# More base money more problems?

## A look at endogeneity of money supply in Iceland

# The Icelandic Hyman Minsky Memorial Prize

Kári Gunnlaugsson
Copenhagen Business School - Financial Econometrics Home assignment
kag45@hi.is

Kári Gunnlaugsson
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## Introduction

In this paper, I will examine the relationship between base money, money supply, loans and assets of the Icelandic economic eco system. To do the analysis I will utilize a VAR model of the variables, which is a multivariate approach to the evolution of the variables. Expecting the variables to move together is a contested subject. Those that believe that money is exogenous think that central banks control the flow of money that then influences the lending of commercial banks, which means that money is supply driven. Other economists believe that money supply is endogenous to the system and that commercial banks meet the demand of the eco system, meaning that money is demand driven (Cepni, 2017).

This is an oversimplification of the school of ideas. Those who endorse that money supply is exogenous believe in monetarism, which was championed by Friedman. In the Post Keynesian School there are at least three ideas about endogeneity of money supply presented. These ideas are then further split up. There are those that believe that central banks have no other option than to accommodate the increases in funding needs of banks because that is their obligation as lenders of last resort. The supporters of this idea are called either Accommodationists or Horizontalists. This group can then be subdivided based on whether they hold strong or weak positions. The strong view is that interest rates are unaffected by lending and supply of bank loans are horizontal, while the weak position is that interest rates might rise with lending. The weak position is also referred to as liquidity preference because economic agents have different preferences about liquid holdings. Then there are those that believe that central banks do not meet all the demand and that commercial banks must look elsewhere for funding. Those who support these ideas are called Structuralists, and they partially agree with monetarism in that central banks have some control over money supply (Palley, 2008).

Through my analysis, I find evidence that in the case of Iceland, loans in the system and base money are co-integrated. I do not find evidence that money supply and loans are co-integrated post 2008. However, there is evidence that suggests that Base money and loans are co-integrated. Therefore, the data points towards the conclusion that in the case of Iceland, money is demand driven.

## Methodology

In order for the VAR analysis to be consistent, I begin by looking for unit root in the time series. If individual time series are stationary, or if time series are not co-integrated, three things might happen. First, the test might lose power because there are too many extra parameters being estimated. Second, the Granger causality test will not have a standard F-distribution, and third, the impulse response in long run forecasting will not be constant. If the variables are not co-integrated and stationary, taking the first difference can be helpful (Enders, 2014). In the following analysis, I will look at unit root, stationarity, Granger causality and forecasting. To achieve this it is crucial to ensure that the VAR model is consistent.

To test for a structural change in individual time series I use the Chow test, which can be done because I have a clear idea of when the structural break happens. After having controlled for the structural break by splitting the data, I can see if there is a unit root in the series by doing an Augmented Dicky-Fuller (ADF) test. Due to the low power of the Dicky-Fuller test I also do a KPSS test for stationarity as a robustness check. Once non-stationary series have been identified, a Johansen trace test is used to sort out what pairs of time series are co-integrated. A Johansen maximum Eigen value test is also performed for robustness. Two I(1)-series are co-integrated if they share the same stochastic trend. If co-integration is present between two variables, they might evolve in a different way in the short run, however in the long run they should converge towards the same point in the future (Pala, 2013). For the variables that are not co-integrated, I do a Granger causality test to see in which way the causality flows. The Granger causality test can be used because the data is not co-integrated and is stationary.

A VAR model is used to estimate the relationship between variables that are co-integrated. In the model a system of equations is estimated because a single equation model might have simultaneity bias. The bias comes from the regressors and the error terms being correlated. In the research that follows here one might expect that all variables affect each other so that no variable is truly exogenous to the system. For research purpose we might expect some variables to be weakly exogenous (Enders, 2014). Therefore, VAR analysis is perfect to investigate the internal relationship of the variables. In order to estimate the model with ordinary least squares (OLS) we need to impose some restrictions on the matrix that represents the contemporaneous relationship of variables, matrix B in the equation below. The VAR equation is represented below in matrix format with two dependent variable y and z.

$$VAR\text{: } \mathrm{BX}_t = \Gamma_0 + \Gamma_1 \mathrm{X}_{\mathrm{t}-1} + \varepsilon_{\mathrm{t}}$$

$$\text{Where: } \mathrm{B} = \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix}, \mathrm{X}_{\mathrm{t}} = \begin{bmatrix} y_t \\ z_t \end{bmatrix}, \Gamma_0 = \begin{bmatrix} b_{20} \\ b_{10} \end{bmatrix}, \Gamma_1 = \begin{bmatrix} \gamma_{11}\, \gamma_{12} \\ \gamma_{21}\, \gamma_{22} \end{bmatrix}, \varepsilon_{\mathrm{t}} = \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

To estimate the VAR model, we need to transform it into a reduced form of a VAR model. Then we have to multiply the equation with the inverse of B and then restrict the B matrix. The restriction is the assumption that B is a lower triangular matrix with one on the diagonal, which is called a Choleski decomposition. In the example above this would make $b_{12}$ equal to zero, then the model can be estimated with OLS. The series will be co-integrated if the rank of $\Gamma_1$ has reduced rank, or the rank of the matrix is lower than full rank. The co-integrated relationship between the variables can then be further explored with a Vector error correction model. VECM reports both the short-term dynamics and the long run impact a change in one variable will have on the other variables. The VECM model equation is:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i}\, \Delta y_{t-1} + \sum_{i=1}^{n} \beta_{2i}\, \Delta x_{t-1} + \sum_{i=1}^{n} \alpha \mathrm{EC}_{t-1} + \epsilon_t$$

$$EC_{t-1} = y_{t-1} - \gamma x_{t-1}$$

Where $y_t$ is the dependent variable, $x$ is the independent, EC is the error correction term and $\epsilon_t$ is the error term. The error correction term can be interpreted as last period's deviation from the equilibrium and is the OLS residual from the long-run co-integration regression between variables. The short-term causality is checked by looking at the joint significance of the $\beta_{2i}$ coefficients, while the long run effects are examined by looking at whether the error correction term is significant from zero. The coefficient $\alpha$ measures the speed of adjustment, or the rate at which the dependent variable returns to equilibrium after a change in the independent variable. The properties of the regressors are also examined to see if they are well behaved. This is done by looking at the serial correlation between error terms and seeing if there are any ARCH effects left in the residual.

After having looked at the VECM model we move on to looking at the impulse response function of the model. The idea behind the impulse response function is that we let a shock hit one variable and then examine the effects that has on the other variables and the system. Bootstrapping is used to find the confidence bounds of the estimation. Next, we move forward with a forecast error variance decompression (FEVD). This is done to try to see how important shocks in one variable are to future realizations in another variable, which will give some insight about how to understand the dynamics in the system. To estimate the FEVD the Choleski decomposition is needed.

## Data

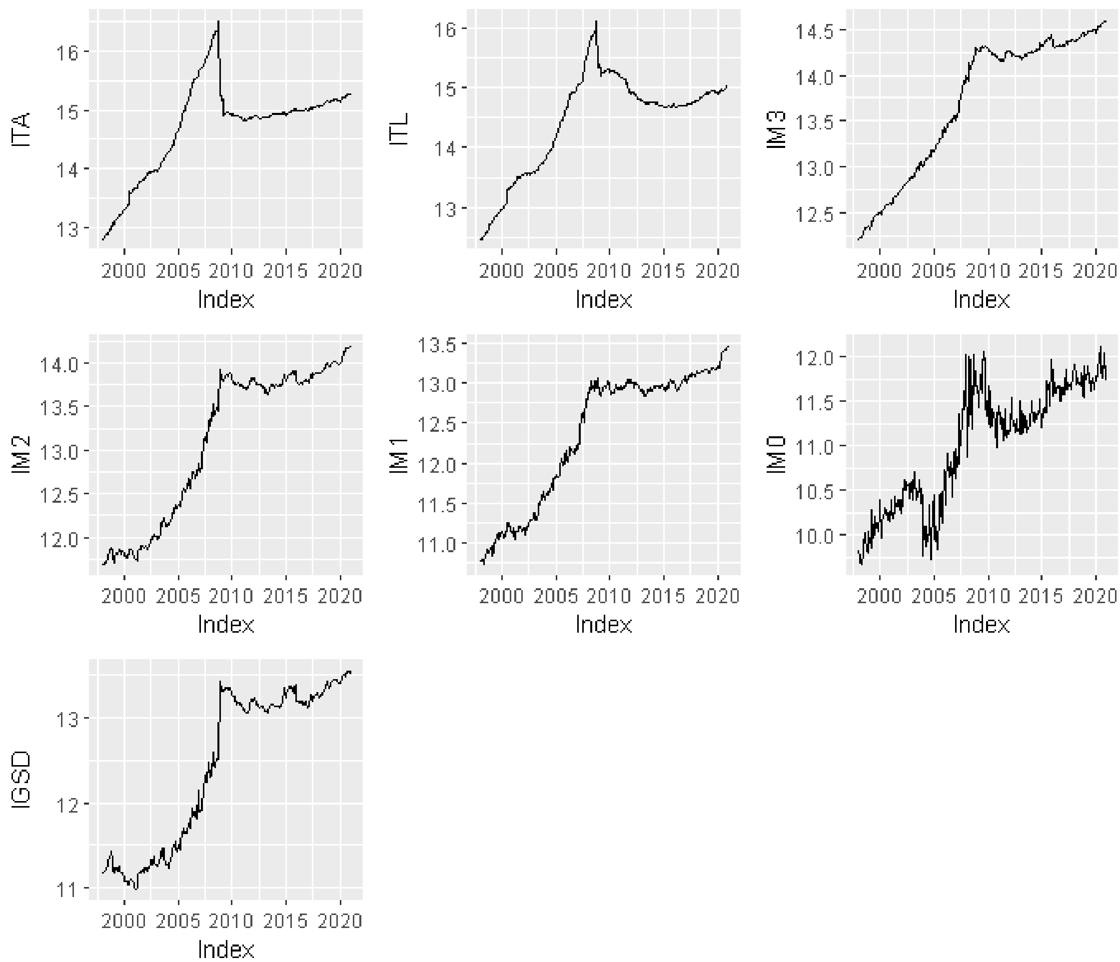
The data sample used in this study is from the Central bank of Iceland (CBI), which is reported in monthly intervals. In the dataset there are 275 observations, ranging from December 1997 to December 2020. All variables are transformed to a logarithmic form. The variables that are included are: Total loans of the commercial banks to homes and businesses, both indexed and non-indexed loans (Loans). Total assets of homes and businesses (Assets). Base money consisting of notes, coins and deposits of commercial banks at CBI (M0). Money supply consisting of M0 and current accounts of commercial banks (M1). Money and sight deposits, consisting of M1 and general savings (M2). Broad money consisting of M2 and time deposits (M3). I also use General savings deposits as the difference between M1 and M2, referred to as

GSD hereafter. The time before 2008 is indicated as time 1, for example Base money before 2008 is referred to as M0 1. The time after 2008 is indicated as time 2, so base money post-2008 is M0 2.

## Empirical Findings

The empirical analysis begins by looking at a descriptive graph of our variables, Figure 1. From the figure, we see a big drop in both Assets and Loans around 2008, M2 has a spike up around the same time. Base money, M0, is also hectic around 2008. M0 also has a drop down in 2005.

*Figure 1 Descriptive plot of data*




At a glance figure 1 suggests a structural break around 2008 for almost all time series. M0 shows some indicators of a structural break earlier in the data series, around 2004. In 2004, the CBI began raising the main interest rates of the bank from around 5 percent in the end of 2004 to about 10 percent at the end of 2005. Therefore, investigating the series for a structural break is important for moving forward. Some knowledge of the breaking points is known based on reading CBI quarterly paper *Peningamál.* In the test, M3 is used as a baseline that the series are regressed on. The results from the Chow test are reported in table 1.

*Table 1 Chow test for structural break*

| Chow - test | | | |
|---|---|---|---|
| Variable | Break point | F-critical value** | Chow-stat |
| Loans | 2008M05 | 1.326 | 870.98 |
| Assets | 2008M08 | 1.326 | 2537.11 |
| M0 1st break | 2004M1 | 1.548 | 231.25 |
| M0 2nd break | 2008M08 | 1.326 | 225.07 |
| GSD | 2008M08 | 1.326 | 844.912 |

*Significance: ***=0.01, ** = 0.05, * = 0.1*

The highest Chow-stat is around May of 2008 for the Loans variable, but October for Assets. This indicates that a tug on the loan lines happened before October of 2008. The first structural break in base money is around January of 2005 and the second one is in October of 2008. October is chosen as the point to split the sample. This is done to split the sample into pre- and post-bank collapse. Even though we see a structural break in M0 before 2008 we still keep it as is. However, this will cause the variable to be inconsistent in subsequent analysis.

The stationarity of the time series is checked with an augmented Dicky-Fuller test where the null hypothesis is that a unit root is present. The findings of the ADF test are then compared with a KPSS test where the null is that the series are stationary. The results of the tests are reported in table 2.

*Table 2 unit root tests for stationarity*

| | ADF - test | | | KPSS - test | | |
|---|---|---|---|---|---|---|
| **Variables** | Lags | Tau2 | Phi1 | p-value | Unit root | Results |
| Loans 1 | 10 | -0.3353 | 1.5361 | 0.1 | Yes | I(1) Non-stationary |
| Loans 2 | 9 | -1.8078 | 1.637 | 0.075* | Yes | I(1) Non-stationary |
| Assets 1 | 7 | -0.685 | 1.792 | 0.1 | Yes | I(1) Non-stationary |
| Assets 2 | 3 | 1.5334 | 3.354 | 0.092* | Yes | I(1) Non-stationary |
| GSD 1 | 10 | 4.0424 | 10.1616 | 0.1 | Yes | I(1) Non-stationary |
| GSD 2 | 12 | -1.183 | 0.852 | 0.1 | Yes | I(1) Non-stationary |
| M3 | 6 | -2.0239 | 5.759** | 0.01*** | No | Trend-Stationary |
| M2 | 2 | -1.1826 | 6.8446* | 0.01*** | No | Trend-Stationary |
| M1 | 1 | -1.5907 | 7.9468*** | 0.01*** | No | Trend-Stationary |
| M0 1 | 4 | -1.5514 | 3.0583 | 0.04385** | Yes | I(1) Non-stationary |
| M0 2 | 2 | -1.7317 | 1.5442 | 0.1 | Yes | I(1) Non-stationary |

*Significance: ***=0.01, ** = 0.05, * = 0.1*

The ADF test is followed up with an ADF test of the variables in difference. This is done to find out to what degree the variables are integrated. The result of the ADF test reveals that no time series is integrated above one meaning that the first difference is sufficient to make the series stationary.

The next step in my analysis is to look at pairs of nonstationary variables to see if they are co-integrated. This is done with a Johansen co-integration test. Variables that are stationary cannot be co-integrated with other variables therefore they are not included but they will be examined later. The trend stationary variables are M1, M2 and M3. To do this analysis I set up a VAR with pairs of integrated variables. Both Trace value and Eigen values are reported, the number of lags included is decided with an Akaike information criterion. The results are reported in table 3.

*Table 3 Johansen test for co-integration*

| Variables | Lags | Trace value | Eigen value | Co-integrated |
|---|---|---|---|---|
| Loans 1 & M0 1 | 10 | 10.92 | 9.26 | No |
| Loans 2 & M0 2 | 3 | 29.31*** | 25.74*** | Yes |
| Assets 1 & M0 1 | 10 | 24.14*** | 25.74*** | Yes |
| Assets 1 & M0 1 | 3 | 17.77* | 17.12** | Yes |
| Loans 1 & Assets 1 | 3 | 8.70 | 8.7 | No |
| Loans 2 & Assets 2 | 2 | 30.69*** | 17.51** | Yes |
| Deposits 1 & Loans 1 | 2 | 9.33 | 8.3 | No |
| Deposits 1 & Assets 1 | 3 | 13.66 | 12.91 | No |
| Deposits 1 & M0 1 | 3 | 25.35*** | 21.27 | Yes |
| Deposits 2 & Loans 2 | 2 | 21.95** | 18.81** | Yes |
| Deposits 2 & Assets 2 | 2 | 14.54 | 13.73* | No |
| Deposits 2 & M0 2 | 2 | 11.20 | 10.74 | No |

*Significance: ***=0.01, ** = 0.05, * = 0.1*

From the reported Johansen test, we see that before 2008 M0 and Loans were not co-integrated but after 2008 they are. This might be explained by the structural break between 2004 and 2005 that causes the test to be inconsistent. Before 2008 Loans and Assets were not co-integrated but after 2008 they are, which could be explained by the fact that before 2008 foreign currency loans were more popular than they are now.

*Table 4 Granger Causality test*

| Pre 2008 | | | | | |
|---|---|---|---|---|---|
| Dependent variable | Independent variable | F-stat | P-value | Lags | Conclusion |
| Loans 1 | M0 1 | 2.090 | 0.071* | 5 | M0 1 GC→ Loans 1 |
| M0 1 | Loans 1 | 0.9847 | 0.430 | 5 | Inconclusive |
| Loans 1 | M1 1 | 2.3204 | 0.047** | 5 | M1 1 GC → Loans 1 |
| M1 1 | Loans 1 | 1.241 | 0.2946 | 5 | Inconclusive |
| Loans 1 | M2 1 | 1.186 | 0.320 | 5 | Inconclusive |
| M2 1 | Loans 1 | 0.793 | 0.556 | 5 | Inconclusive |
| Loans 1 | M3 1 | 1.380 | 0.236 | 5 | Inconclusive |
| M3 1 | Loans 1 | 0.351 | 0.880 | 5 | Inconclusive |
| Post 2008 | | | | | |
| Loans 2 | M1 2 | 1.158 | 0.333 | 5 | Inconclusive |
| M1 2 | Loans 2 | 0.306 | 0.908 | 5 | Inconclusive |
| Loans 2 | M2 2 | 3.007 | 0.013** | 5 | M2 2 GC→ Loans 2 |
| M2 2 | Loans 2 | 0.865 | 0.506 | 5 | Inconclusive |
| Loans 2 | M3 2 | 3.984 | 0.0021*** | 5 | M3 2 GC→ Loans 2 |
| M3 2 | Loans 2 | 1.7623 | 0.125 | 5 | Inconclusive |

*Significance :***=0.01, ** = 0.05, * = 0.1*

The results from table 4 shows us that pre 2008 there is Granger causality from M1 to Loans, but post 2008 the test is inconclusive. This does not reinforce the hypothesis that base money is endogenous to the system. Post 2008 M3 and M2 both influence Loans so the system is obviously complicated and needs to be investigated further.

Due to the structural break in M0 before 2008 that was not accounted for, we move forward with a VECM of post 2008 data. The data that is looked at is the co-integrated time series. Because Loans and Assets are different sides of the same coin, Assets is excluded from the VECM model. An intercept is included because of the linear trend that was apparent in figure 1. Both a serial test and an ARCH test show little serial correlation left in the residuals. However, an autocorrelation function and a partial autocorrelation function show quite high correlation in later lags, around 10-15. This indicates that there is some higher lag order correlation that is not captured in the model. Capturing these higher lags in the model however caused the residual to become correlated and not well behaved, therefore I opted to keep the VECM model with fewer lags for a more parsimonious model.

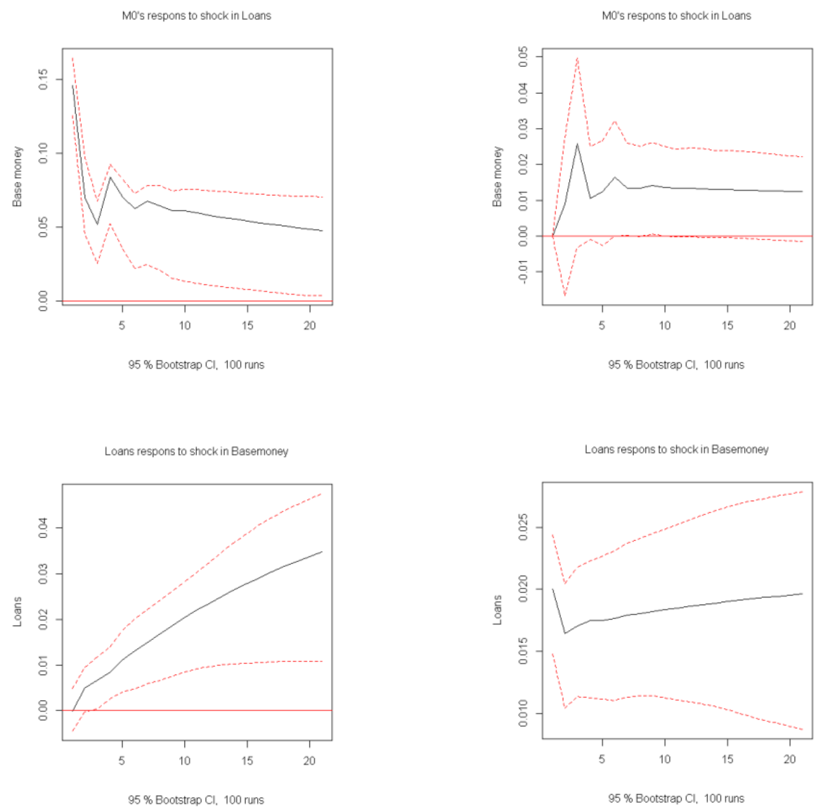
*Table 5 VECM results*

| | ECT | Intercept | M0 lag 1 | Loans lag 1 | M0 lag 2 | Loans lag 2 |
|---|---|---|---|---|---|---|
| M0 | -0.1033*<br>(0.0561) | 0.4334<br>(0.2328) | -0.4152***<br>(0.0888) | 0.3988<br>(0.5941) | -0.3042***<br>(0.0835) | 1.0961*<br>(0.5882) |
| Loans | 0.0376***<br>(0.0077) | -0.1577***<br>(0.0321) | -0.0026<br>(0.0122) | -0.1622**<br>(0.0819) | -0.0025<br>(0.0115) | 0.0010<br>(0.0811) |

*Significance: ***=0.01, ** = 0.05, * = 0.1*

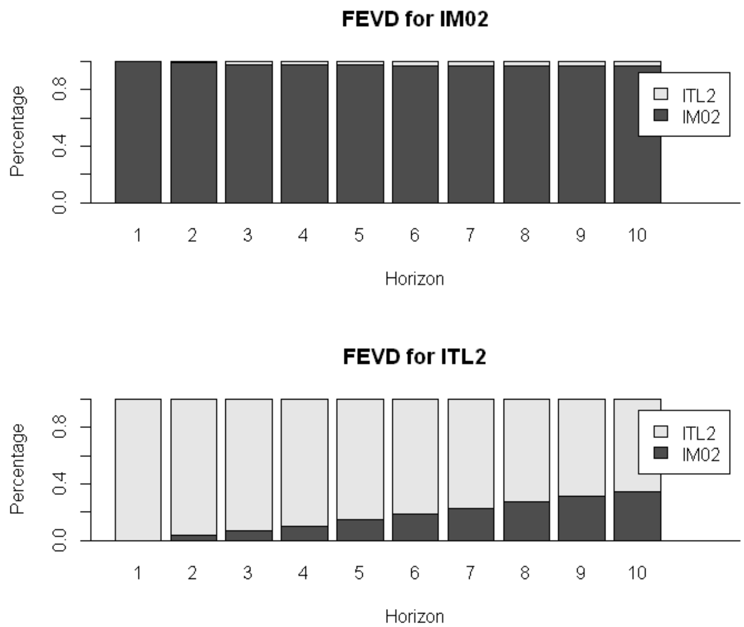
From the above table we see that the error correction term is significant from zero. Meaning that there is long run causality from money base to loans and from loans back to money base. This is indicative that banks of the economy do meet supply for money which then moves back to the CBI to deal with. The coefficients of the short term are not jointly significant. We cannot say that Loans Granger cause M0 or that Loans Granger cause M0 in the short term. Therefore, we can draw the conclusion that this model is not the correct model for estimating the short term relationship between the variables. The coefficient of the speed of adjustment is negative for M0 meaning that when a shock hits M0 it heads back to a new equilibrium. However, the coefficient of loans is positive, implying that the system spirals out of control. Given these findings, I still move forward with an impulse response function to see how the variables react to a shock. The impulse responses are reported in figure 2.

*Figure 2 Impulse response function*




In the figure above, we see the impulse response function for both a shock in base money and a shock in loans. From Loans response to a shock in base money we see that base money has a lot of influence on loans, and if the shock in negative we see that it takes about 3 periods for the variable to reach equilibrium. To put these graphs into better perspective we also look at the forecast error variance decompression.

*Figure 3 Forecast error variance decompression*




From figure 3, we see that most of the shock to money base are explained by money base but for loans we see that money base will have some increasing effect when we move further way from the shock. These findings suggest that more relative causality runs from money base to loans than from loans to money base.

## Conclusions

In this study I looked at the relationship between base money, money supply, loans, assets and deposits. This is done in an effort to try to answer the question of whether banks meet the demand for money. By controlling for structural breaks around 2008 I can try to find out how the money relationship has evolved over time. Through my analysis I find causality from base money and money supply to loans before 2008. After 2008 I only find evidence that supports causality between base money and loans but not for money supply. These findings support the hypothesis that banks meet the demand for the money and that monetary policy must consider demand when choosing the correct path forward.

## References

Central bank of Iceland. (2004). *Peningamál 2014(4)*. accessed May 2021 from: https://www.sedlabanki.is/utgefid-efni/rit-og-skyrslur/rit/2005/12/01/Desember-2005/

Cepni, O., & Guney, E. (2017). *Endogeneity of Money Supply: Evidence from Turkey*. International Journal of Finance &Amp; Banking Studies (2147-4486), 6(1), 1–10.

Enders, W. (2014). *Applied Econometric Time Series.* USA: Wiley.

Pala, A. (2017). *Structural Breaks, Cointegration, and Causality by VECM Analysis of Crude Oil and Food Price.* International Journal of Energy Economics and Policy (2146-4553), 3, 238-246.

Palley, T. (2008). *Endogenous Money: Implications for the Money Supply Process, Interest Rates, and Macroeconomics,* Political Economy Research Institute, University of Massachusetts at Amherst.