

# Demand deficiency, money velocity and heterogeneity

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## **Abstract:**

**Aim:** Money velocity data for the United States show that there is a decline in all of the broad money aggregates in recent decades. This points to a sustained demand deficiency element. Can consumer heterogeneity be the cause of this declining trend? The aim of this paper is to find an answer for this question.

**Design / Research Methods:** To achieve our aim we use Agent Based Modelling (ABM). In our model, the agents are heterogeneous consumers with different spending propensities.

**Conclusions / findings:** We show that heterogeneous consumers with different spending propensities alone puts a downward pressure on money velocity. This pressure is coupled with a sustained worsening in the wealth distribution. We observe that as money accumulates in the hands of agents with the lowest propensity to spend, money velocity keeps declining. This also puts a downward pressure on nominal aggregate demand and hence a deflationary bias on the general price level.

**Originality / value of the article:** This paper shows that heterogeneity of economic agents should not be ignored and that ABM is a very powerful tool to analyse heterogeneity.

**Implications of the research:** The implication for policy makers is that the demand deficiency associated with the fall in money velocity will persist until the worsening of wealth dispersion comes to a halt.

*Key words: Demand Deficiency, Money Velocity, Heterogeneity, Wealth Distribution, Agent Based Modelling*

*JEL: D31, D9*

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## 1. Introduction

Visual inspection shows that money velocity for the United States (US) has a declining trend in recent decades. The issue of temporary declines in money velocity was quite a popular topic for academics during 1980's. But somehow, this popularity vanished during the following decades although the velocity declines became very significant and persistent. This paper attempts to explain this recent trend that gives way to a significant deflationary bias. This is important because deflation can be considered as a new problem for the countries, for example especially for Japan. Historically inflation was a problem that was faced by almost every country from period to period either in high or low rates. Dealing with inflation and finding solutions to the problem was studied extensively and the cure is available. However, the problem of deflationary bias due to demand deficiency is a new phenomenon and there exists no consensus on its solution. This paper points the attention to one source of this recent problem of sustained demand deficiency.

In the existing literature, the issue has been analysed from the point of view of the relation between volatility of money growth and money velocity. This relation has been called the Friedman Hypothesis after the influential paper by Milton Friedman (1983).

Yet, there is another theory developed by Santoni (1987) which mentions the possibility of a negative relationship between wealth relative to income and money velocity. We will recall this relation the Santoni Hypothesis here, as an alternative to the Friedman Hypothesis for the explanation of decline in the money velocity. We will enrich the Santoni Hypothesis by allowing for behavioural heterogeneity across consumers since this might explain the decline in money velocity and hence the demand deficiency observed in advanced countries<sup>1</sup> together with worsening of the wealth distribution. Therefore, expansionary monetary policies are not as effective as they could otherwise be. Analysing the issue from the perspective of heterogeneity can be considered as the second contribution of the paper.

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<sup>1</sup> Basci et al. (2019) presents the evidence on the presence of a significant demand deficiency problem for the G7 Countries.

Unlike other papers in the literature we use “Agent Based Modelling” (ABM) to explicitly model consumer heterogeneity. Although ABM is a very powerful tool for making such analysis, we do not see much use of this technique in the macroeconomics literature where the “representative agent” is the dominant paradigm. Therefore, the third contribution of the paper is to demonstrate that heterogeneity can be captured quite easily via ABM in macroeconomic modelling as well.

In the paper, we construct a model where we assume (without loss of generality) that there is no money growth in the economy and initially money is distributed equally among the consumers. Moreover, the only income of the agents is the wage they earn which also is a constant share of total nominal income over time. Working time (labor supply) is not changing as well.

We find by using simple ABM that as money starts to accumulate in the hands of agents who have a lower propensity to spend, money velocity, nominal total demand and the price level all start to decline over time.

The paper proceeds as follows. Section II contains the literature review. We present our model and the methodology in Section III. The data analysis is included in section IV. Outcomes of the ABM can be found in Section V. Finally, Section VI concludes.

## **2. Literature review**

Mehra (1989) points attention the two temporary declines, namely those in 1982-83 and 1985-87. In Friedman (1983), the possible reason of these declines is given as increased volatility of money growth caused by uncertainty due to an announcement of procedural changes by Federal Reserve in October 1979. According to the paper, increased volatility of money growth contributed to increasing the demand for money which also means reducing the money velocity. It entered the literature under the name “Friedman Hypothesis”.

Friedman Hypothesis is studied in papers by Mascaro and Meltzer (1983), Chowdhury (1988) and Fisher and Serletis (1989). Hall and Noble (1987) and Payne (1992, 1993) used a Granger causality method to support the Friedman Hypothesis. However, the results of Darrat and Suliman (1994) suggest that there is no relation between volatility of money growth and money velocity where the analysis is made explicitly by using a six-variable vector-autoregressive model.

Blundell-Wignall et al. (1984) try to explain the decline in money velocity during 1980's for the OECD countries. They state that for the US, the declines in M1, M2 and M3 are very large compared to the historical standards. There might be two reasons. The first one is a movement along the money demand function due to changes in interest rates or inflation expectations.

Santoni (1987) develops an economic theory for the relationship between wealth relative to income and money velocity. According to the theory, increases in wealth relative to income is an important cause of decline in money velocity. However, when the period of 1982 to 1985 is analysed in the paper, it is observed that during the period with the exception of stock market measure of wealth, all other measures did not increase significantly relative to current income. For this reason, the paper concludes that the evidence does not support that the decline in the income money velocity since 1981 is due to increases in these measures of wealth relative to current income.

The Benk et al. (2010) study provides US money velocity data for the period 1919-2014 by using annual time series data. The paper refers to long cycles around a 1.25% per year upward trend. They explain these cycles by shocks constructed from a Dynamic Stochastic General Equilibrium model.

The above stated papers try to explain the visual inspection of the decline in money velocity by using theory and econometric techniques. On the other hand, the influential paper of Kirman (1992) explains how use of representative agents in macro modelling can miss the behaviour of whole society consisting of millions of individuals, several organized groups and firms. Therefore, based on this idea, one other methodology to analyse the issue can be to use ABM.

In line with Kirman (1992), there are examples of papers which guide how to use ABM in some specific areas of economics. Arthur (1991) models bounded rationality of human agents by using ABM. The recent paper Zhao et al. (2019) use ABM to find out the degree of rationality for monetary policy and macroeconomic fluctuations in China. LeBaron (2001) explains researchers interested in modelling financial markets how to build their own ABM. Axtell et al. (2002) explains how ABM can be used to analyse industrial ecology, that is, how millions of individuals making decisions on product purchases, attitudes of recycle and usage of private cars or public transportation that cannot be brought down to a representative agent analysis.

### 3. Model and methodology

The general price level of goods and services is directly proportional to the amount of money in circulation or in other words money supply according to the *quantity theory of money*, which can be shown by the below equation:

$$Mv = Py \quad (1)$$

where  $M$  is the total amount of money in an economy during a given period,  $v$  is the money velocity,  $P$  is the price level associated with transactions for the economy during the period and  $Y$  is the real total income of the economy.

Quantity theory of money is one simplistic example for models which reflects the complexity of real life economies where for millions of decentralized heterogeneous agents, aggregated results of economic subjects such as growth, wealth, income distribution, labor force, business cycles, etc. are to be studied. However, this model requires very strong simplifying assumptions to obtain a straightforward result. This extremely constrained approach which regards velocity of money as constant provides little help for explaining real life economies, especially if the underlying economic phenomena exhibit highly complex behaviour.

From 1980's onward the "representative agent" assumption very often used in the literature. Although not realistic, since, in fact agents are physically, psychologically and economically heterogeneous, this assumption was needed because there was not a convenient method to deal with heterogeneity. Moreover, the interactions between heterogeneous agents have similarly been ignored. However, there is no immediate justification for this approach.

Some recent studies suggest an alternative methodology for analysing the complex real life economies by using the new technique known as Agent Base Modelling (ABM). It allows to model heterogeneous adaptive agents who interact with each other. This methodology does not resort to oversimplifying assumptions. Arthur (1991) sketches the most important features of this methodology.

Therefore, in this paper, by using ABM, we try to find out whether heterogeneity alone can cause a gradual shifting of wealth from the ones who spend more to the ones who spend less, leading to a decline in money velocity and hence demand deficiency. Our simple model assumes that money is the only asset in which wealth may be held. For simplicity we assume a zero rate of money growth in the economy. Initially we assume an equal distribution of money across the consumers. The only income of the agents, which is also assumed to be equally distributed, is the wage they earn. The labor is supplied inelastically so that labor income is the same for all individuals.

There are  $N$  agents.  $M$  is the total amount of money in the economy.  $\{M_{1t}, M_{2t}, \dots, M_{Nt}\}$  is the vector of amounts of money each individual has at time  $t$ .  $M = M_t = \sum_{i=1}^N M_{it}$  for all  $t$ . The budget constraint for agent  $i$  at time  $t$  is:

$$M_{it} = M_{i(t-1)} + WL - C_{it} \quad (2)$$

where  $W$  is wage,  $L$  is working time and  $C_{it}$  is the consumption level of the  $i^{th}$  agent at time  $t$ . Since at the beginning, money is distributed equally among the agents in the economy, the initial condition is:

$$M_{i,0} = M/N \text{ for all } i \quad (3)$$

We assume that consumption is a linear function of money so:

$$C_i(M_i) = \gamma_i M_i \quad 0 < \gamma_i < 1 \text{ for all } i \quad (4)$$

where  $\gamma_i$  is propensity to spend out of money for agent  $i$ .  $C$  is the total nominal demand in the economy.  $\{C_{1t}, C_{2t}, \dots, C_{Nt}\}$  is the vector of amounts of consumption each individual has at time  $t$ .  $C_t = \sum_{i=1}^N C_{it}$  for all  $t$ .

A more general but similar macroeconomic model is presented in Asona et al. (2019). In their model agents are heterogeneous as well but in addition they also make decisions about their savings. There are poor households with low savings rates and rich households with high savings rates.

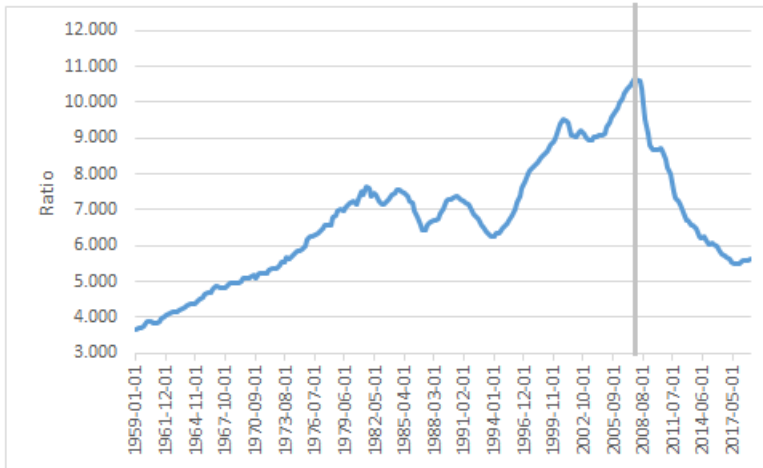
#### 4. Analysis of the data

M1 is the narrow definition of money supply. It includes notes and coins, traveller's checks, demand deposits, and checkable deposits. Declining velocity of M1 means that final expenditures per unit of money are declining as well. In Figure 1, money stock velocity of M1 can be seen for the US economy over time.

In Q1 of 1959, the velocity of M1 was 3.66 and it was 7.59 in quarter 4 of 1981. This means, during that period there was an average annual increase of velocity of 4.88 percent. This period can easily be explained by a rising trend in inflation. Yet, in the recent decade a decline trend has started. In Q3 of 2019, the velocity is 5.57. It is even lower than the velocities of 1980's and early 1990's which end up with an average annual decrease of 4.35 percent. The most striking observation in Figure 1 is the region after the plotted vertical line at the Q4 of 2007 with a fall from a peak velocity of 10.68.

M2 includes M1 and saving deposits, certificates of deposit and money market deposits for individuals. The velocities of M1 and M2 gives a similar pattern. In Figure 2, money stock velocity of M2 can be observed over time for the US economy.

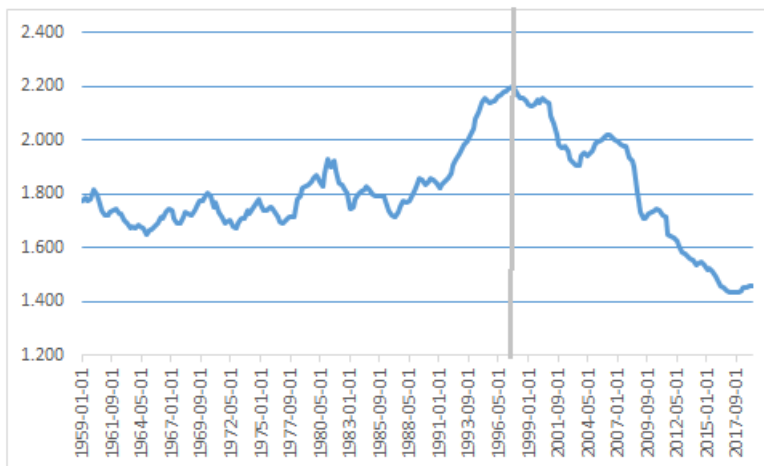
**Figure 1. M1 money stock velocity for the US**



Source: Federal Reserve Bank of St. Louis, <https://fred.stlouisfed.org/>.

Note: Seasonally adjusted quarterly data (downloaded: April 26, 2019).

**Figure 2. M2 money stock velocity for the US**



Source: Federal Reserve Bank of St. Louis, <https://fred.stlouisfed.org/>.

Note: Seasonally adjusted quarterly data (downloaded: April 26, 2019).

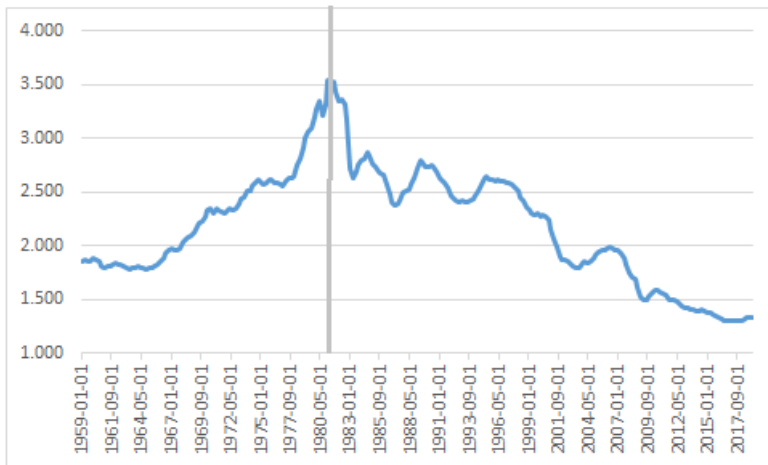
As can be seen in Figures 1 and 2, M2 is more volatile compared to M1 for the whole period and an increasing trend cannot be observed for M2 similar to M1



before 1980s. The decline period is longer for M2 compared to M1 where it is 11 years for M1 and 21 years for M2. The average annual decline is 4.35 percent for M1 and it is 1.93 percent for M2. The most important region of Figure 2 is the region after the vertical line at the peak in the Q3 of 1997 with a velocity of 2.20.

MZM (money with zero maturity) consists of the supply of notes and coins in circulation, traveller’s checks, demand deposits, other checkable deposits, savings deposits, and all money market funds. The velocity of MZM is important for determining how often financial assets are switching hands in the economy. In Figure 3, money stock velocity of MZM for the US economy can be seen.

**Figure 3. MZM money stock velocity for the US**



Source: Federal Reserve Bank of St. Louis, <https://fred.stlouisfed.org/>.

Note: Seasonally adjusted quarterly data (downloaded: April 26, 2019).

For MZM, we observe mainly two periods, the rising period and the falling period. The rising period is from the starting date of the data to the Q1 of 1981. In Q1 of 1959, the velocity was 1.85 and it was 3.54 in Q1 of 1981 with an average annual increase of 2.28 percent. This rising trend in velocity can easily be explained by a rising inflation trend. In Q3 of 2019, the velocity was 1.31 and the average annual decrease was 1.70. The question is why does money velocity values keep falling even *after* inflation is stabilized at 2 percent. The most important region of

Figure 3 is the region after the vertical line at the Q3 of 1981 with a peak velocity of 3.53.

Table 1 summarizes the above observations on the data. Since all the values of average annualised changes of the last row of Table 1 are negative, we can conclude that declining money velocity continues to be a problem after 2007, even after the inflation rate has been stabilized.

**Table 1. Average annualized changes for velocity of M1, M2 and MZM**

Year	Velocity of M1	Average Annualized Change	Velocity of M2	Average Annualized Change	Velocity of MZM	Average Annualized Change
Q1 1959	3.66		1.77		1.85	
Q1 1981					3.54	2.28
Q4 1981	7.59	4.88				
Q1 1991			1.83	0.09		
Q1 1994	6.26	-1.46				
Q3 1997			2.20	4.10		
Q4 2007	10.68	5.88				
Q3 2019	5.57	-4.35	1.44	-1.93	1.31	-1.70

## 5. Outcomes of the Agent Based Model<sup>2</sup>

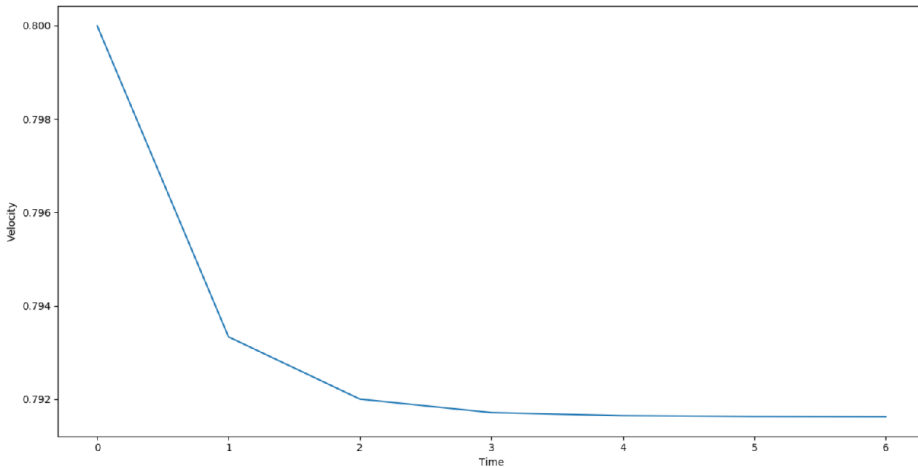
For simplicity of demonstration and without loss of generality, the number of agents (i.e. consumers) in the economy,  $N$ , is taken as 3. The total amount of money in the economy,  $M$ , is taken as 300 and by Equation (3),  $M_{i0} = 100$  for  $i = 1, 2, 3$ . Total real production level,  $y$ , is taken as 100 units of consumption goods. The three agents are assumed to be heterogeneous and have propensities to spend of 0.9, 0.8 and 0.7 for  $i = 1, 2, 3$  respectively. This section reports the outcomes of the ABM under this setting.

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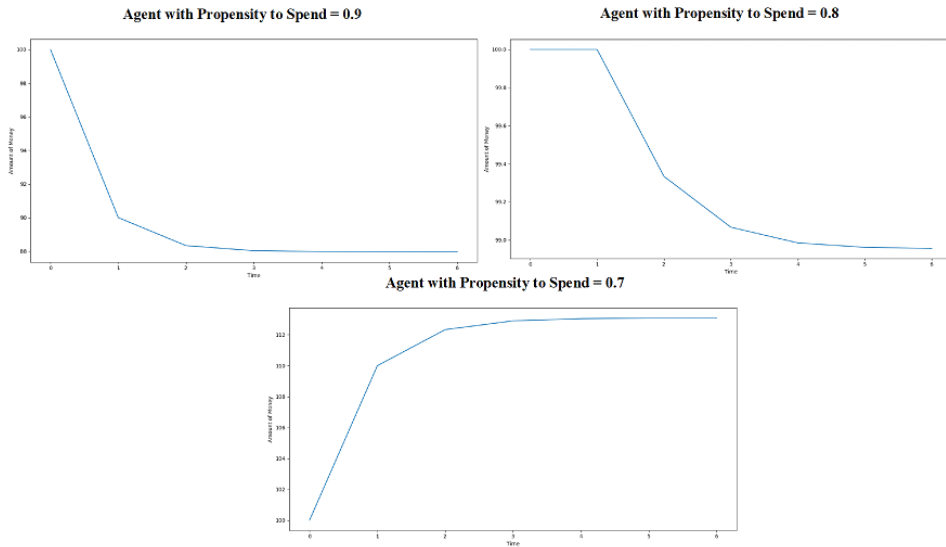
<sup>2</sup> Results are obtained by using an ABM code written for Python and is available upon request from the authors.

For this study, the most important outcome is the decline in velocity of money which is presented in Figure 4. The horizontal axis is time (i.e. number of iterations) and the vertical axis is the velocity of money generated by the model. The convergence to the value 0.792 is reached at time period 6 where there is a new wealth distribution.

**Figure 4. Decline of velocity**



This new wealth distribution can be seen in Figure 5. The convergence pattern of the amount of money balances for the three types of agents is seen in this Figure. The horizontal axis is time and the vertical axis is the amount of money of a particular agent. All three agents start with an initial amount of money of 100 units. For agents with propensity to spend of 0.9 and 0.8, we see a decline in money balances. The convergence values for the money balances of agents with propensity to spend of 0.9 and 0.8 are 88 and 99, respectively. On the other hand, for the agent with propensity to spend of 0.7, there is an increase in the amount of money up to the value 113. The convergence is reached after iteration six. These three values add up to 300 since we have the assumption that money stock does not grow in the aggregate.

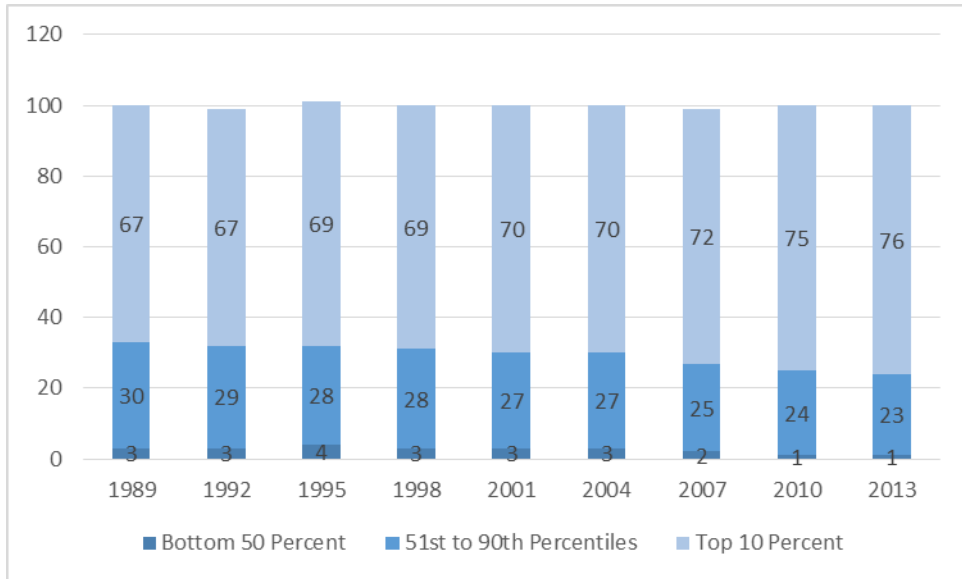
**Figure 5. Convergence of the amount of money balances**

This result is in line with the Santoni Hypothesis with heterogeneity added. To remind, according to this hypothesis, increases in wealth relative to income is an important cause of decline in money velocity. The outcome of the ABM is a transfer of wealth, which is the money in the model, from the ones who have high propensities to spend to the ones who have low propensities to spend. Therefore, money velocity keeps declining until the steady state is reached.

Real data also supports this form of the Santoni Hypothesis as well. Figure 6 is drawn by using the data from the Survey of Consumer Finances reported in Karamcheva (2016). This survey is conducted every three years and it includes detailed information on family wealth, income, and pensions. It covers nearly the full distribution of family wealth. The measure of wealth in the survey is marketable wealth (i.e. the difference between a family's assets and its debt). Assets consist of financial assets, home equity, and other assets such as real estate, vehicles, and business equity. Debt is non-mortgage debt, which consists of a family's consumer debt and other debt like student loans. The declines in money stock velocities for

recent years can indeed be a consequence of this worsening trend in the distribution of wealth.

**Figure 6. Shares of family wealth, by wealth group for the US**

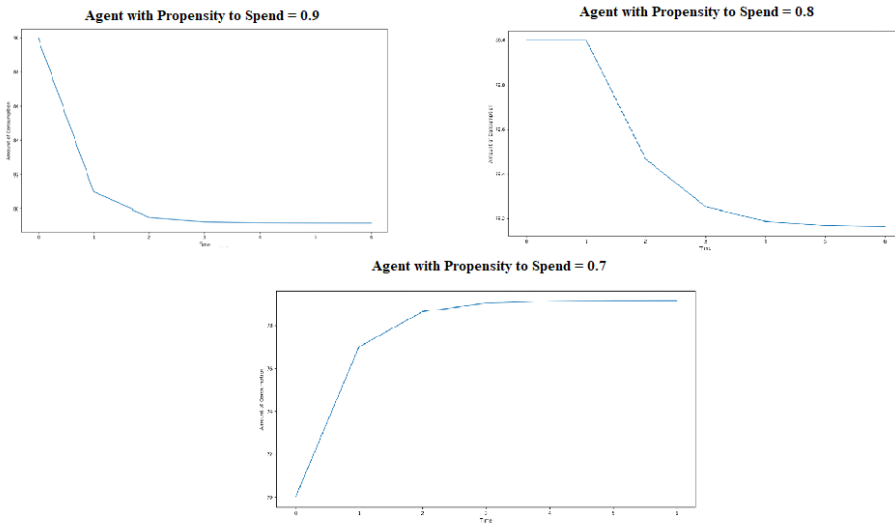


Source: Congressional Budget Office US; Karamcheva (2016).

According to Equation (4), consumption is a linear function of the amount of money for all agents. Therefore, it is not surprising to observe convergence in consumption as well. We can see this in Figure 7. Horizontal axis is time and the vertical axis is consumption. Depending on the propensity to spend of the individual, i.e.  $\gamma_i$ , initial amount of consumption differs for the agents. Since  $0 < \gamma_i < 1$  for all  $i$ , the directions of the convergences are same as the ones for amount of money. For agents with propensity to spend of 0.9 and 0.8, we see a decline. The convergence is after iteration two for the agent with propensity to spend 0.9 and it is after iteration four for the agent with propensity to spend 0.8. On the other hand, for the agent with propensity to spent 0.7, there is an increase in consumption. The convergence is reached after iteration three. The timing of these convergences are same as the case for amounts of money. The eventual consumption level is almost the same for the

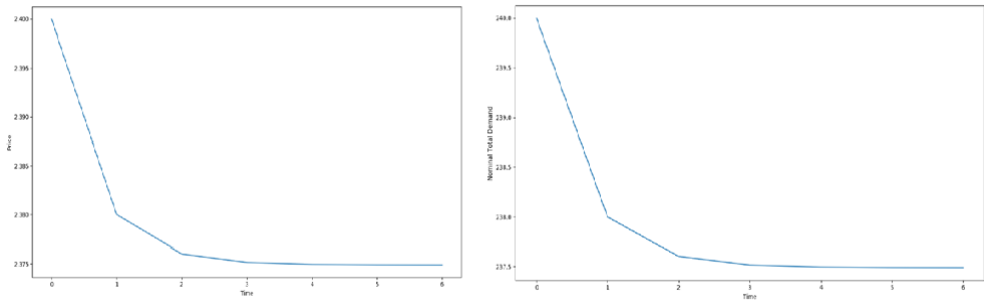
three agents and is around 80, despite the sustained dispersion of wealth in a steady state.

**Figure 7. Convergences of consumptions**



The effects on price and nominal total demand can be seen in Figure 8. For both left and right hand side parts of the figure time is on the horizontal axis. Price level is the vertical axis on left and nominal total demand is the vertical axis on the right. The convergence is at the level 2.375 for price and it is at the level 237.5 for nominal total demand after period six. They both decline consistent with a demand deficiency and a deflationary bias as would be predicted by the agent based version of the “Quantity Theory”.

**Figure 8. Decline of price and nominal total demand**



## 6. Conclusion

Visual inspection of money velocity for the United States shows that there is a declining trend in recent decades. During 1980's there were temporary declines in money velocity and these periods were studied by academicians extensively. Although the rates of declines became much more significant and persistent in recent decades the interest on this issue has diminished.

This paper attempts to bring the problem to the agenda again and tries to explain this recent trend that gives way to a significant deflationary bias. This is important because although inflation is a long time known problem, deflation can be considered as a new problem for especially the developed countries.

We used in the paper an ABM approach. By this way we could address consumer heterogeneity explicitly, instead of using the dominant paradigm of a “representative agent”. The outcomes of the model showed that as money starts to accumulate in the hands of agents who have lower propensities to spend, money velocity starts to decline. Since in our model money was the only form of wealth, this relation between amount of money and money velocity supported the Santoni Hypothesis. We also showed the similarities of our results with the real data of distribution of wealth.

Two other outcomes of the model were on price level and nominal total income. They both have a declining trend as time goes on. This is in line with the deflationary bias in developed countries during recent decades associated with a

demand deficiency. Therefore, it can be suggested to the policy makers that expansionary monetary policies might not be as effective as they would be in the absence of heterogeneity.

Our ABM model is a simple one, yet it has striking results. The first simplicity comes from the setting that the only wealth of the agents is money. Moreover, the total amount of this money is constant over time and it is distributed equally among the agents initially. Coming to the income of the agents, which is the wage they earn, it is also distributed equally. The only heterogeneity between the agents is the difference in their spending behaviour.

In future studies these assumptions can be relaxed. For example, money growth can be added to the model, as well as alternative forms of wealth. Moreover, a stochastic version with idiosyncratic shocks can easily be considered. We are of the view that none of these would change the main conclusion: Heterogeneity matters for macroeconomic modelling.

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## DEMAND DEFICIENCY, MONEY VELOCITY AND HETEROGENEITY

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