out of the total cash in circulation, around 40-60% is in *actual* circulation, while the remaining cash is stored in homes, bank deposit boxes, or in the underground economy.

The Riksbank emphasizes multiple factors as to why the trend of moving from cash to non-cash payments will continue. These factors include the establishment of new payment innovations competing with cash, a younger generation with a lower cash usage replacing the older generation with a higher propensity to use cash, the increased use of e-commerce, as well as the fact that banks and stores are less inclined to accept cash as a result of the increased risk of and costs associated with handling cash.

Based on a survey examining consumer payment behavior in 2014, the Riksbank concluded that the most common payment method, regardless of transaction size, was debit cards for Swedish consumers in 2014. The Riksbank conducted the same survey in 2010 and 2012 and their results show that 2014 was the first year when debit cards surpassed cash and credit cards as the primary method of payment even for smaller below 100kr ($12.50) transactions. These results indicate that the Swedish payment system is moving quickly away from cash and towards the use of debit cards. In addition, the proportion of non-cash payments in Sweden is rising. According to the Riksbank, 98% of the Swedish population had access to a debit card, 88% to Internet banking, 50% to a credit card, and 22% to the mobile app Swish in 2014.

Chart 2

Debit Card Transactions are Rising in Sweden
Number of Transactions in SEK million



Source: The Riksbank

Arvidsson and many other economists state that the reason cash still exist is because it remain an important function for the economy. In smaller businesses with low margins, the handling costs of card payments are too high, making cash an important form of payment. In addition, in some situations cash still has no substitute. Also, some consumers prefer cash as a form of payment. In addition, a study conducted by the Riksbank concluded that cash payments were the least costly option for transactions under 20kr in 2012. However, the same study also concluded that the use of debit cards in relation to cash should increase further in order to make the Swedish payment system even more efficient (Segendorf & Jansson, 2012.). A more efficient payment system means that each transaction is less costly. As a result, the number of transactions in the economy is likely to rise, which generates higher economic output.

Looking ahead, in *"Det kontantlösa samhället",* Arvidsson predicts that Sweden is likely to evolve into a cashless society, although this is not likely to happen prior to year 2030. The Riksbank launched new coins and bills in 2016, an indicator as to why a cashless society won't happen within the nearest future.

III. Cost and Benefits of a Cashless Society

Extensive research has been made regarding the possible economic effects of a transition towards a cashless society for various countries. Some economists focus on the pure costs and benefits from an economic standpoint, whereas others focus on the implication on monetary policy and the role of central banks in a cashless society. Some claim the move towards a cashless society will make monetary policy more efficient, while others claim that it would cause central banks to lose their independence, making monetary policy less efficient.

In the academic literature, a cashless society is defined by three characteristics (Storti and De Grauwe (2001) and Dusansky and Koc (2009). First, no notes and coins in circulation issued by central banks. Second, all money is issued by private institutions. Third, central banks have no monopoly in the issue of money. Money will still serve as a unit of account, numeraire and store of value, but no longer as a physical medium of exchange.

In the podcast Nordea Market Insights, released by one of the largest banks in Sweden, Unell and Enlund argues that a cashless society reduces the likelihood of bank runs in the presence of negative interest rates. This type of bank run would differ from the traditional bank run in which consumers withdraw bank deposits due to an expected bank failure. Instead, in this case consumers would withdraw their deposits in order to avoid interest fees caused by the

negative interest rates. Thus, this implies that a cashless society in the case of negative interest rates might strengthen the power of the central bank to conduct monetary policy.

Unell and Enlund argue that if the negative interest rates were to be carried over to private households, Sweden would benefit from their transition towards a cashless society as their probability to experience a bank run would be much lower relative to a cash based economy. They state that *"no country in the world hates cash as much as Sweden. We are not using cash anymore, meaning that if there is one country that could handle negative interest rates, it would be Sweden"*.

The reason as to why Sweden is less likely to experience a bank run is due to their highly developed electronic payment system. The payment options for the public commute in Stockholm for example would have to be restructured completely, as they no longer accept cash. In turn, a person would have to visit the bank to deposit their cash for every bill payment, as the majority of bills in Sweden are paid through Internet banking.

As a result, Swedes will most likely not see the value in first visiting the bank to withdraw their money, to then revisit the bank to deposit their cash again in order to process payments. However, central banks could still carry out a number of actions in order to prevent a bank run, even if a cashless society is not the case. For example, they could stop printing bank notes of high value, which would force people to carry around very large volumes of money, which could disincentive cash payments, and thus prevent large bank runs. However, the ability for Sweden to avoid bank runs at the zero lower bound would require capital controls. Without capital controls, a Swedish consumer could simply transfer their account to a foreign bank account, without negative interest rates.

One of the most famous and recent cost-benefit analyses focusing on Sweden was conducted by Segendorf & Jansson (2012) on behalf of the Riksbank. In this study, the different cost structures for cash and card payments were analyzed. In turn, the authors concluded that debit cards are the cheapest payment option compared to credit cards and cash payments. In turn, an increased usage of debit cards relative to cash would increase the efficiency of Sweden's payment system. However, a transition towards a cashless society would only be beneficial if debit cards replace cash, and negative if replaced by credit cards. Many other studies have reached similar results, including a study conducted by the Danish central bank which estimates the costs for payments in stores (POS terminals) at around 0.29-0.72% of GDP, and that the largest share of this cost comes from cash (Danmarks Nationalbank, 2011).

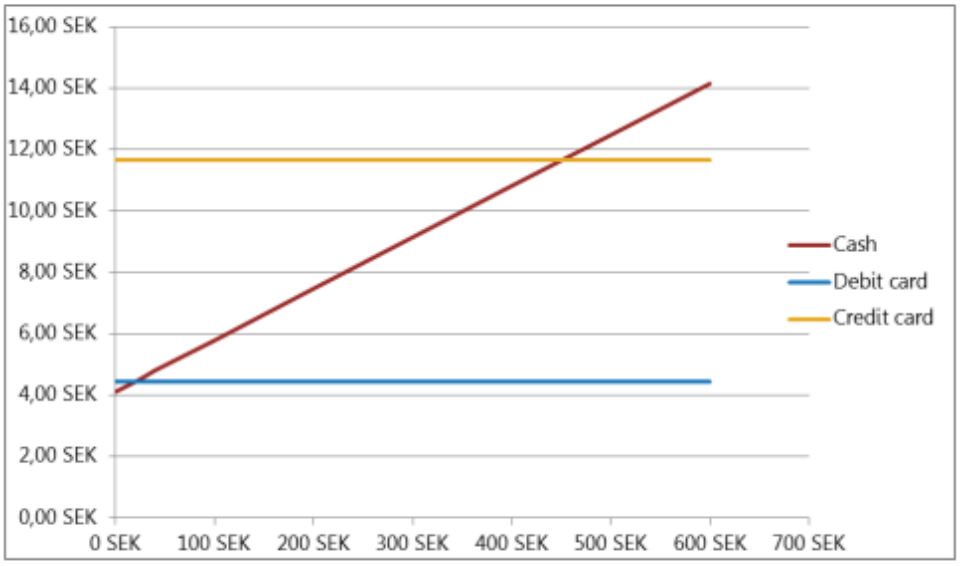
This is due to the different cost structures of cash, credit, and debit cards. Costs for debit cards include transaction handling, information technology and communication, customer service, payment authorization and other controls/checks. Costs for credit cards include marketing, credit testing, customer service and bonus programs. Costs for cash include printing, transportation, deposits, withdrawals, personnel costs related to counting cash sales at the end of each day, back-office administration, and the largest cost for consumers is seignorage and fees to banks as well as the time to perform a cash transaction.

In addition, cash payments generate other indirect costs such as safety costs, work time, administrative information, other insurances for cash handling, as well as the risk of the cash handling system going out of order, and the risk for robbery. For example, the Swedish Commerical Employee's Union estimate that the direct cost of a robbery is 100,000kr ($12,427) and cover costs for work time spent with police and staff, sick leave, reduced operating hours, and loss of sales due to lost customers. However, the Riksbank is making a sizeable profit from

seignorage, which in 2009 reached 5.8 billion kr ($7.2M), whereas the banks are suffering a loss from their cash operation as they bear the major costs.

In turn, the threshold value where the costs of cash and debit cards are equal is 20kr ($2.5), and for cash and credit cards 450kr ($56). In other words, for payments below 20kr, it is more efficient to pay with a debit card. Despite this, the estimated average value of a cash payment in Sweden is 252kr ($31). This indicates that consumers use cash more often than what is economically efficient for the society as a whole. Thus, there is possibility to make the payment system in Sweden more efficient by increasing the use of debit card payments and reducing cash payments. In addition, the transaction cost for a credit card is always higher than debit cards, which means that the society would benefit from minimizing credit cards.

Figure 2. The social threshold transaction values (SEK) under which cash is socially preferable to debit cards and credit cards.



There are multiple other benefits of transitioning towards a cashless society besides reduced transaction costs. These include improved efficiency for businesses, increased tax revenues, and the development of innovative payment companies, which can drive exports and

create new jobs. Payment innovations could, for example, develop additional services to map consumer behavior, register bonus points, and direct communication with customers. It would also be beneficial for Sweden to lead the cashless development from an innovational perspective in order to generate business opportunities abroad and thus increase export, GDP, and create more jobs. Criminal activities will also be more difficult to carry out in a cashless society. According to the Swedish Tax Ageny, the black economy comprises 65 billion kr ($8.08B) annually in lost tax revenues. This huge loss in tax revenues is likely to be reduced significantly without cash in circulation.

IV. Monetary Policy Implications of a Cashless Society

The main objective of the Riksbank is to keep inflation low and stable, of which they can do in two different ways, by 1) controlling the money supply, and 2) by adjusting the short-run interest rates on loans between banks according to some variant of the Taylor rule. In turn, since the money supply consists of the liabilities of the Riksbank, which is the sum of currency outstanding plus deposits held with them by commercial banks, a cashless society would, ceteris paribus, reduce the money supply. This has raised the question if monetary policy will be efficient in a cashless society.

More recently however, most industrialized countries' central banks, including the Riksbank in Sweden and the Federal Reserve in the United States, have stopped targeting the money supply, and thus pay little attention to monetary aggregates including M0, generally defined as currency in circulation. This means that the falling demand for cash should have little effect on monetary policy. Instead, the Riksbank follows a real interest rate rule in which they manipulate the short-run interest rate on loans between banks, known as the federal funds rate in

the U.S., and reporäntan in Sweden. Generally, when inflation rise the Riksbank increases the nominal short-term interest with the goal to influence the real interest rate upwards, and thus tighten the economy and prevent further inflation (Romer 2000).

This adjustment process is formally known as the Taylor Principle, and was formulated by John Taylor in November 1992 at the Carneige-Rochester Conference on Public Policy. The idea originated based on the behavior of the U.S. economy in the 1980s and early 1990s. One way the Taylor Principle is used by central banks, while also including concerns about economic output or unemployment, is through the Taylor Rule. This rule suggest that the policy rate should normatively be set and could positively be explained, by equation (1).

$$r = \pi + 0.5y + 0.5(\pi - \pi_T) + 2 \qquad \textbf{(1)}$$

- r: real policy rate set by the central bank
- y: percentage deviation of real GDP from trend
- π: rate of inflation over previous year
- π_T: inflation target set by central bank (the Riksbank's inflation target is 2%)

Assumptions:

- Real GDP is growing at an average rate of 2% annually
- y=0, the real ex post
- $r - \pi = 2$

The Riksbank has officially stated that they follow a variant of the Taylor Rule when setting the short-term interest. However, their version differs from the usual Taylor Rule in three ways. First, The Riksbank uses rules that have been calibrated instead of estimated. Second, The

Riksbank includes real-time forecasts of future inflation and real output to base their monetary policy decisions. Lastly, interest rate smoothing is used to a substantial degree.

Due to this process of adjusting the short-term interest rate to influence economic variables, multiple country-specific studies have concluded that a transition towards a cashless society will not hurt monetary policy (Stix et al. (2014), Odior et al. 2012, Romer (2000). Moreover, besides targeting the short-term interest rate, there are many other tools a central bank can use in order to control inflation. These include imposing cash reserve requirements, liquidity ratio open market operations, and moral suasion (Odior et al 2012). However, it is generally agreed among economists that in the case of a cashless society, the role of a central bank will need to be revised towards a greater focus on regulatory issues and supervision of private institutions issuing money. Arvidsson (2013) predict that the Riksbank will have to develop an increased role in regulation, integrity protection, and tax overview in the case of a cashless society.

One recent study on the development of a cashless society in Nigeria by Odior et al. (2012) predicts monetary policy to become more efficient with less cash in circulation. In 2012, Nigeria implemented the "Cash-Less Nigeria Project" as a part of the goal of being one of the world's 20 top performing economies by 2020. The policy introduces cash handling charges with the goal to decrease the number of cash payments to prevent revenue leakage, improve efficiency, and reduce transaction costs and the risk for robbery. Other studies by Segendorf, et al. and Arvidsson suggests implementing similar cash handling fees in Sweden to better reflect the social cost of cash to make the Swedish payment system more efficient by reducing cash transactions.

Rather than relying on inflation targeting, Nigeria will place a greater focus on open market operations and reserve requirements. Moreover, the study predicts that transaction costs will fall in Nigeria as a result of removing the central's bank monopoly in issuing currency as it allows for competition in the financial sector. In addition, even though seignorage revenues for the central bank will fall, the cost savings from not printing currency will balance this loss. In turn, cashless banking is estimated to increase the velocity of circulation in the long-run which stimulates trade and commercial activities.

In contrast, Sorti and De Grauwe (2001), argue that central banks and monetary policy will be negatively affected by a transition towards a cashless society. They claim that private institutions issuing money will not be able to control for inflation and that central banks will lose their independence. They conclude that there will be no mechanism to control for price stability if private institutions take on the role to print money. This is due to the problem of price indeterminacy, which can be illustrated by the equation for money market equilibrium, $M=P(Y,r)$. According to this equation, there are an infinite number of combinations of the money stock, M, and price level, P, in which the money market is in equilibrium. Both of these are nominal variables, and assuming that private agents are free of money illusion (implying that they only care about relative prices, and not nominal variables), private agents have no incentive to control the nominal variables M and P. Today, central banks take on the responsibility to control the money stock in order to prevent inflation. However, in a cashless society central banks will no longer be able to maintain this role of protecting these nominal variables.

In contrast, Sorti and De Grauwe argue that if a central bank is able to take on a supervisory role in a cashless society, and control inflation by granting privately issued money

legal tender characteristics and imposing legal reserve requirements, they could succeed in remaining independent in a cashless society at the same time as controlling for inflation.

A central bank could for example implement a system where they certifies the quality if the issue of private money, both traditional private money (deposits) and e-money, by printing a "logo", and thus giving the money legal tender characteristics. In addition, a central bank could implement macroeconomic criterias to control the money stock and interest rate by increasing the capital adequacy ratio during a boom, or increase the collateral banks are required to use in extending loans. Thus, supervision could become an instrument to affect macroeconomic conditions in a counter-cyclical way to be able to stabilize the price level despite having lost the traditional monetary policy instruments. Legal reserve requirements would still be in place, but include non-traditional types on money, such as e-money.

In conclusion, the role of the Riksbank will most likely need revision in the case of a transitions towards a cashless society towards a more regulatory role. Despite this, the ability of the Riksbank to carry out monetary policy will remain efficient in a cashless society, because the ability to target the repo rate will be unaffected. In addition, the Riksbank can implement other measures to control inflation such as reserve requirements, liquidity ratios, and open market operations.

V. Monetary Aggregates and the Quantity Theory of Money

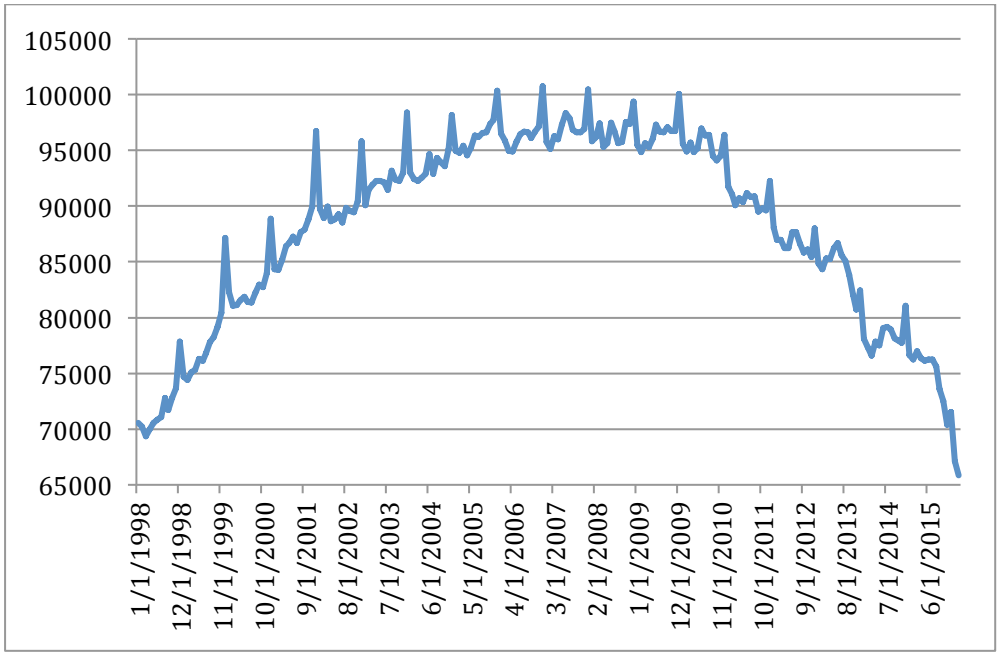
The Riksbank categorizes the total money supply into four categories known as monetary aggregates with decreasing levels of liquidity. M0 is the most liquid form of money whereas M3 is the least liquid. In other words, M0 can easily be used for payments in comparison to M3,

which has to be converted to a more liquid form prior to payment. Below is a definition of each category.

- **M0** consist of banknotes and coins in circulation issued by the Riksbank, and is measured as a debt instrument on the Riksbank's balance sheet. Also known as "narrow money" or the "monetary base"
- **M1** includes M0 plus demand deposits which is defined as overnight loans and deposits in transaction accounts
- **M2** includes M1 plus deposits in Swedish Monetary Financial Institutions (MFI) and the Swedish National Debt Office (RGK) by the Swedish public with a maturity of up to two years
- **M3** includes M2 plus interest bearing securities. Also known as "broad money"

Chart 3

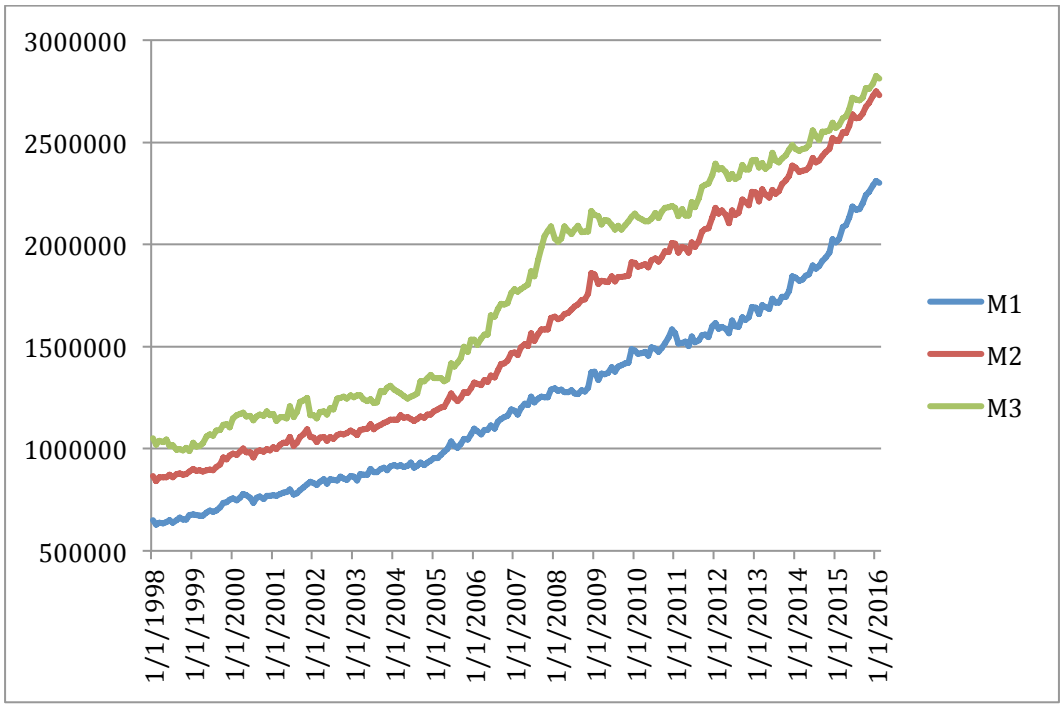
Money Supply M0 in Sweden 1998-2015
SEK million



Source: The Riksbank

Chart 4

Money Supply M1, M2, M3 in Sweden 1998-2015
SEK million



Source: The Riksbank

The Quantity Theory of Money

The quantity theory of money originated in the 18th century, and was later reformulated in the 1970s by Milton Friedman, which set the theoretical foundation for monetarism and strongly influnced the way central banks conducted monetary policy across the globe. Besides this, Frieman is well-known for his famous quote:

"Inflation is always and everywhere a monetary phenomenon, in the sense that it cannot occur without a more rapid increase in the quantity of money than in output."

Milton Friedman, 1970

According to the quantity theory of money, a rise in the stock of money should lead to an proportionate rise in nominal GDP (P*Y), assuming velocity, defined as the rate at which money is exchanged to purchase goods and services, is constant. The reason why velocity is assumed to be constant is because historically, payment mechanisms changed very slowly. However, after the introduction of debit and credit cards this assumption may no longer be true, which I prove graphically in chart 9 through 12. Equation (2) illustrates the equation of exchange, developed by economist Irvine Fisher, which in turn describes the quanity theory of money.

$$M*V=P*Y \quad \textbf{(2)}$$

- M= Money stock
- V= Velocity of money stock circulation
- P = Price level
- Y = Volume of transactions of goods and services (real GDP)

Moreover, this equation can be reconstructed into growth rates by transforming the variables into logarithms and time derivatives. This transformation leaves us with equation (3), which ultimately can be simplied into equation (5).

$$\partial(M) * (\partial (V) = \partial(P) * \partial(Y) \qquad \textbf{(3)}$$

Given that velocity is assumed to be constant, the variable for the growth rate of velocity drops out when taking its derivative ($\partial (V) = 0$). In addition, the growth rate of the price level equals the inflation rate, denoted as π. Thus, $\partial(P) = \pi$. This leaves us with equation (4).

$$\partial(M) = \pi * \partial(Y) \qquad \textbf{(4)}$$

In turn, since the growth rate of real GDP multiplied by the rate of inflation equals the nominal growth rate of GDP ($\pi * \partial(Y) = \partial(NGDP)$) the equation states that the growth rate in the money stock should equal the growth rate of nominal GDP, as seen in equation (5).

$$\partial(M) = \partial(NGDP) \qquad \textbf{(5)}$$

This basic equation shaped the way central banks conducted monetary policy for many years as it implies that an increase in the growth rate of the money leads to equal increases in nominal GDP. Thus, it was believed that central banks could target the money supply by conducting either expansionary or contractionary monetary policy through open market operations. In other words, if an economy was facing a recession, its central bank could increase the money supply in a way such that the growth rate of money equals the desired growth rate of the economy, and thus bring the economy back to its potential nominal output by manipulating the money supply.

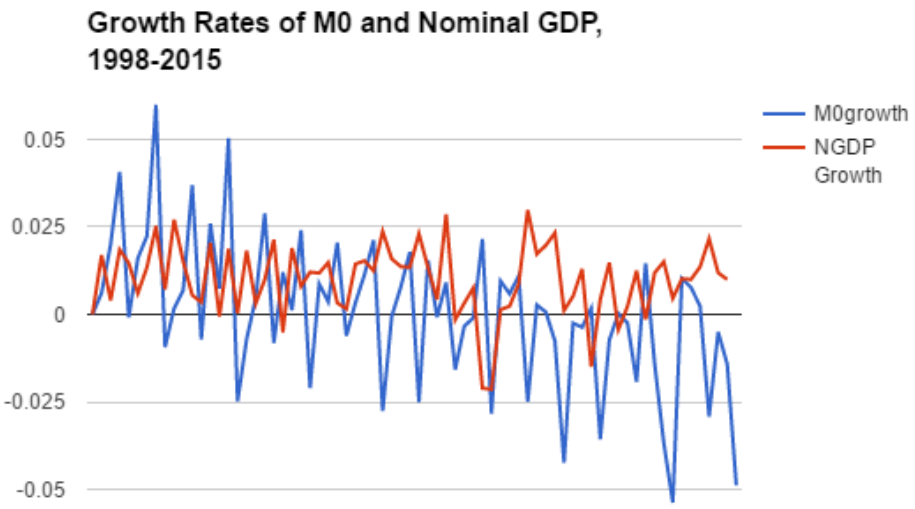
However, the support for the quantity theory of money has in more recent years been questioned by many economists. More specifically, the Federal Reserve, and many other central

banks around the world, responded to the plunging economy caused by the 2007 subprime mortgage crisis by conducting aggressive expansionary monetary policy in the form of quantatative easing. This in turn increased the money base significantly in the United States and many other countries. According to the quantity theory of money, this increase in the money stock should generate a symmetric boost to nominal GDP, holding velocity constant. However, this rise in nominal GDP was nowhere to be seen, which arguably serve as proof against the quantity theory of money (Graff).

However, the support for the quantity theory of money started to lose traction long before the global financial crisis in 2007, as money targeting was replaced by inflation targeting by most central banks, starting in the 1980s. The Riksbank announced that they implemented this new way of conducting monetary policy through interest rate targeting in 1994 (Mitlid and Vesterlund). In turn, The Federal Reserve officially stopped targeting the money supply in 1980, and the European Central Bank downgraded the importance of money targeting versus interest rate targeting more recently in 2003. In other words, most central banks in the modern economy no longer base their monetary policy on the quantity theory of money.

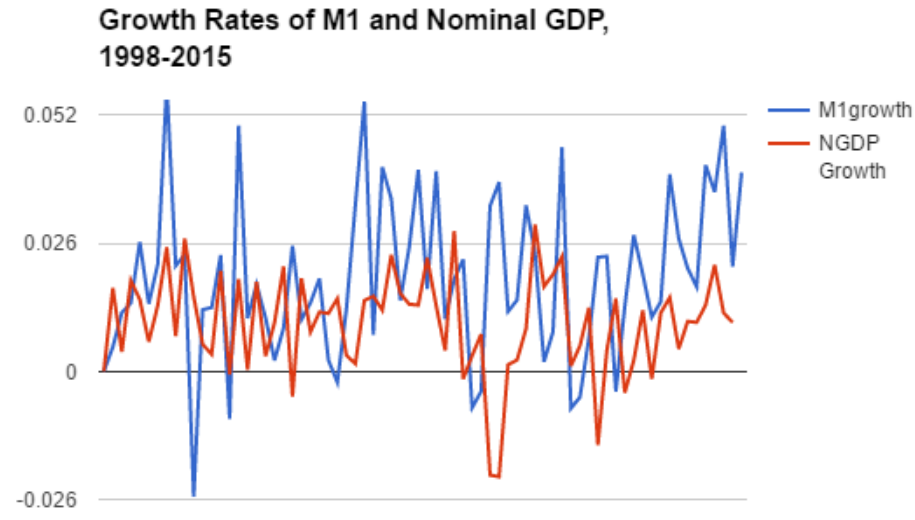
In turn, as seen in charts 5 through 8, the growth rates of money aggregates in Sweden do not align with the growth rate of nominal GDP. This can also be seen by their low correlation rates: 0.07, 0.12, -0.10, and 0.11, for M0, M1, M2, M3 and Nominal GDP respectively. This should suggest that the quantity theory in fact does not hold, which I also prove econometrically in section VI.

Chart 5



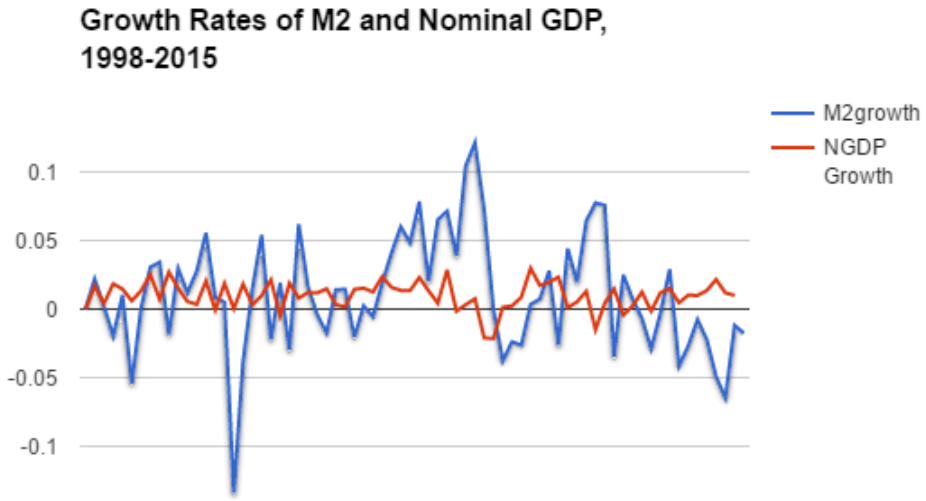
Correlation coefficient M0Growth and NGDPgrowth: 0.07

Chart 6



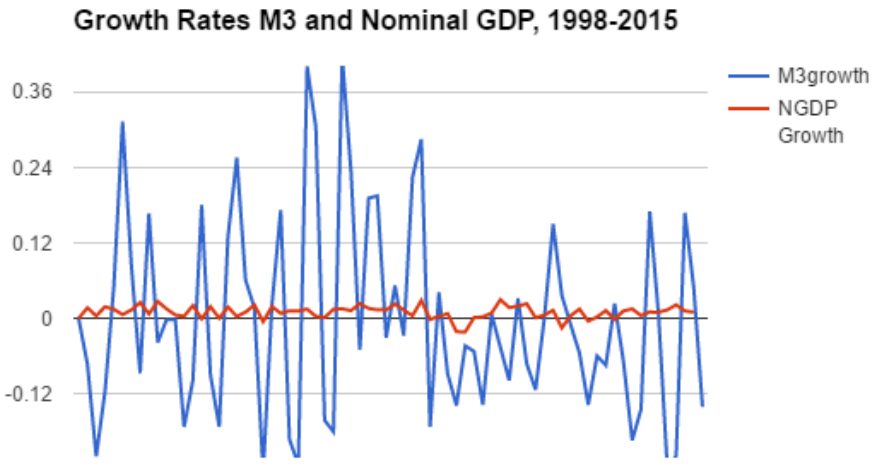
Correlation coefficient M1Growth and NGDPgrowth: 0.12

Chart 7



Correlation coefficient M2Growth and NGDPgrowth: -0.10

Chart 8



Correlation coefficient M3Growth and NGDPgrowth: 0.11

VI. Data

The empirical analysis presented in this paper is based on data measuring the levels of M0, M1, M2, M3, and the Consumer Price Index (CPI) in Sweden on a monthly basis between 1998 and 2015. This data originates from the Riksbank via Trading Economics. In addition, quarterly data for nominal and real GDP have also been used in the regression analysis, which were collected from Statistics Sweden via Bloomberg covering the same time period.

For the purpose of the regression analysis, the monthly data has been transformed into quarterly in order to match the available data set on nominal and real GDP. In turn, all variables have been transformed from levels into growth rates. In addition, I have subtracted M0 from M1, M1 from M2, and M2 from M3 in order to obtain the incremental money supplies.

VII. Econometric Methodology

To evaluate the causal effect of the growth rates of money aggregates on the growth rates of nominal GDP, real GDP, and inflation respectively, a log-log econometric model described below was used.

$$RGDPgrowth = \alpha + \beta(M0growth) + \beta(M1growth) + \beta(Mgrowth2) + \beta(M3growth) \quad \textbf{(1)}$$

$$NGDPgrowth = \alpha + \beta(M0growth) + \beta(M1growth) + \beta(Mgrowth2) + \beta(M3growth) \quad \textbf{(2)}$$

$$CPIgrowth = \alpha + \beta(M0growth) + \beta(M1growth) + \beta(Mgrowth2) + \beta(M3growth) \quad \textbf{(3)}$$

Let NGDPgrowth be the quarterly growth rate of nominal GDP, RGDPgrowth be quarterly growth rate of the real GDP, CPIgrowth be the quarterly growth rate of the Consumer Price Index, and M0growth, M1growth, M2growth, and M3growth be the quarterly growth rate of each money aggregate. All data are based on Sweden throughout the time period 1998 Q1 – 2015 Q4.

Due to strong evidence of heteroskedasticity, as a result of the changing growth trend of M0 from positive to negative as seen in chart 3, I have split the full data set, consisting of 72 observations, in half to avoid offsetting effects in the regression output. The first half covers the period 1998 Q1 – 2006 Q4, and the second half 2007 Q1-2015 Q4. Moreover, I have divided each equation in five different regressions in which I first regress M0 on each of the dependent variables. I then add each variable (M1, M2, M3) sequentially. This is because money can be broken down to these four categories. Thus, by adding each money aggregate sequantially, I will be able to detect if any of these have an impact on nominal GDP.

Let the null be that the coefficient on M0, M1, M2, and M3 respectively are not statistically different from zero at the 5% significance level. Thus, let the alternative be that the coefficients on M0, M1, M2, and M3 respectively are statistically different from zero at the 5% significance level. According to my hypothesis, I expect to find no significant results for the coefficient on M0, and thus fail to reject the null for M0. This is because I hypothesize that the growth rate of cash should not have an effect on nominal GDP. In turn, this suggests that a decrease in the growth rate of cash, M0, in Sweden should have no effect on the Riksbank's ability to conduct monetary policy as changes in money aggregates have no effect on economic output.

Moreover, since the money supply can be broken down into multiple money aggregates, i.e. M0, M1, M2, and M3, I will test the significance of each of these sequentially to see if any of these growth rates may have an impact on economic output. However, since velocity of money is no longer constant in Sweden due to the introduction of debit- and credit cards as well as payment innovations, I expect that the quantity theory of money should not hold for any money aggregate.

In addition, I will regress the growth rate of inflation and the growth rate of real GDP on the growth rate of each money aggregate sequentially to test if the quantity theory of money holds for any economic variable. This is because the left hand side of the equation of exchange, describing the quantity theory of money, states that growth rates in the money supply should have a proportionate positive effect on nominal GDP, which can broken down into ∂(P) (growth rate of inflation), multiplied by ∂(Y) (growht rate of nominal GDP) as seen in equation (5).

$$\partial(M) * (\partial (V) = \partial(P) * \partial(Y) \qquad \textbf{(5)}$$

Thus, by testing both the relationship between growth rates of money aggregates and nominal GDP, as well as the two economic variables nominal GDP consists of: inflation and real GDP, I will be able to detect if the quanitity theory of money holds in part, or not at all. I expect to find no significant results for neither real GDP, nor inflation, due to the same reason as I expect to find no significant results for nominal GDP. That is, the velocity for money in ciruclation is no longer constant, thus falsifying the quantity theory of money.

VIII. Estimation Results

Regression output nominal GDP, first half of dataset covering time period 1998 Q1 – 2006 Q4

	(1)	(2)	(3)	(4)
Dependent Variable	**NGDPGrowth Rate**	**NGDPGrowth Rate**	**NGDPGrowth Rate**	**NGDPGrowth Rate**
M0growth *t-value* *p-value*	.0593 0.77 0.447	.0301 0.44 0.666	.0257 0.37 0.717	.0224 0.31 0.757
M1growth *t-value* *p-value*		.1280 1.72* 0.095	.1279 1.71* 0.098	.1382 1.76* 0.089
M2growth *t-value* *p-value*			.0078 0.22 0.826	.0068 0.19 0.849
M3growth *t-value* *p-value*				.00348 0.47 0.639
Constant	.0111	.0091	.0091	.0089
R^2	0.0206	0.0934	0.0946	0.1005
N	36	36	36	36
Robust Standard errors	.00797	.00778	.0079	.008

Regression output nominal GDP, second half of dataset covering time period 2007 Q1-2015 Q4

	(1)	(2)	(3)	(4)
Dependent Variable	**NGDPGrowth Rate**	**NGDPGrowth Rate**	**NGDPGrowth Rate**	**NGDPGrowth Rate**
M0growth *t-value* *p-value*	3.162 1.07 0.292	2.951 1.08 0.287	2.950 1.07 0.294	2.892 1.03 0.312
M1growth *t-value* *p-value*		-1.8322 -1.07 0.294	-1.772 -1.05 0.301	-1.758 1.03 0.312
M2growth *t-value* *p-value*			.0485 0.16 0.873	.0357 0.12 0.909
M3growth *t-value* *p-value*				.0274 0.30 0.763

Constant	.0072	.0423	.0404	.0407
R^2	0.1263	0.1552	0.1554	0.1557
N	36	36	36	36
Robust Standard errors	.1597	.1594	.1617	.1644

According to the regression output above, I fail to reject the null for M0, M2, and M3 in the first time period, as the coefficients are not statistically significant from zero at the 5% significance level. This supports my hypothesis that the growth rate of money aggregates, in particular M0, has no effect on nominal GDP. However, the coefficient on M1 is statistically significant in the first time period, meaning that I reject the null at the 5% significance level for the relationship between the growth rate of M1 on the growth rate of nominal GDP.

The coefficient on M1 was 1.72 in regression (2), 1.71 in regression (3), and 1.76 in regression (4). This means that a 1% increase in the growth rate of M1 leads to a 1.72%, 1.71%, and 1.76% average increase in nominal GDP respectively, holding all other variables constant. Thus, for M1, the quantity theory of money seems to hold in the first time period, as the theory suggest a positive relationship between the growth rates of the money supply and nominal GDP.

In contrast, I fail to reject the null for all money aggregates, including M1, in the second time period, indicating that the quantity theory of money breaks down in the second time period. In addition, the sign of the coefficient on M1 reverse to negative, which is further proof against the validity of the quantity theory of money. Thus, this negative sign indicates that an increase in the growth rate of M1 in fact *decreases* nominal GDP. More specifically, my regression output state that a 1% increase in M1

leads to a 1.83% decrease in nominal GDP in regression (2), and a 1.77%, and 1.76% decrease in nominal GDP in regression (3) and regression (4) on average, holding all other variables constant. Though, none of these coefficients are statistically significant.

In contrast, the sign of the coefficient on M0, M2, and M3, remains positive, as the quantity theory of money would suggest. Although, despite the correct sign, the coefficients on M0, M2, and M3, are all statistically insignificant at the 5% significance level. This indicates that these growth rates of these money aggregates have no effect on nominal GDP, and thus that the quantity theory of money does not hold.

The fact that the quantity theory of money partly holds in the first time period, but breaks down entirely in the second time period, can most likely be explained by the increasing velocity of money in circulation due to payment innovations over the last two decades. Given that the quantity theory of money assumes velocity to be constant, a rise in velocity falsifies the theory, and thus makes the relationship between the growth rates of money supply and nominal GDP insignificant.

Regression output real GDP, first half of dataset covering time period 1998 Q1– 2006 Q4

	(1)	**(2)**	**(3)**	**(4)**
Dependent Variable	**RGDPGrowth Rate**	**RGDPGrowth Rate**	**RGDPGrowth Rate**	**RGDPGrowth Rate**
M0growth *t-value* *p-value*	-.0232 -0.34 0.500	-.04118 -0.68 0.500	-.0498 -0.81 0.425	-.0548 -0.87 0.393
M1growth *t-value* *p-value*		.0814 1.55 0.129	.0812 1.55 0.131	.0969 1.73* 0.094
M2growth *t-value* *p-value*			.0142 0.47 0.644	0.128 0.43 0.673
M3growth *t-value* *p-value*				.0053 0.99 0.331

Constant	0.0085	.0072	0.0072	.0068
R^2	0.0054	0.0553	0.0621	0.0852
N	36	36	36	36
Robust Standard errors	.0061	.0061	.0061	.0062

Regression output real GDP, second half of dataset covering time period 2007 Q1-2015 Q4

	(1)	**(2)**	**(3)**	**(4)**
Dependent Variable	**RGDPGrowth Rate**	**RGDPGrowth Rate**	**RGDPGrowth Rate**	**RGDPGrowth Rate**
M0growth *t-value* *p-value*	-.1038 -0.86 0.396	-.1074 -0.84 0.406	-.1049 -0.87 0.390	-.1757 -1.32 0.197
M1growth *t-value* *p-value*		-.0311 -0.23 0.819	-.1442 -0.88 0.384	-.1266 -0.82 0.420
M2growth *t-value* *p-value*			-.0917 -1.87* 0.071	-.1074 -2.35* 0.026
M3growth *t-value* *p-value*				.0336 2.00* 0.054
Constant	.0029	.0035	.0072	.0075
R^2	0.0271	0.0287	0.1356	0.2329
N	36	36	36	36
Robust Standard errors	.01195	.01212	.01161	.01111

The regression output from regressing the growth rate of real GDP on the growth rate of M0, indicate that there is no significant relationship between the two variables. This further reinforces my hypothesis that a decline in cash should have no effect on economic output, and thus monetary policy. This is proven by the failure to reject the null for the variable M0growth at the 5% significance level for regression (1) through (4). In

the same way, I fail to reject the null for M1growth for the same regressions, proving that changes in M1 also has no impact on economic output.

However, the coefficient on M2growth in regression (3) is significant at the 5% significance level. The results state that a 1% increase in the growth rate of M2 generates on average a 1.87% decline in real GDP, holding all other variables constant. In turn, in regression (4), the coefficient on M2growth is significant at the 1% significance level, with a coefficient indicating that a 1% increase in the growth rate of M2 generates on average a 2.35% decline in real GDP, holding all other variables constant.

Despite these significant results and rejection of the null, we cannot use these results to support the quantity theory of money. In contrast, since the sign of these coefficients are negative, this actually serves as proof *against* the quantity theory of money. This is because the theory predicts that an increase in the growth rate of the money supply should generate a proportionate *positive* increase in economic output.

The only regression output supporting the quantity theory of money when using real GDP as the dependent variable can be seen in regression (4) in terms of M3growth. The coefficient on growth rate of M3 is significant at the 5% significance level. This suggests that a 1% increase in the growth rate of M3 generates a 2% increase in real GDP on average, holding all other variables constant.

Regression output CPI, first half of dataset covering time period 1998 Q1 – 2006 Q4

	(1)	**(2)**	**(3)**	**(4)**
Dependent Variable	**CPIGrowth Rate**	**CPIGrowth Rate**	**CPIGrowth Rate**	**CPIGrowth Rate**
M0growth	.0647	.0603	.0617	.0603
t-value	1.74*	1.47	1.52	1.42
p-value	0.091	0.150	0.137	0.166

M1growth *t-value* *p-value*		.0194 0.65 0.523	.01944 0.64 0.525	.0236 0.71 0.481
M2growth *t-value* *p-value*			-.0024 -0.10 0.922	-.0028 -0.11 0.911
M3growth *t-value* *p-value*				.0014 0.31 0.760
Constant	.0024	.0021	.0021	0.002
R^2	0.0584	0.0623	0.0626	0.0626
N	36	36	36	36
Robust Standard errors	.00507	.00514	.00522	.00529

Regression output CPI, second half of dataset covering time period 2007 Q1-2015 Q4

	(1)	**(2)**	**(3)**	**(4)**
Dependent Variable	**CPIGrowth Rate**	**CPIGrowth Rate**	**CPIGrowth Rate**	**CPIGrowth Rate**
M0growth *t-value* *p-value*	0.1417 2.85** 0.007	.1326 2.73** 0.010	.1318 2.68** 0.011	.1069 2.07* 0.047
M1growth *t-value* *p-value*		-.0790 -1.07 0.292	-.0438 -0.56 0.576	-.0376 -0.49 0.625
M2growth *t-value* *p-value*			.0286 1.39 0.175	.0231 1.25 0.219
M3growth *t-value* *p-value*				.0118 1.54 0.134
Constant	.0038	.0053	.0042	.0043
R^2	.0058	0.2182	0.2553	0.2978
N	36	36	36	36
Robust Standard errors	.00581	.00575	.0057	.00563

When regressing the growth rates of CPI on each money aggregate, I find no significant results in the first time period, except for M0 in regression (1). The coefficient on M0 indicates that a 1% increase in the growth rate of M0 generates a 1.74% increase in CPI on average, holding all other variables constant. However, the significance is eliminated when adding more variables to the regression. This further reinforces my hypothesis, by proving that the growth rate of money aggregates has no effect on the growth rate of inflation.

Interestingly, we find significant, and highly significant, results between the growth rates of M0 and CPI during the second time period, both at the 1% and 5% significance level. However, I believe that these results can be explained by the financial crisis and the falling growth rate of cash in Sweden during the second half of the data set. More specifically, the second half of the data, covering the time period 2007 Q1-2015 Q4, captures the entire global financial crisis, triggered by the 2007 subprime mortgage crisis in the United States. In turn, this financial crisis put downward pressure on inflation rates all over the world. At the same time, Sweden started reducing the growth rate of cash, i.e. M0, as represented by the inflection point in chart 3. Thus, falling inflation combined with falling growth rates of M0, should generate positive results, as seen in the regression output.

Because of this, I am not surprised to find highly significant results of M0 on CPI growth in the second time period. However, this does *not* suggest that the quantity theory of money holds, as M0 in fact was falling throughout this time period. On the contrary, if the quantity theory of money in fact holds, we should see a fall in the growth rate of CPI, illustrated by a negative coefficient, which is not the case here. Thus, even though these results are highly significant, they further reinforce the hypothesis that the quantity theory of money does not hold. In turn, all other money aggregates illustrate insignificant results, further reinforcing this point.

As mentioned earlier, the reason as to why the quantity theory of money does not hold is because the velocity of money in circulation is not constant for any money aggregate, as seen in charts 9 through 12.

Chart 9

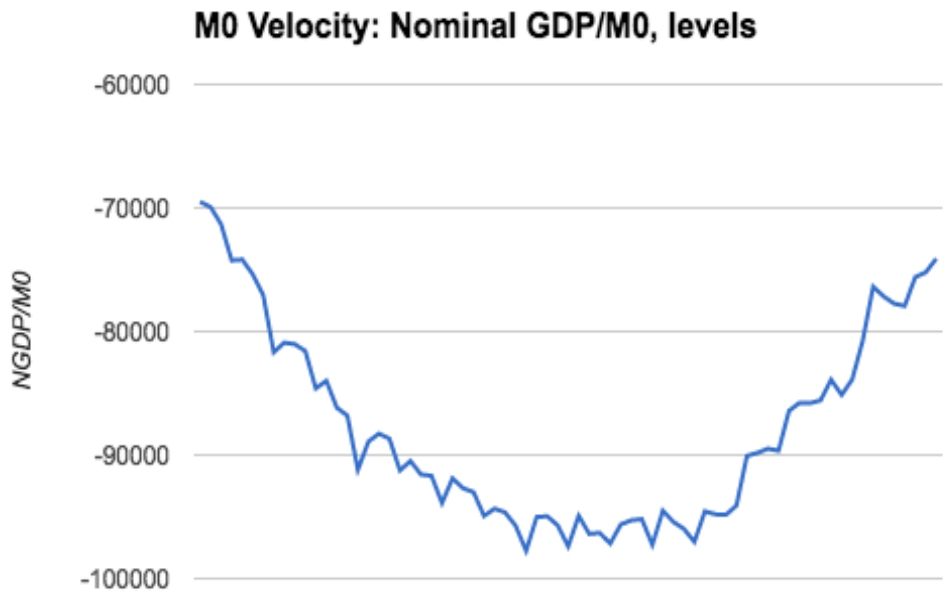


Chart 1

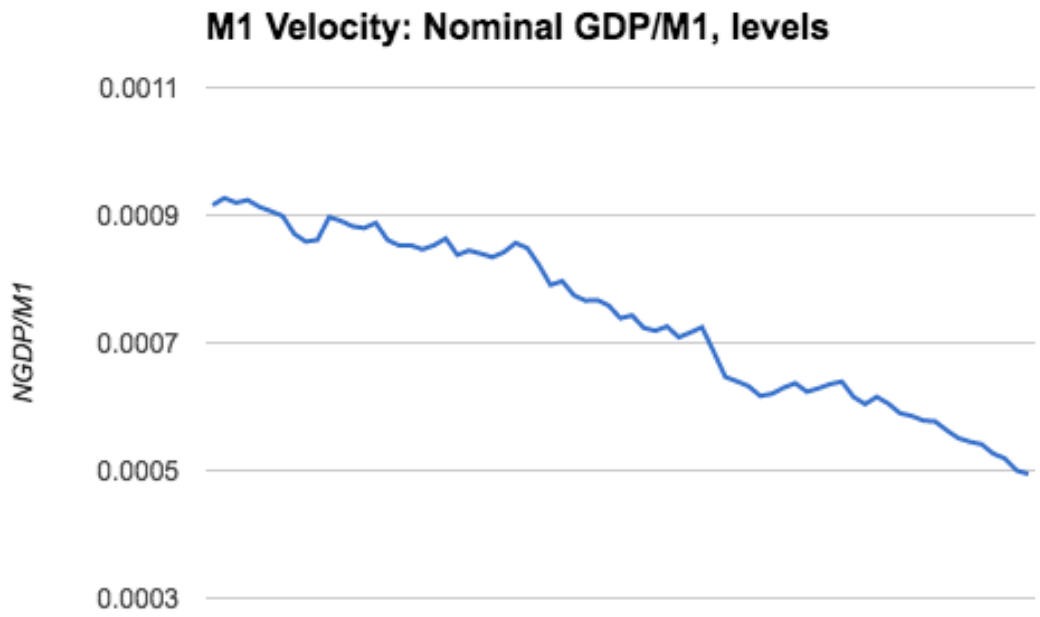


Chart 11

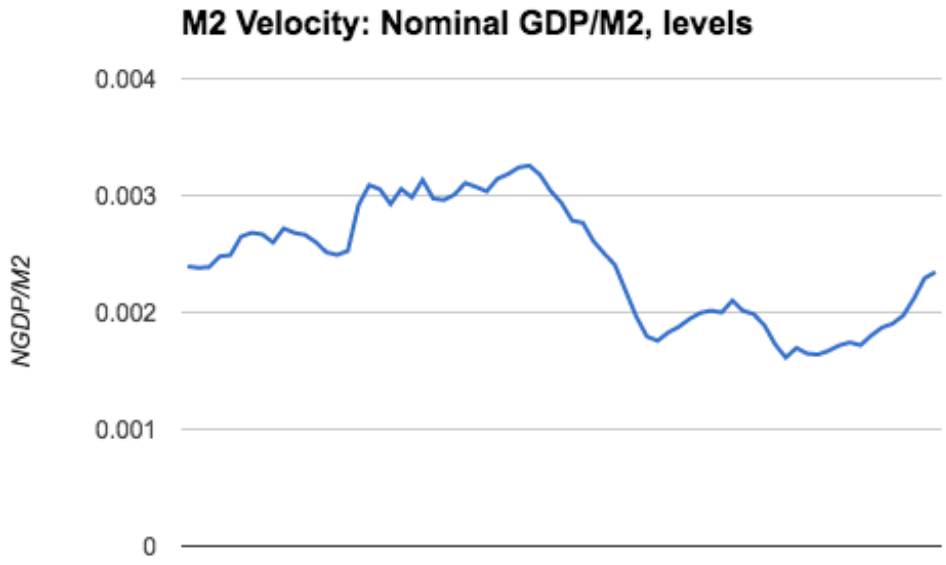
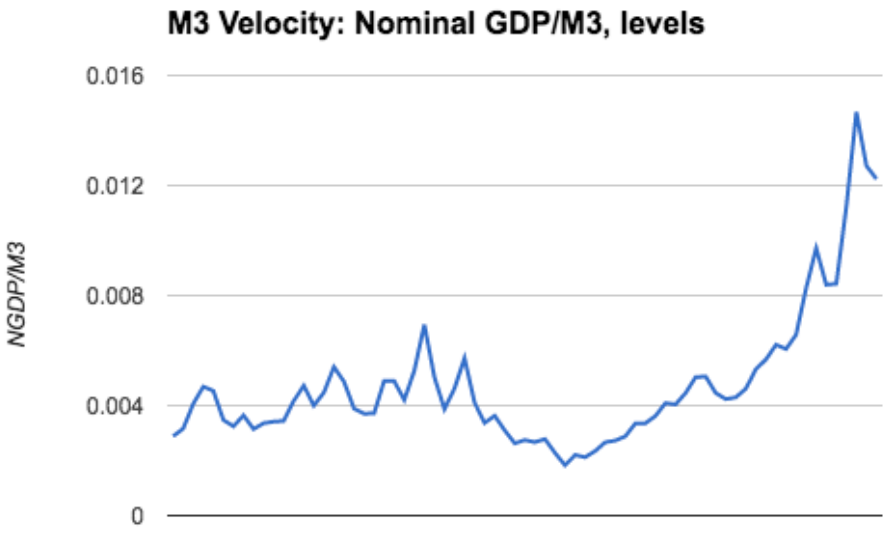


Chart 12



IV. Conclusion

In this paper, I hypothesize that Sweden's transition towards a cashless society will not negatively affect the Riksbank's ability to conduct monetary policy. Further, I argue that this is due to the invalidity of the quantity theory of money. I prove this through econometric analysis by showing that there is no relationship between the growth rates of the money supply and economic output, as suggested by the theory.

In support of my hypothesis, I fail to find significant relationships between the growth rates of nominal GDP, real GDP, and CPI on the growth rates of M0. In turn, these findings indicate that the quantity theory of money does not hold in terms of cash in circulation. Moreover, this can be explained by the volatility in the velocity of payments, caused by the introduction of debit and credit cards as well as payment innovations over the last decades.

Historically, the quantity theory of money has served as the basis for the monetary policy tool of targeting the money supply. Although, today most central banks have officially announced that they have moved away from targeting the money supply, and instead target the short-term interest rate by following some variation of the Taylor Principle. Thus, since the reduction in M0 will have no impact on the Riksbank's ability to control the short-term interest rate, their ability to conduct monetary policy will not be negatively affected by Sweden's transition towards a cashless society.

In contrast, there are many benefits to a cashless society. These benefits include a less costly, and thus more efficient, payment system, which is likely to generate higher economic activity and output. Moreover, the risk for robbery is expected to decline as stores no longer would carry cash. However, the risk for cyber crimes in terms of Internet fraud is likely to increase in a cashless society. Moreover, at the zero lower bound, Sweden might be less prone to experience a bank run, which in fact would strengthen monetary policy and the overall financial stability.

X. References

Arvidsson, N. 2013. “Det kontantlosa samhället - rapport från ett forskningsprojekt”, KTH. Web.

Asso, Pier Francesco et al., 2010. ”The Taylor Rule and the Practice of Central Banking”. The Federal Reserve Bank of Kansas City Research Department. Web.

Berg, Claes et al., 2004, “How Useful are Simple Rules for Monetary Policy? The Swedish Experience”, Sveriges Riksbank, Working Paper Series, 169, August. Web.

Costa, Claudia et al. “Monetary Policy in a Cashless Society” *Research Gate.* July 2001. Web.

Danmarks Nationalbank, 2011. “Omkostninger ved betalinger i Danmark”. Copenhagen, Danmark. Web.

Dusansky, R., Koc, C. 2009. “Demand for Cash Balances in a Cashless Economy”. International Journal of Economic Theory. Web.

Enlund, M., Unell, H. 2015. “Dollarn up eller ner? Ska vi bry oss?” Nordea Market Insights. Podcast, 11:00, 27 October, 2015. Web.

“Financial Market Statistics”. Statistics Sweden. February, 2009.

Graff, Michael, 2014. “The Quantity Theory of Money in Year Six after the Subprime Mortgage Crisis”. Annual International Conference on Qualitative & Quantatative Economics Research”. Web.

Hakan Ylmazdukay and M. Ege Yazgan, 2009.“Effects on Credit and Debit Cards on the Currency Demand”. Applied Economics. Web.

Hortlund, P. & A. Svensson. 2012. Vad kostar korten? Synliga och dolda kostnader för hushåll och handel. HUI Research. Web.

Ingves, S. 2006. Speech. Sveriges Riksbank. Web.

Mitdlid and Vesterlund, 2001. “Steering Interest Rates in Monetary Policy – How Does it Work?” Economic Review. Web.

Odior, Ernest Simeon et al, 2012. “Cashless Banking in Nigeria: Challenges, Benefits and Policy Implications” *European Scientific Journal*, June Edition vol. 8, N0.12. Web.

Romer, D, 2000. “Keynsian Macroeconomics without the LM Curve” Journal of Economic Perspectives, Volume 14, nr 2. Web.

Segendorf, B. & Jansson, T. 2012. The Cost of Consumer Payments in Sweden. Sveriges Riksbank, Working Paper Series, 262, June. Web.

Segendorf and Wilbel, 2014. "Does cash have any future as legal tender?" Sveriges Riksbank Economic Commentaries, NO 9. Stockholm. Web.

Stix, H. et al, (2014). The role of Card Acceptance in the Transaction Demand for Money. Bank of Canada: Working Paper 2014-44. Web.

Stix, Helmut, 2014. "The Impact of ATM Transactions and Cashless Payments on Cash Demand in Austria". Oesterreichische Nationalbank *Monetary Policy & The Economy*. Web.

Svenska Bankföreningen, 2012. Bank- och finansstatistik 2011, September. Web.

Sveriges Riksbank. "Money and Power – The History of Sveriges Riksbank". Accessed on May 4th, 2016. Web.

Sveriges Riksbank, 2014. "Notes and Coins – Statistics". Accessed on May 4th, 2016. Web.

Sveriges Riksbank, 2014. "The Payment Behavior of the Swedish Population". Accessed on May 4th, 2016. Web.