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The impact of digital payments on the velocity of money in the Chinese market

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Master in Economics

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November, 2021

BUSINESS SCHOOL

CIÊNCIAS SOCIAIS E HUMANAS

Department of Economics / Department of Political Economy

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Abstract

To study the impact of digital payments on the velocity of money circulation, this paper selects the velocity of money circulation at the M2 level in the Chinese market from FY2012 to 202112 quarters as the dependent variable, the size of digital payment transactions as the independent variable, and gross national product, inflation rate and opportunity cost of money as control variables. In terms of model selection, since the inflation rate and opportunity cost of money are monthly data, while the transaction size of digital payment and the circulation speed of money at the M2 level are quarterly data, the MIDAS series model is chosen to compare with the traditional OLS model, and it is found that MIDAS-PDL has the best fitting effect and prediction accuracy. Through the empirical results of the MIDAS-PDL model, we find that for the Chinese market, digital payments have a significant positive effect on the velocity of money circulation, in addition, inflation has a significant positive effect on the velocity of money circulation, while the opportunity cost of money has a significant negative effect on the velocity of money circulation.

Key words：M2, Digital payment, Opportunity cost, Inflation, MIDAS_PDL

1. Introduction

The history of the development of money, from the very beginning of the barter exchange system, payment methods have accompanied the spirit of society as well as economic development and innovation in science and technology, going through the main stages of physical, metal, and paper money. With the advancement of science and technology and the advent of the electronic information age, payment methods have taken on a new paradigm, gradually moving towards electronic and virtualization, forming a payment method based on digital payments. This can be considered a complete innovation, a major paradigm shift in the way payments are made from physical to virtual digital. Compared with traditional physical currency, digital payments use digital currency, which has several most intuitive advantages, the first is the convenience associated with its use, as well as no need to change, recharge transfer than traditional currency transactions, while also being much more convenient. This is coupled with the fact that multiple merchants currently support and favor digital payments, and that digital payments also promote online shopping; secondly, transactions are fast and digital payment transactions are basically instant; and finally, it is less risky, as it avoids the risk of carrying large amounts of banknotes as well as the risk of counterfeit currency, plus each transaction has a record of the transfer, so incoming and outgoing funds are well documented and safe.

Digital payments are currently the trend, and the consensus of governments to encourage and promote the development of digital payments, which have grown rapidly in China in recent years and have been integrated into every aspect of people's lives, is already the norm. In China, consumers can pay their utility bills online, city buses support mobile phone payments, VIPs in various shops are bundled with mobile phones, and even roadside vendors support QR codes for payment. In short, you can pay digitally when you go out to take a taxi, shop, eat, or stay in a hotel. Digital payments not only improve the efficiency of life, but also increase the consumer's enjoyment. For vendors, shops, and businesses, digital payments reduce the risk of counterfeit and bad currency, reduce the hassle of cash handling and save costs. Moreover, transaction records exist for each digital payment, making it easy for companies to reconcile their accounts and improve their daily work efficiency. The development of digital payments has thus also led to the emergence of new business models in society. For example, the sharing economy, which is currently the most popular, has developed along with the popularity of digital payments. For the government, digital payments can save some social payment costs, promote the development of related industries, and through digital payments big data can also quickly and accurately grasp the relevant economic development. The state also has its own internet procurement system, which makes it easier and more transparent, and digital payments also reduce the cost of printing banknotes, which saves some money.

The development of digital payments will be the dominant trend of the future in every sense of the word and will further penetrate our lives, gradually taking the place of cash. Digital payments use electronic money, which is more liquid than cash, and transactions can be completed quickly across time and distance, plus they often have a yield that makes people prefer to hold electronic money rather than cash. The rapid development of digital payments will have a major impact on the traditional money market and will have a major impact on the speed of money circulation.

The current development of information technology can be described as rapid, while financial innovations are also numerous. Various forms of electronic money have emerged, and payment methods are slowly changing from traditional paper money transactions to digital payments. As digital payments have many intuitive advantages over traditional payment methods, such as convenience, speed, and efficiency, the trend towards replacing traditional paper money transactions is arguably irreversible. This digital payment method, which combines the latest electronic information technology with mobile smart devices, will revolutionize consumers' payment habits and lifestyles.

At the same time, however, its development will inevitably affect the traditional payment system and thus the money market. A number of questions arise that need to be examined and resolved, such as: how far will digital payments replace traditional payments? How secure are digital payments? Are there limits to the amount of money that can be paid digitally? How do digital payments affect the money supply? Can digital payments be counterproductive to central bank monetary policy? ...... and more. This paper focuses on the impact of digital payments on the speed of money circulation, using the Chinese money market as a sample. In general, in China, the central bank regulates the money market in three main ways: (i) through open market operations; (ii) adjusting the discount rate; and (iii) changing the legal reserve ratio. With the emergence of digital payment methods, the long-standing monopoly of banks in the field of currency issuance and payment has been gradually broken, and economic agents are gradually changing their habits of storing and using money. Agents can also easily spend their future wealth through third party digital payment companies. Instead of people's monetary assets simply flowing around banks, they are beginning to make personal payments and store their money through third-party digital payment companies. This has caused the core position of traditional banks in the money market to be shaken to some extent, and the money supply system is slowly being affected by the addition of a new player to the money market - third party digital payment companies - which has caused some changes to the money supply model in the money market. The level of digital payments in China is at the forefront of financial development in the world, but its historical development is actually relatively short. A number of third-party payment companies, such as Ali Alipay and Tencent Pay, were established as early as 2005, but their early development was extremely slow. It was not until 2011 that the Central Bank officially issued the first batch of electronic payment licenses, while digital payments only took over the market rapidly in 2013 and 2014 with the introduction of QR codes, which is a typical example of the scale and development of digital payments in China for studying the impact of digital branches on the speed of money circulation.

Some scholars argue that the issuance of electronic money and the emergence of new digital payment methods have broken the long-standing monopoly of banks in the field of currency issuance and payment, especially the replacement of electronic money for cash in circulation, which has a certain impact on the circulation of money and money supply. From a theoretical point of view, in addition to the traditional factors influencing the money supply, the element of digital payment is added to explore how digital payment affects the money multiplier and thus the money supply through its impact on cash in circulation; some scholars also believe that the electronic money associated with digital payment remains within the banking system, only changing the form of the existence of money in circulation, reducing the transformation of money from deposits to cash. However, digital payment has major advantages, such as strong liquidity, low transaction costs, and convenient transaction, which has led to a substitution effect and accelerated transformation effect on traditional money. The corresponding impact on monetary policy transmission mechanism and monetary policy transmission effect cannot be ignored.

This paper explores the role of digital payments on the speed of money circulation using the Chinese money market as a model. It examines whether traditional monetary policy and theories of money supply and demand are applicable in the context of digital payments and whether they need to be supplemented. This article not only conducts a qualitative study on the relationship between digital payments and the speed of money circulation, but also uses an empirical approach to explore the impact of the role between digital payments and the speed of money circulation. The practical significance of this paper's research is that in today's rapidly developing network economy, the formulation and implementation of monetary policy have become more complex, and the supply of money cannot be entirely determined by the subjective will of the monetary authorities.

This paper is organized as follows: section 2 reviews the more recent academic literature on this academic topic; section 3 presents the models used in this paper, section 4 presents the data used in the analysis of this paper, section 5presents the analysis results of models such as Mixed Frequency Data Sampling Regression, section 6 presents the conclusions obtained from the modeling analysis of this paper, and section 7 presents the discussion and policy recommendations for the analysis conclusions.

2. Literature Review

In 1997, the Bank of Japan held a forum on "Digital Payment Technology Development" and in the report, the following definition of digital payment was given: “Digital payment means refers to the use of information and communication technologies such as digital keys, networks and IC cards to make payments. It includes stored value products and channel products” (Kobrin Stephen J, 1997， p70). This definition basically covers the various ways of transferring funds under modern ICT. The Bank for International Settlements (BIS, 2003) classifies digital payment systems into retail payment systems and wholesale payment systems. The wholesale payment system is mainly for processing large amounts of money or for transferring funds in tight time, which is commonly used among banks; the retail payment is mainly for small amounts or for consumer payments without strict time requirements.

The definition of digital currency is also defined as: "Digital currency refers to stored value or prepaid products owned by consumers that store funds or monetary value, including prepaid cards (sometimes called digital wallets) and prepaid software products that can be accessed through computer networks (sometimes called digital cash). Such digital currencies are distinct from channel products that allow consumers to access traditional payment services through digital means of communication" (Heinrich Gregor, 2003: P701. Digital payments essentially use the act of payment as a starting point for interpreting digital currencies from a different perspective. Humphrey (2001) views digital payments as a way to transact money with the help of digital media, and electronic media would include the Internet and other digital means to pay bills directly through the banking system without having to go to the bank to receive cash.

Ksenija, Anita, and Irena (2014) have developed a model for internet banking in EU countries by building a multiple regression models, based on the empirical results they focus on calling out that the monetary sector should focus on internet financial risks and on the risks posed by third-party digital payment companies' own irregularities. Raden and Budi (2017) investigate the positive impact of mobile payments on consumers through a theoretical analysis. Theoretical analysis examines the positive impact of mobile payments on consumers and argues that digital payments will change people's payment habits, as the integration of wallets and mobile phones will make people's lives more convenient and reduce the use of cash as mobile phones become an essential tool for people on the go. The integration of wallets and mobile phones will make people's lives more convenient and reduce the use of cash.

The velocity of money circulation has long been a classic object of study in economics and has been studied by many domestic and foreign experts and scholars throughout the ages. The British classical political economist William D. Deeds (1664) first proposed the velocity of money circulation function, and he believed that the distribution of wealth, policy guidance, the scale and frequency of payments and the effectiveness of the banking system all affect the velocity of money circulation, thus pointing out that there is an inverse relationship between the velocity of money circulation and the money supply. The neoclassical scholar Irving Fisher (1911) proposed that the degree of financial development, population density, etc. would affect the velocity of money circulation, and proposed the transaction equation $MV = PT$, where M represents the total amount of money in circulation in a certain period; V represents the velocity of money circulation; P represents the average price of goods traded in society; and T represents the total amount of goods and services traded in society. The British economist Pegu (1917) proposed the Cambridge equation: Md = K*P*Y, where Md represents the demand for money, K represents the ratio of cash to nominal income, P represents the price level in the period, and Y represents the real income of the population.

Among the modern scholars, Bord and Jonung (1981) found that the U-shaped distribution characterizes the velocity of money circulation by examining past data, and the authors argue that this U-shaped distribution has a correlation with institutional changes. Hugo (2006) argues that the increasing abundance of means of payment reduces the correlation between the velocity of money circulation and inflation, and that endogenous changes in the velocity of money circulation can lead to an imbalance between the price level and the money supply. If the speed of money circulation is slow for a long time, the increase in the money supply will cause a general increase in prices, so monetary authorities should keep the money circulation speed relatively stable.

Priyatama and Apriansah (2010) use the actual cash balance method to study the relationship between local digital payments and correlation between the velocity of money circulation. They argue that with the development of digital payments, digital money will have an impact on previous cash demand function and reduce people's willingness to hold cash, and that the use of digital payments. The use of digital payments will thus increase the speed of money circulation.

Yu (2012) analyze the impact of digital payment on money demand from Fisher equation theory, Keynesian money demand theory, and Friedman demand theory, respectively, and although no empirical analysis is conducted, the conclusions derived from the formula are basically in line with expectations.

Carroll (2013) further classifies the multiple payment methods in society by using this to develop a general equilibrium model to study the impact of digital stored value cards on monetary policy. He argues that digital stored value cards are a form of payment for customers and a form of financing for issuers and based on related. He argues that digital stored value cards are a form of payment for customers and a form of financing for issuers. Thus, the liquidity of the currency depends not only on the central bank's interference with the currency, but also on the factors related to digital payment stored value cards issued by the private sector. The liquidity of the currency depends not only on the central bank's disruption of the currency, but also on the factors related to digital payment cards issued by the private sector.

Zhao (2014) first analyzes monetary policy in terms of the broad concept of Internet finance, and then analyzes the possible impact on the velocity of money circulation, using digital payments as an example. The article only analyzes the impact of the velocity of circulation of broad money, and although it concludes that the velocity will decrease, it lacks arguments for cash and narrow money. However, the impact on the circulation speed of cash and narrow money may be different from that of broad money because the low-cost nature and high efficiency of digital payments may contribute to a faster circulation speed of cash, although this hypothesis needs to be further tested.

In recent years, with the continuous development of digital payments in China, more and more scholars have begun to study the relationship between digital payments and currency circulation. By constructing a co-integration model between the third-party payment growth rate variable and the velocity of money circulation, Lu (2015) found that there is a long-term influence relationship between the two and it is positive. Li and Zhang (2015) use co-integration model and Granger causality test and impulse response function in VAR model to study that third-party internet payment would cause the speed of money circulation at all levels to accelerate, as the degree of monetization and financial modernization of China's economy would be inhibited, so the government should increase the supervision of the third-party payment industry and strictly prevent the risk problems of the third-party payment industry. Liu (2017) argues that the development of third-party Internet payments has a transformative effect on the monetary hierarchy and a substitution effect on cash and demand deposits, which in turn affects the money supply at each level and ultimately affects the velocity of money circulation calculated based on the Fisher equation. The acceleration effect is even stronger for V0 and V1 and finds that there is no significant change in the velocity of money circulation before and after the central bank strengthened its regulation of third-party payments in 2010. Fang and Guo (2017) consider the influence of the virtual economy when calculating the velocity of money circulation, using the total market value of stock market circulation to represent the market value of the capital market and the GDP to represent the output of the real economy. By building a TVP-VAR model, the analysis concludes that the Internet payment index increases the velocity of broad money circulation. Tao and Zou (2017) establish the VEC to explore the impact of the scale of third-party internet payments, and the model results show that in the short term it speeds up the velocity of cash circulation and the velocity of narrow money circulation and slows down the velocity of broad money circulation, and in the long term the opposite is true.

Digital payment constitutes a novelty of recent years, and all sectors are very concerned about it. At present, research in the field of digital payments mainly includes technical research, business models, customers' willingness to use, and risk regulation, and there are not many empirical studies on digital payment, and most of the empirical analysis is based on the data of third-party Internet payment transactions, and there is a lack of exploration of digital payment. This paper summarizes the development status and research of digital payments, combining the theoretical analysis framework of previous authors, and making an empirical analysis using the latest and comprehensive data on digital payments in China. It further examines the impact of digital payments on the speed of money circulation from an economic perspective.

3. Methodology

3.1 Mixed Frequency Data Sampling Regression Models（MIDAS）

A large number of macroeconomic variables are not sampled at the same frequency. Some are sampled in quarterly frequency while others are released monthly (or even higher frequencies). For example, GDP data are sampled quarterly (and with substantial temporal delay), while a range of other leading and coincident indicators (employment, inflation, retail sales, housing starts) are released monthly. Interest rates and equity prices are available at daily frequencies. Given the availability of higher frequency data, we may want to construct a forecast of the current quarter data based on the higher frequency observations (this is known as nowcasting). In contrast, this paper hopes to model GDP (quarterly data), digital payment transaction size (quarterly data), inflation change rate (monthly data), and interest rate data (monthly data) with the velocity of money circulation (quarterly data) and achieve a prediction of the velocity of money circulation.

The traditional solution to this problem is to aggregate the higher frequency data in some fashion – either by taking the average, or the sum, or by using the last observation, thus converting them into lower-frequency observations in order to carry out the regression. However, there are some major inconveniences related to the use of these procedures, as these temporal aggregations quite often entail a loss of information. In addition, they may also modify the data-generating process so that the dynamics of the model can be rather different from that of the high frequency data. One way to address the mixed-frequency nature of the data is to use MIDAS models (Mixed Data and Sampling).

MIDAS fits a polynomial model to the higher-frequency data. This is a compromise between the two approaches: simple aggregation techniques (sum or average) which tend to place equal weights on each higher-frequency observation (i.e., averaging three monthly observations belonging to a specific quarter). Allowing for different coefficients for each high-frequency observation (i.e., each month within the quarter has a different coefficient). The problem with this method is that the number of estimated coefficients tends to be quite large. And MIDAS offers a compromise between these two approaches by allowing for non-equal weights between observations, but by also reducing the number of coefficients required to estimate. This is achieved by fitting a (exogenously chosen) distributed lag model as a weighting function.

The model under consideration is given as follows:

$$Y_t^L = \sum_{i=1}^{q} \beta_i W_{t-i}^L + \lambda f\left(\gamma, X_{j,t}^H\right) + \varepsilon_t \tag{1}$$

where,

Y_t^L-- is the dependent variable sampled at low frequency

W_t^L-- is the set of regressors sampled at the same (low) frequency as the regressand (possibly including lags of *Y*)

$X_{j,t}^H$-- is the set of regressors sampled at a higher frequency

β_i, λ, and γ – are the parameters to be estimated

f () – is a function translating the higher frequency data into the low frequency

3.1.2 MIDAS with Almon (PDL) Weighting

MIDAS regression shares some features with distributed lag models. In particular, one parametrization used is the **Almon lag weighting** (also known as PDL weighting), which is widely used in autoregressive models. The weighting scheme can be written as follows:

$$Y_t^L = \sum_{i=1}^{q} \beta_i W_{t-i}^L + \sum_{i=1}^{p} \gamma_i \sum_{j=0}^{k} j^{i-1} X_{t-j}^H + u_t \tag{2}$$

where,

- *k* -- is the chosen number of lags (which may be longer or shorter than *m*)
- *p* – is the order of the polynomial

- Notice that the number of coefficients to be estimated depends on the polynomial order ***(p)*** and not on the number of lags *(k)* chosen.

3.1.3 MIDAS with Step Weighting

Perhaps the simplest weighting scheme is a step function, where the distributed lag pattern is approximated by a number of discrete steps. The **Step weighting** can be written as:

$$Y_t^L = \sum_{i=1}^{q} \beta_i W_{t-i}^L + \sum_{j=0}^{k} \phi_{t-j} X_{t-j}^H + u_t \tag{3}$$

where, $\phi_j = \gamma_k$

- k – is a number of lags (k may be longer or shorter than m)
- $k = \frac{j}{\eta}$ and η is the number of steps.

Step-weighing lowers the number of estimated coefficients since it restricts consecutive lags to have the same coefficient. For example, if k=12 and η=4, the first 4 lags have the same coefficient, the next four lags have the same coefficient and so on, all the way up to k=12

3.1.4 MIDAS with Unrestricted Weighting

When the difference in sampling frequencies between the regressed and the regressors is large, distributed lag functions are typically employed to model dynamics avoiding parameter proliferation. In macroeconomic applications, however, differences in sampling frequencies are often small. In such a case, it might not be necessary to employ distributed lag functions and parameters can be estimated by OLS. In essence, the **U-MIDAS** approach can be written as:

$$Y_t^L = \sum_{i=1}^{q} \beta_i W_{t-i}^L + \sum_{j=0}^{m-1} \gamma_{t-j} X_{t-j}^H + u_t \tag{4}$$

where we estimate a different slope coefficients for each high-frequency lag

3.2 ARMA Model

In a multiple linear regression model, the target variable (variable of interest) can be predicted by a linear combination of multiple predictor variables. In an autoregressive model, the target variable is predicted based on the combination of historical data of the target variable. The autoregression is a regression on the variables themselves. Thus, an autoregressive model of order p can be expressed as follows:

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \varepsilon_t \tag{5}$$

Here ε_t is white noise. This is equivalent to replacing the predictor variable with a multiple regression of the historical values of the target variable. This model is called the AR(p) model (p-order autoregressive model).

Unlike regressions that use the historical values of predictor variables, moving average models use historical forecast errors to build a regression-like model.

$$y_t = c + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-q} \tag{6}$$

The ε_t in the above equation is white noise. This model is the MA(q) model, i.e., the q-order moving average model, which is not really a linear model in the general sense. When combining differential and autoregressive models and moving average models, an ARIMA model is obtained. ARIMA stands for AutoRegressive Integrated Moving Average. (Here Integrated means the inverse of Difference.) The ARIMA model is represented as follows:

$$y'_t = c + \phi_1 y'_{t-1} + \cdots + \phi_p y'_{t-p} + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q} + \varepsilon_t \tag{7}$$

In the above equation y'_t is the difference series (it may be differenced several times). The ‘predictor variables’ on the right-hand side include the delayed value of yt and the error of the delay.

3.3 Prediction accuracy

When selecting a model, one can speak of dividing the available data into two parts, a training dataset for estimating arbitrary parameters in the prediction method and a test dataset for assessing the prediction accuracy. Since the training dataset is not used to determine the prediction model, it reliably tests the prediction accuracy of the model for new data. For the measurement of prediction accuracy, the following centralized methods are generally used.

$$If\colon\ e_{T+h} = y_{T+h} - \hat{y}_{T+h|T} \tag{8}$$

$\{y_1, \ldots, y_T\}$ is training dataset， $\{y_{T+1}, y_{T+2}, \ldots\}$ is test data.

(1) Mean absolute error

$$MAE = \mathrm{mean}(|e_t|) \tag{9}$$

(2) Root mean squared error

$$\mathrm{RMSE} = \sqrt{\mathrm{mean}(e_t^2)} \tag{10}$$

(3) Mean absolute percentage error

$$\mathrm{MAPE} = \mathrm{mean}\left(\frac{|y_t - \hat{y}_t|}{(y_t + \hat{y}_t)}\right) \tag{11}$$

4. Data

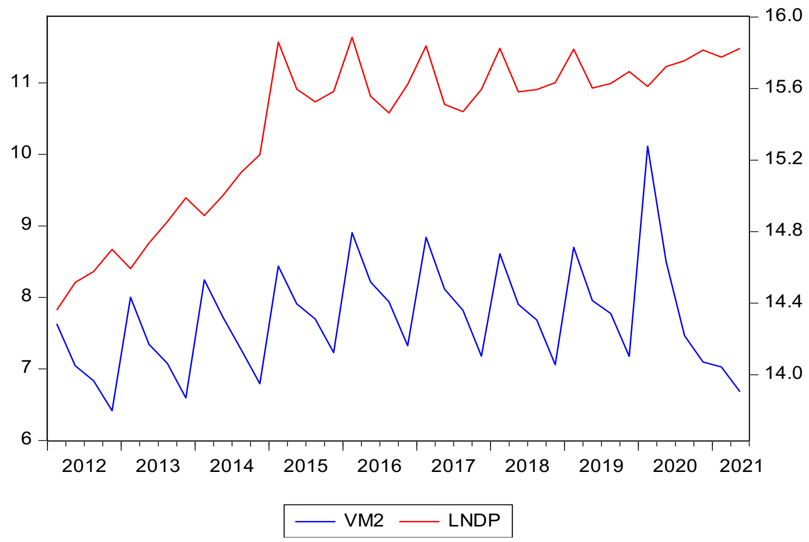
Herein, a specific dataset is used to study the impact of digital payments on the velocity of money in China. In this paper, we choose the ratio of M2 to GNP in China as the dependent variable, the transaction size of non-cash payments as the independent variable, and the inflation rate, GDP and opportunity cost of money as the control variables. The time interval for the above time series is from January 2012 to June 2021.

In this article, all data are obtained from Bloomberg and Wind Information [1]. The details are as follows.

Table1: Description of Variables

Category	Variables	Frequency	Description
Dependent Variables	VM2	Quarterly	Ratio of M2 and Chinese nominal output
Independent variables	LNDP	Quarterly	Value of ln function of Size of non-cash transactions
Control variables	LNGDP	Quarterly	Value of ln function of Chinese nominal output
	INFLAT	Monthly	Change of the CPI
	OC	Monthly	The difference between the interest rate on China's 10-year government bonds and the interest rate on monthly deposits

Garph1: The time series of VM2 and LNDP



As seen in Figure 1, both VM2 and LNDP are fluctuating upward, with LNDP having a very significant increase in 2014, while VM2 does not rise into 2021 as it did lead into the annual cycle but falls further.

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[1] Wind Information is recognized as the leading firm in financial data, information services and solutions in China. In China, more than 90% of the financial institutions including hedge funds, asset management firms, securities companies, insurance companies, banks, research institutions, and government regulatory bodies rely on Wind's services.

Table2: Summary description of Variables

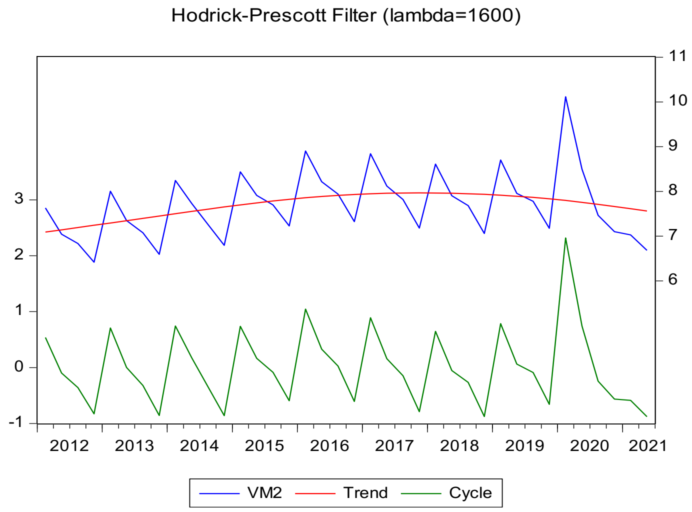
	VM2	LNDP	LNGDP	INFLAT	OC
Mean	7.69	15.39	12.16	2.11	3.09
Median	7.69	15.59	12.16	2.11	3.04
Maximum	10.11	15.89	12.60	4.97	4.13
Minimum	6.42	14.36	11.67	(0.03)	2.35
Std. Dev.	0.76	0.45	0.24	0.94	0.43
Skewness	0.81	(0.92)	(0.07)	0.59	0.59
Kurtosis	3.99	2.48	2.01	4.96	3.01
Jarque-Bera	5.71	5.79	1.56	8.29	2.21
Probability	**0.06**	**0.06**	0.46	**0.02**	0.33
Observations	38	38	38	38	38

As can be seen from Table II, a total of 38 data were selected for the variables in this paper, of which the distributions of VM2 and LNDP significantly conformed to a normal distribution at 10%, while Inflat significantly conformed to a normal distribution at 5%. For the next better selection of the fitted model, a total of 33 data observations from the first quarter of 2012 to the first quarter of 2020 are used as the estimated time interval, while a total of 5 data from the second quarter of 2020 to the second quarter of 2021 are used as the forecast interval in this paper.

Table 3: Time series stationary test (ADF) of variables

Series	Prob.	Lag	Max Lag
VM2	0.2781	8	9
LNDP	0.1861	0	9
LNGDP	0.9032	7	9
INFLAT	0.1521	4	9
OC	0.4952	0	9

Graph 2: HP-Filter of time series of VM2



From the results of the ADF-unit root test for each variable, each variable accepts the assumption of time series is stationary at 5%. And it can be seen through Figure 2 that VM2 can be decomposed into a periodic term and an upward trend.

5. Empirical Results

5.1 Regression Results

1. Trend Approach model

First, this paper performs a trend analysis of the independent variables and d time variable T is regressed.

Table 4: Regression results of trend approach model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.1656	0.2362	30.3369	0.0000
@TREND	0.0362	0.0127	2.8542	0.0076

When a time trend term is added to the model in this paper, it can be found that the coefficient of the time trend term is 0.0362, which is significant in the 1% case, but it is clear that this equation does not capture the trend of VM2 cycle change.

2. **OLS model**

Table 5: Regression results of OLS model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10.9204	5.4014	2.0218	0.0529
LNGDP	(3.0270)	0.6778	(4.4658)	0.0001
LNDP	2.1332	0.3600	5.9252	0.0000
MONTHLYDATA\OC	(0.0668)	0.2344	(0.2851)	0.7777
MONTHLYDATA\CPI	0.4381	0.1254	3.4926	0.0016

From the traditional OLS model (Table 5), the gross national product, the transaction size of digital payments, and the inflation rate all have a significant effect on the velocity of money circulation. The coefficient of digital payments is 2.1332, which means that a 1% increase in the size of digital payment transactions will increase the velocity of money circulation by 2.13. The coefficient of inflation rate is 0.4381, which means that a 1% increase in the inflation rate will increase the velocity of money circulation by 0.4381.

3. **MIDAS_U model**

Table6: Regression results of MIDAS_U model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.00381	7.779441	1.157385	0.2622
LNGDP	**-3.202263**	0.82878	-3.863826	0.0011
LNDP	**2.357819**	0.477018	4.942826	0.0001
MONTHLYDATA Series: OC Lags: 6				
LAG1	**-1.69513**	0.971974	-1.744006	0.0982
LAG2	1.387489	1.32077	1.050515	0.3074
LAG3	0.641963	1.22406	0.524454	0.6064
LAG4	-0.23065	1.182684	-0.195023	0.8476
LAG5	0.215771	1.412813	0.152724	0.8803
LAG6	-0.301021	0.920396	-0.327056	0.7474

MONTHLYDATA Series: CPI Lags: 6				
LAG1	0.17742	0.347276	0.510889	0.6156
LAG2	0.139864	0.314761	0.444351	0.6621
LAG3	0.009565	0.421638	0.022686	0.9822
LAG4	-0.147655	0.554452	-0.266308	0.793
LAG5	0.264367	0.316402	0.83554	0.4144
LAG6	0.124645	0.190446	0.65449	0.5211

From the model MIDAS_U, similarly, the digital payment transaction size has a significant positive effect on the velocity of money circulation, while opportunity cost has a significant negative effect on the velocity of money circulation. Specifically, when the transaction size of digital payments increases by 1%, the velocity of money circulation will increase by 2.3578. When the opportunity cost increases by 1%, the velocity of money circulation will decrease by 1.70.

4. MIDAS_Step model

Table7: Regression results of MIDAS_Step model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10.9204	5.4014	2.0218	0.0529
LNGDP	(3.0270)	0.6778	(4.4658)	0.0001
LNDP	2.1332	0.3600	5.9252	-
MONTHLYDATA Series: OC Lags: 3				
STEP01	(0.0223)	0.0781	(0.2851)	0.7777
MONTHLYDATA Series: CPI Lags: 3				
STEP01	0.1460	0.0418	3.4926	0.0016

From the model MIDAS Step, similarly, the digital payment transaction size has a significant positive effect on the velocity of money circulation, and the inflation rate has a significant positive effect on the velocity of money circulation.

Specifically, when the transaction size of digital payment increases by 1%, the velocity of money circulation will increase by 2.1332. When the inflation rate increases by 1%, the velocity of money circulation will increase by 0.146%.

5. **MIDAS_PDL model**

Table8: Regression results of MIDAS_PDL model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.5434	6.2220	1.5338	0.1382
LNGDP	(3.1405)	0.6829	(4.5986)	0.0001
LNDP	2.2832	0.3762	6.0684	-
MONTHLYDATA Series: OC Lags: 3				
PDL01	(5.5352)	2.7252	(2.0311)	0.0535
PDL02	5.0438	2.6097	1.9327	0.0652
PDL03	(0.9430)	0.5101	(1.8486)	0.0769
MONTHLYDATA Series: CPI Lags: 3				
PDL01	0.2679	0.3841	0.6973	0.4923
PDL02	(0.1307)	0.2641	(0.4949)	0.6252
PDL03	0.0183	0.0368	0.4958	0.6246

From the model MIDAS_PDL, again, the digital payment transaction size has a significant positive effect on the velocity of money circulation, while the opportunity cost has a significant negative effect on the velocity of money circulation at 10%. Specifically, when the transaction size of digital payment increases by 1%, the velocity of money circulation will increase by 2.2832. When the opportunity cost increases by 1%, the velocity of money circulation will decrease by 5.5352.

6. Model Summary

Table9 : Regression Summary

Model	Trend	OLS	MIDAS_U	MIDAS_STEP	MIDAS_PDL
VARIABLES	VM2	VM2	VM2	VM2	VM2
Trend	0.0362***				
	0.0127				
LNGDP		-3.027***	**-3.2023*** **	-3.027***	**-3.1405*** **
		0.6788	0.8288	0.6788	0.6829
LNDP		2.1332***	**2.3578*** **	2.1332***	**2.2832*** **
		0.3600	0.477	0.3600	0.3762
INFLAT		**0.4381*** **	0.2354	**0.1406*** **	0.2679
		0.1254	0.286	0.0418	0.3841
Lags of INFLAT			LAG1	LAG3	LAG6
OC		-0.0668	**-1.6951***	-0.0223	**-5.5352***
		0.2344	0.9883	0.0781	2.7252
Lags of OC			LAG1	LAG3	LAG4
Constant	7.1656***	10.9204*	9.0038	10.9204*	9.5434
	0.2362	5.4014	7.7794	5.4014	6.2220
R-Square	0.02081	0.6113	**0.7031**	0.6113	0.6931
Observations	33	33	33	33	33

*** p<0.01, ** p<0.05, * p<0.1

The above models show that the national product has a significant negative effect on the velocity of money circulation at 5%, mainly because the larger the national product is, the slower the velocity of money circulation will be. In addition, four of the models show that the transaction size of digital payments has a significant positive effect on the velocity of money circulation at 5%, with coefficients around 2. As for the effect of inflation rate and the opportunity cost on the circulation speed of money, although different models have different significant cases, the overall inflation rate has a significant positive effect on the circulation speed of money, mainly because the increase of inflation rate will lead to the increase of price, which will affect the total amount of money needed to be paid in economic activities and thus affect the circulation speed of money. The opportunity cost has a significant negative impact on the speed of money circulation, mainly because when the opportunity cost is higher, it means that money in the bank has a lower return, so there will be more money in the market, which in turn has a dampening effect on the speed of money circulation.

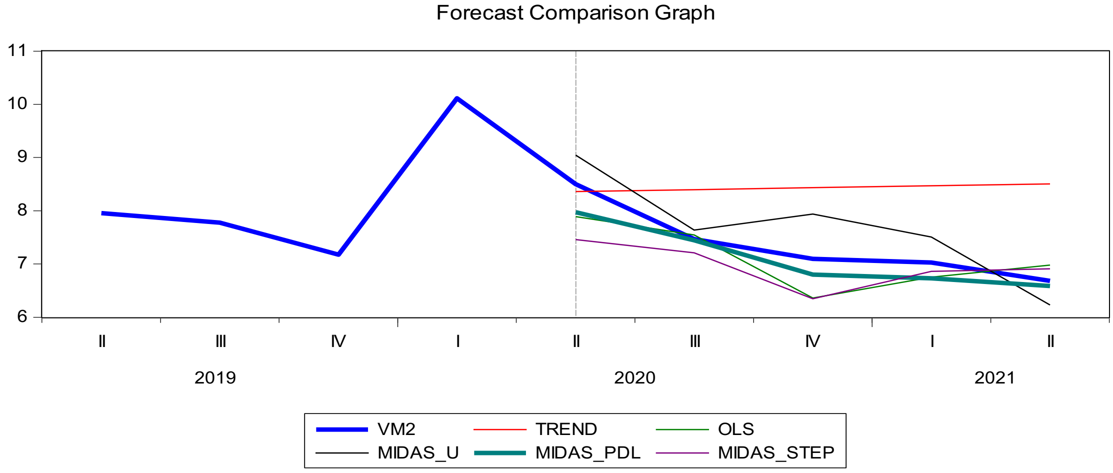
From the fit of the models, we can see that the R-squared of MIDAS_U is 0.7031 and MIDAS_PDL is 0.6931. The fit of these two models is significantly higher than the other models and can explain about 70% of the residuals in the regression equation, so this paper suggests that these two models should be chosen from the estimation effect.

5.3 Forecast Compare

Table 10: Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
TREND	1.2697	1.1332	16.1305	14.6287	0.0803	2.7813
OLS	0.4664	0.3997	5.3968	5.5603	0.0321	0.8190
MIDAS_U	0.5422	0.4985	6.8386	6.6649	0.0359	1.0516
MIDAS_PDL	**0.3058**	**0.2488**	**3.2833**	**3.3620**	**0.0211**	**0.4263**
MIDAS_STEP	0.5989	0.4890	6.4139	6.6984	0.0417	0.8007

Figure 3: Forecast Comparison Graph



As previously described, this paper uses the 1st quarter of 2012 to the 1st quarter of 2020 (with a total of 33 data observations) as the estimation interval, and the 2nd quarter of 2020 to the 2nd quarter of 2021 as the forecast interval. By comparing the prediction results of different models with the actual results, the difference in prediction accuracy between them. As can be seen in this paper, the MIDAS_PDL model has better results, both based on the difference between the forecast magnitude and the difference between the forecast proportions. It can also be seen in Figure 3 that the MIDAS_PDL model captures the declining trend in 2021 very well, with very little difference in fluctuations from the original data.

Combining the goodness of fit of the model and the prediction accuracy of the model at the time of prediction, this paper concludes that the MIDAS PDL model is the optimal fit model, which shows that the transaction size of digital payments has a significant positive effect on the circulation speed of money, which is also in line with the conception of the relationship between the circulation speed of money and digital payments at the beginning of this paper.

6. Discussion and Policy Recommendations

In recent years, the development of digital payment has been relatively rapid, and its monetary substitution and replacement effect on traditional money and accelerated substitution effect has gradually emerged. The development of digital payment has led to changes in the speed of money circulation by influencing the demand for money. The development of digital payment is a financial and electronic necessity, in line with financial consumers' wishes. The analysis of this paper shows that changes in the monetary hierarchy and the speed of money circulation in China has lead to changes in the actual ability of the Chinese Central Bank to control the money supply, which can further stimulate the effects of monetary policy. Therefore, in order to avoid the velocity of money circulation being affected by the development of broad-based e-money, which in turn affects the effectiveness of monetary policy, based on the empirical analysis in this paper, this paper attempts to make the following policy recommendations for the Chinese money market.

1. In order to avoid unanticipated impacts on the speed of money circulation due to the development of payment technologies such as bank card payments, online payments, and digital payments, Central Banks need to track and count the development process and scale of payment technologies such as electronic traditional money and mobile networks in a timely manner, and prospectively estimate their impact on money supply and demand and the speed of money circulation, and then consider the impact of electronic traditional money and mobile networks in their monetary policies. The impact of the development of payment technologies such as digital payment and mobile networks is then taken into account in monetary policy. In recent years, digital payment has grown rapidly, with a large volume and variety of types of money, and there is a lack of professional and detailed tracking data on it. This lack of data will make it difficult for monetary policy makers to comprehensively identify the problems faced by the Chinese economy and will make macroeconomic regulation and control appear to lack a basis. Therefore, it is recommended that the central bank should track and compile timely statistics on the development process and scale of electronic payment technologies such as traditional money and mobile networks, and regularly publish

detailed data on statistical indicators related to digital payment, so as to provide the necessary data basis for policy formulation.

2. digital payment regulation and a sounder digital payment risk monitoring system should be strengthened. Although China's digital payment development is very rapid, but the development process has encountered problems that cannot be ignored, the supervision of digital payment is still relatively weak, and the construction of digital payment risk monitoring system is relatively slow. While the development of electronic currency in Europe and the United States is more mature in the electronic currency regulation, but always adhere to the principle of prudence. China's financial market might be still slightly less mature, and the supervision of electronic payment needs to be further strengthened. Since the development of digital payment has facilitated financial consumer's lives and changed their payment habits, representing the development trend of financial electronics in China, we can neither still let it develop nor hinder its further development. Therefore, it is very necessary and urgent to strengthen the supervision of all aspects of digital payment issuance and payment settlements. In order to ensure the effectiveness of monetary policy and macro-controls, it is suggested that the relevant departments should strengthen the supervision of digital payment and establish a more sound risk monitoring system for e-money, so as to mitigate the negative impact of digital payment development on the Chinese market in a timely manner and make it develop in a more healthy direction.
3. To prevent possible liquidity risk of digital payment and to mitigate the substitution of broad-based e-money for currency and demand deposits, it is recommended that e-money issuers be required to withdraw a certain percentage of their legal reserve. In general, the excess reserve withdrawal will reduce the liquidity risk of e-money issuers and mitigate the impact of e-money on monetary policy and the velocity of money circulation. The legal reserve ratio will affect the issuance of e-money and the substitution of e-money for traditional money and may become one of the

monetary policy tools for national macro-control.

4. Strengthen the supervision of e-money issuers and payment institutions. The issuing body of e-money has not been limited to banks and other financial institutions. The overall strength and technical level of non-bank institutions are very different from banks. For example, the shopping card issued by a large retailer can only be spent in the same retail company nationwide, and the shopping card loses its value when it is separated from the retail company. Even credit cards issued by banks have no shortage of over-issuance and abuse, and credit cards have serious cash-out problems and high default risks. Therefore, if there is a lack of supervision of e-money issuers, it may pose a threat to the whole payment system. Although payment and settlement institutions are non-financial institutions, they have a great impact on the whole payment system and financial stability because they are engaged in the whole electronic payment field of fund payment and settlement business. Therefore, it is suggested that the number of e-money issuance should be limited to prevent the oversupply of e-money; the use of e-money can be expanded by uniting several e-money issuers to jointly launch stored-value e-money through an alliance; and the regulatory system of payment and settlement institutions should be formulated to regulate the process of payment and settlement and credit approval of e-money.
5. It is recommended to limit the amount of a single transaction of digital payment, and to limit the maximum stored value of digital payment in conjunction with the type of digital payment. At present, the technology of electronic payment, network payment and digital payment in China is not perfect enough, and money laundering through electronic currencies is liable to occur from time to time. In order to reduce the possible capital loss of electronic payment and prevent the unlawful elements from laundering money through electronic currency, it is necessary to limit the single transaction amount and stored value limit for different electronic currencies.
6. Strengthen the supervision of third-party Internet payment platforms. There are

currently some problems in China's third-party Internet payment industry, including vicious competition among enterprises, blind business expansion, and even misappropriation of settlement funds by some third-party Internet payment companies. In addition, some data show that Alipay and Tencent Pay have more than two-thirds of the market share of China's third-party Internet payment companies, and the third-party Internet payment industry tends to become a monopoly, which increases the ability of third-party Internet payment companies to influence the monetary system. In order to ensure the healthy development of the third-party Internet payment industry and the stability of the financial system, the third-party Internet payment industry (firms/enterprises) also needs some artificial regulation to assist in the market regulation, in order to promote the stability of China's financial and monetary systems.

6.1 Regulating the deposit and use of settlement funds of third-party Internet payment companies. Third-party Internet payment affects the degree of economic monetization and financial modernization by influencing the amount of money at different levels, which in turn affects the speed of money circulation. The Central Bank should stipulate that the funds of third-party Internet payment companies be placed in custodian institutions for easy supervision, and regulate the use of settlement funds by third-party Internet payment companies, so as to reduce the negative impact of third-party Internet payment on the speed of money circulation.

6.2 Improve the business approval system for third-party Internet payment companies. At present, Chinese third-party payment companies are no longer satisfied with small payments in e-commerce and have started to expand their business frantically, encroaching on the payment and settlement business of commercial banks. If third-party Internet payment companies are allowed to expand their business without implementing corresponding regulatory measures, it will certainly increase the fluctuation of the currency circulation rate, which in turn will have a negative impact on the financial and economic systems. Therefore, there is a need for the Central Bank and the Government to establish a sound regulatory rule and business approval system for third-party Internet payment companies.

6.3 Develop a diversified payment system and encourage large financial enterprises to participate in it. The explosive growth and business expansion of third-party Internet payments has posed a major threat to traditional payment systems and payment companies such as UnionPay. If left unchecked, third-party Internet payments could take control of the payments market, increasing the volatility of money flows and weakening the central bank's ability to control the financial system. Therefore, it is important to develop a diversified payment system, encourage large financial companies to enter the third-party Internet payment industry, and bring them all under the Central Bank's comprehensive monitoring system.

Although the development of information technology is particularly fast, it is important for theoretical researchers and policy makers to promote rational thinking at all times. The digital payment system should not only be planned rationally, but also in a gradual manner. The development of digital payment also has two sides, the development of digital payment in the convenience of financial consumers' lives, but also make the latter consumers' lives more proactive in the emergence of new problems. We have to avoid the reverse influence of digital payment development. Nowadays, what inconveniences many financial consumers is no longer the inconvenience and insecurity of stacks of cash in the wallet, but the inconvenience of stacks of cards in the wallet, the tedious memorization of various passwords, and the insecurity of network information.

7. Conclusion

This paper explores the impact of digital payments on the money market from the perspective of the impact of digital payments on the velocity of money circulation. By addressing the impact of digital payments on the velocity of money circulation, we first review the theories related to the velocity of money circulation, and then explore its specific impact through theoretical analysis and empirical methods such as constructing models with Chinese data.

The empirical results show that MIDAS-PDL has a good fitting effect and prediction accuracy for the research of digital payments and the velocity of money circulation at the M2 level. The results show that there is a significant accelerating effect of rapidly developing digital payments on the velocity of money circulation at the M2 level, a positive effect of inflation rate on the velocity of money circulation at the M2 level, and a negative effect of opportunity cost of money. From the theoretical point of view, with the increasing share of digital payments in monetary payments, a substitution effect on traditional money is derived, which is manifested in the following two aspects, namely substitution acceleration and substitution transformation utility, and these two different substitution methods bring about different effects on the monetary structure level and circulation speed. From the perspective of substitution acceleration effect, digital payment is a new type of payment method with unique advantages, which might prompt it to replace currency and thus further accelerate the circulation of money, i.e., increase the circulation speed of money. In terms of substitution and transformation effects, the development of digital payments allows for faster and deeper transformation between different levels of money. The new payment method related to digital payment transcends the limitation of time and space and brings about rapid transformation between different levels of money, and this rapid transformation further reduces the cost. In the current era of rapid development of the virtual economy, currencies located at higher levels can bring more benefits to people and are cheaper to hold, speeding up the circulation of money.

According to the above conclusions on the speed of currency circulation, this paper believes that the impact of digital payment on the currency market is also reflected in the following aspects: First, digital payment makes the boundaries of different caliber currencies blurred, and various Internet financial products accompanying with digital payment enable people to manage their money and annual capital more quickly and conveniently, and economic agents might even no longer keep their extra money in banks. They manage their funds through digital payment internet finance companies, and when they come to buy funds or financial products through these companies, they can turn their annual funds and financial products into liquid digital payments in a very short period of time. Even the ability to liquidate some fixed assets has been dramatically increased through Internet finance. As a result, digital payments have blurred the boundaries of the monetary hierarchy, making the original M0, M1, and M2 somewhat inaccurate as indicators of the country's monetary classification. Second, digital payments also affect the traditional role of banks to a certain extent. As digital payment makes people pay more attention to Internet finance and online banking, financial consumers are more enthusiastic about high interest rate products and reduce bank deposits, and both demand and time deposits of banks will decline, which, together with the rising status of digital payment in the field of payment, will affect the traditional functions of banks such as payment intermediation, financial services, and credit creation. Third, digital payments will also affect the central bank's monetary policy transmission mechanism. Since the digital payments used in digital payments can basically replace the cash channel in circulation, when the central bank conducts monetary control and implements monetary policy, such as open market operations or discounting policy to release money to the market, this part of money will be largely replaced by digital payments and eventually lower the effectiveness of monetary policy implementation. Coupled with the impact of digital payments on commercial banks, the effectiveness of monetary policy will be further disrupted. Fourth, digital payments will create more uncertainty about the money supply in the money market. For example, digital payments will release more illiquid money to increase the money supply, while the more digital payments do not go through the credit system of banks, the more the expansion effect of money will be reduced. The total money supply decreases again because more digital payments do not go through the banking system. Therefore, the different effects of digital payments on the money supply should be considered together.

References

Chingarande, A., (2012). The Impact of Interest Rates on Foreign Direct Investment: A Case Study of The Zimbabwean Economy (February 2009 – June 2011). *International Journal of Management Sciences and Business Research*,1(5), pp:1-24

Arewa, A. & Nwakanma, P. C. (2013). Money Supply and Velocity of Money in Nigeria: A Test of Polak Model. Journal of Management and Sustainability, Vol, 3. No,

Raden Agoeng Bhimasta., & Budi Suprapto. 2017. Exploring Consumer Decision-making Processes Regarding the Adoption of Mobile Payments: A Qualitative Study. Journal of Management and Marketing Review (JMMR), 2(3), 108-115.

Bordo M D, Jonung L.(1981).The long run behavior of the income velocity of money in five advanced countries, 1870-1975: an institutional approach[J]. Economic Inquiry, 19(1): 96-116.

Dumičić, K., Časni, A. Č., & Čibarić, I. (2008). Comparative analysis of bank concentration in selected South East European countries. Financial Systems Integration Of Balkan Countries In The European Financial System, 44.

Durgun, Ö., & Timur, M (2015). The Effects of Electronic Payments on Monetary Policies and Central Banks. Procedia - Social and Behavioral Sciences, 195, 680-685.

Fang Xing, Guo Zirui(2017)，Third-party Internet payments, money circulation speed and monetary policy effectiveness: a study based on TVP-VAR model. Exploration of Economic Issues, (3): 183-190

Humphrey, David B., Substitution of Noncash Payment Instruments for Cash in Europe. *Available at SSRN: https://ssrn.com/abstract=280658*Heinrich Gregor. CPSS Core Principles for Payment Systems. 2003.. *Mpra Paper*, 2003

Kobrin Stephen J(1997), Electronic cash and the end of national markets[J]. Foreign Policy,, 3（107）: 65-77.

Kamnar, N. P. (2014). The Use of Electronic Money and Its Impact on Monetary Policy. JCBEI, Vol, 1. No, 2.

Lardic, S and V. Mignon. (2008). Oil Prices and Economic Activity: An Asymmetric Cointegration Approach. *Energy Economics* (30), pp. 847 – 855.

Liu D (2017), Do third-party Internet payments speed up money circulation[J]. *Journal of Central University of Finance and Economics*, (2): 32-42

Lu Hua-Lan (2015）, Empirical analysis of the velocity of money circulation [J], *Statistics and Decision Making*, (8): 157-160

Popovska-Kamnar, N (2014). The use of electronic money and its impact on monetary policy. *Journal of Contemporary Economic and Business Issues*, 1(2), 79-92.

Prakash Ranjan, R., & Kar, R (2014). The Dynamics of Money Velocity, External Sectors and Electronic Transactions in India: Connecting dots using Empirical Approach. *Journal of Applied Economics and Business Research*, 4(3), 189-209.

Priyatama, Abednego and Apriansah, Apriansah (2010) Correlation Between Electronic Money And The Velocity Of Money. Global Management Conference.

Tao Shigui, Zou Yi (2017), The impact of third-party payments on the velocity of money circulation in China[J], *Monthly Journal of Finance and Accounting*, (36): 108-114

Tri Kartika, V., & Budi Nugroho, A., (2015). Analysis on Electronic Money Transactions on Velocity of Money in ASEAN-5 Countries. *Journal of Business and Management*, 4(9), 10081020.

Tule, M., & Oduh, M (2016). Financial innovations and the future of monetary policy in Nigeria. *Economics of Innovation & New Technology*, 26(5), 453-476.

Yu Xue (2012)， The impact of the development of electronic money on China's money supply and demand and empirical analysis.*Jimei University,MA thesis.*

Zhao Yongjun (2014), The current development of Internet finance and its impact on monetary policy. Dalian: Northeast University of Finance and Economics.

Ghysels, E., Santa-Clara, P., & Valkanov, R. (2004). The MIDAS touch: Mixed data sampling regression models.

Armesto, M. T., Engemann, K. M., & Owyang, M. T. (2010). Forecasting with mixed frequencies. Federal Reserve Bank of St. Louis Review, 92(6), 521-36.