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Abstract

This paper proposes the hypothesis that population aging could lead to higher demand for money. A testable implication is derived from this hypothesis on the basis of Friedman's money demand function, which is that the proportion of old-age population is negatively correlated with the velocity of money. The testable implication is verified with the cross section data of 204 countries and the time series data of the US. This paper's study provides a partial explanation for why the quantity theory of money appears ineffective in developed countries.

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1. Introduction

Inflation is missing in developed countries, and this occurs despite the central banks have pumped enormous amount of money into the economy. This naturally leads to some economists to doubt whether the quantity theory of money is still effective, for instance, Teles*et al.*(2016).

This paper proposes the hypothesis that population aging could lead to higher demand for money. A testable implication is derived from this hypothesis on the basis of Friedman's money demand function, which is that the proportion of old-age population is negatively correlated with the velocity of money. This testable implication is verified with the cross section data of 204 countries and the time series data of the US. Higher demand, given money supply, would lead to lower inflation. This paper's study thus provides a partial explanation for why the quantity theory of money appears ineffective in developed countries.

In the literature, some empirical studies find a negative relationship between demographic change and inflation in developed countries, for instance, Bobeica *et al.*(2017). However, the explanation proposed focuses primarily on the supply side. For instance, Goodhart and Pradhan (2017) argue that the including of China and East Europe into the global economy imposes deflation pressure through increased competition. Though abundant evidence does support this argument, however, it is an incomplete story. As Friedman has convincingly argued, "inflation is always and everywhere a monetary phenomenon". Demographic change has impacts on money demand too, which is the central message of this paper.

The rest of this paper proceeds as follows. The next section constructs a simple model on the basis of Friedman's money demand function. The testable implication derived from this model is verified in section 3. The last section concludes.

2. The Hypothesis of Aging Leading to Higher Money Demand

It is consistent with our common sense that as people become older, other things being equal, their demand for money might increase. This might be due to that, first, older people face with more uncertainty. The natural law states that, the longer you live, the higher is the probability that some parts of your body would dysfunction. More uncertainty would require a larger stash of cash in case of emergence. Second, older people make financial planning for a shorter time span, therefore short term and more liquid assets, money included, would be preferred. Furthermore, other things are not equal. For one thing, older people in general accumulate more wealth than younger people. For another, young people are more comfortable with newer payment technologies, such as credit cards, PayPal, bitcoin, etc. All these factors lead to higher demand for money as people get older. Therefore, we propose the hypothesis that population aging would lead to higher demand for money.

If it is to be taken seriously, the micro-foundation for this hypothesis is required. Such a task will be postponed for future study. Instead, this paper explores the implication of the hypothesis on the basis of Friedman's money demand function, which is subsequently contrasted with real world data. This is, of course, an indirect way to verify the validation of the hypothesis.

The money demand function of Friedman (1956) can be expressed as:

$$M^d = f\left(P\overset{+}{W}, \overset{-}{r_x}, \overset{-}{\pi^e}, u \right) \tag{1}$$

where M^d is the demand for money of a typical individual, P is the nominal price level, W is the real lifetime wealth, r_x is a vector of returns of all kinds of assets which are the opportunity costs of holding money, π^e is the expected inflation rate, and u stands for all other factors that affect money demand. The positive and negative signs above the variables stand for their correlations with money demand.

Friedman (1956, p.10-11) argues that people make decisions based on real variables instead of nominal variables. Technically, this means that equation (1) is homogeneous of degree one with respect to P. That is, for any positive constant λ, we have:

$$\lambda M^d = \lambda f\left(\overset{+}{PW}, \overset{-}{r_x}, \overset{-}{\pi^e}, u\right) = f\left(\lambda \overset{+}{PW}, \overset{-}{r_x}, \overset{-}{\pi^e}, u\right) \tag{2}$$

The demand for money of a country can be divided into two parts: the demand from old age people (those who are 65 or more)and that from the young, which are denoted as M_O^d and M_Y^d respectively. Assume that the population is N_d and the proportion of old age people is α, then the total demand for money (TM^d)is

$$TM^d = \left[\alpha M_O^d + (1-\alpha) M_Y^d\right] N_d \tag{3}$$

Substituting equation (1) into equation (3), we can express the total money demand function as

$$TM^d = \left[\alpha f_1\left(\overset{+}{PW_O}, \overset{-}{r_x}, \overset{-}{\pi^e}, u\right) + (1-\alpha) f_2\left(\overset{+}{PW_Y}, \overset{-}{r_x}, \overset{-}{\pi^e}, u\right)\right] N_d \tag{4}$$

where W_O and W_Y denote the wealth of a typical old age and young people respectively.

According to the hypothesis, other things being equal, old age people prefer to hold money more than young people ($f_1(.) > f_2(.)$), and their lifetime wealth is larger ($W_O > W_Y$).Therefore, equation (4) states that a larger proportion of old age population (α) would lead to higher total money demand.

The hypothesis proposed above is difficult to be tested directly because demand is un observable. However, Friedman (1959) provides a genius approach to test money demand. He argues that the velocity of money is observable, and in equilibrium, the demand for money is equivalent to the velocity of money.

Set $\lambda = \frac{1}{PY}$ for equation (4) and rearrange, we have:

$$\frac{TM^d}{PY} = \left[\alpha f_1\left(\overset{+}{\frac{W_O}{Y}}, \overset{-}{r_x}, \overset{-}{\pi^e}, u\right) + (1-\alpha) f_2\left(\overset{+}{\frac{W_Y}{Y}}, \overset{-}{r_x}, \overset{-}{\pi^e}, u\right)\right] N_d \tag{5}$$

The quantity equation of money states that $\frac{M}{PY} \equiv \frac{1}{V}$. Combining with the properties of equation (4), we can deduce from equation (5) the following testable implication: a larger proportion of old-age population would lead to lower velocity of money.

3. Empirical Tests

We verify the testable implication with two sets of data. The first is the cross section data of 204 countries, the second the time series data of the US. The empirical test using the cross section data finds that countries with higher proportion of old age people tend to have lower velocity of money. The empirical test using American time series data discovers that there is long run equilibrium between the velocity of money and population aging, and the two are negatively correlated. Considering the fact that population aging is exogenous to money demand, the empirical finding is best interpreted as this one way causality: population aging causes higher money demand.

Cross Section Data

The World Bank publishes data of its member countries on the proportion of people aged 65 or more over the total population and M2/GDP. In practice, GDP/M2, the inverse of M2/GDP, is used to measure the velocity of money. To ensure it is a long run relationship, we use the mean over the latest decade (2009-2019) of the proportion of old age people to measure population aging, and that of GDP/M2 to measure the velocity of money, and the data for 204 countries are obtained. The regression results are reported in table 1, which show that a country with a higher proportion of old age people tends to have lower velocity of money. This finding is consistent with the testable implication.

Table 1. Cross Section Data Regression Results

	c	Proportion of old age population	Adjusted R^2	S.E. of Regression
velocity of money	3.08 (20.91**)	-0.13 (-7.43**)	0.21	1.18

Notes: the dependent variable is the velocity of money, c is the constant and the independent variable is the proportion of old age people. The numbers reported in parenthesis are of t statistics. ** stands for significant at 5%, and * stands for significant at 10%.

Time Series Data

The time series data of the US are of four variables: the velocity of money v_t (measured by GDP/M2), the proportion of old age people α_t, and interest rate r_t (measured by the yields of 3-month treasury bills);the fourth variable, wealth W_t, is measured by Friedman's (1957, p.143-7) proxy measurement of permanent income. Specifically, wealth is defined as

$$W_t = \beta GDP_t + (1 - \beta + \alpha) W_{t-1}$$

where $\beta = 0.4$ and $\alpha = 0.02$ as estimated by Friedman.

The results of the ADF tests of the four series are reported in table 2.

Table 2. The Results of the ADF Tests

			W_t	r_t	
D(0)	D(1)	D(0)	D(0)	D(0)	D(1)
1.67 (0.75)	6.15 (0.00**)	8.10 (0.00**)	3.45 (0.01**)	1.51 (0.51)	6.54 (0.00**)

Notes: The data of v_t and α_t are from the World Bank, the data of W_t and r_t are from FRED (https://fred.stlouisfed.org/). Data range: 1960-2019. D(0) stands for the level data and D(1) the first differenced data. The numbers reported in parenthesis are of p values.

The ADF test results suggest that the series of W_t and α_t are stationary, whereas the series of v_t and r_t are integrated of order 1. We can thus construct an ARDL (autoregressive distributed lag) model of the following form:

$$v_t = c + \sum_{i=1}^{p} \beta_i v_{t-i} + \sum_{j=0}^{q_1} \gamma_j \alpha_{t-j} + \sum_{k=0}^{q_2} \delta_k W_{t-k} + \sum_{n=0}^{q_3} \chi_n r_{t-n} + \varepsilon_t \quad (6)$$

Table 4. Estimation of the ARDL(4, 1, 0, 1) Model

c	v_{t-1}	v_{t-2}	v_{t-3}	v_{t-4}	α_t	α_{t-1}
1.25 (5.53**)	0.72 (5.67**)	0.04 (0.26)	-0.09 (0.57)	-0.26 (2.13**)	-0.60 (5.61**)	0.63 (5.63)
W_t	r_t	r_{t-1}	LM Test	F-bounds Test	Adjusted R^2	S.E. of Regression
-0.19 (4.57**)	0.01 (3.06**)	-0.02 (4.44**)	0.52 (0.72)	7.43	0.95	0.05

Notes: the dependent variable is v_t. The numbers reported in the parenthesis are of t statistics; the number in the parenthesis under LM Test is of p-value.

To estimate equation (6), the Schwartz criterion is employed to choose the lagged orders, and the results are $p = 4$, $q_1 = 1$, $q_2 = 0$ and $q_3 = 1$. The estimation results are reported in table 4. The F-statistics of the LM test suggests there is no autocorrelation in the regression residuals. The F-bounds test suggests that there is cointegration among these variables. It thus can be concluded that there is long run equilibrium among these four variables.

Table 5. Regression Results of the Long Run Equilibrium

c	α_t	W_t	r_t	Adjusted R^2	S.E. of Regression
2.07 (16.19**)	-0.08 (3.21**)	0.04 (0.57)	0.01 (2.17**)	0.52	0.11

Notes: the dependent variable is v_t.

Table 5 reports the regression results of the long run equilibrium, from which it is clear that the proportion of old age people (α_t) is negatively correlated with the velocity of money (v_t), and it is statistically significant. This is consistent with the testable implication.

Table 6. Regression Results of the ECM

c	Δv_{t-1}	Δv_{t-2}	Δv_{t-3}	Δv_{t-4}	$\Delta \alpha_t$	$\Delta \alpha_{t-1}$
0.03 (1.06)	0.29 (1.92*)	0.26 (1.73*)	0.07 (0.45)	0.03 (0.20)	-0.53 (1.41)	0.43 (1.13)
ΔW_t	Δr_t	Δr_{t-1}	ect_{t-1}	Adjusted R^2	S.E. of Regression	
-0.72 (0.91)	0.02 (3.49**)	-0.01 (2.52**)	-0.22 (1.96*)	0.19	0.04	

Notes: The dependent variable is Δv_t. Δ stands for differencing; ect is the error correction terms, which are the regression residuals of the regression of the long run equilibrium, as reported in table 5.

Finally, we check whether the long run equilibrium is stable. The estimation results of the corresponding error correction model (ECM), reported in table 6, show that the coefficient of the error correction terms is negative, and the estimation is statistically significant, which suggests that the long run equilibrium is stable.

4. Concluding Remarks

The missing inflation in developed countries is puzzling. The theories proposed, such as the globalization hypothesis, put too much weight on the supply side. But inflation is ultimately a monetary phenomenon. As the supply of money is relatively stable, research would gain more to unravel this puzzle by shifting focus on factors affecting money demand.One of such factors is population aging. We hope this paper could stimulate more rigorous empirical and theoretical studies of the structural changes of money demand in developed countries since the 1980s.

References:

Bobeica, E., C. Nickel, E. Lis and Y. Sun (2017), “Demographics and inflation”, ECB Working Paper, No. 2006.

Friedman, M. (1956), “The Quantity Theory of Money-A Restatement”, in *Studies in the Quantity Theory of Money*, Eds Milton Friedman, Chicago: the University of Chicago Press, 3-21.

Friedman, M. (1957), *A Theory of the Consumption Function*, Princeton: Princeton University Press.

Friedman, M. (1959), “The Demand for Money: Some Theoretical and Empirical Results”, *Journal of Political Economy*, 67(4): 327-351.

Goodhart, C. and M. Pradhan (2017), “Demographics will reversethree multi-decade globaltrends”, BIS working paper, No. 656.

Teles, P., H. Uhlig and J. Azevedo (2016), “Is Quantity Theory still Alive?” *The Economic Journal*, 126(3): 442-464.