THE LAGGED STRUCTURE OF DYNAMIC DEMAND FUNCTION FOR MORTGAGE LOANS IN RUSSIA[1]

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Abstract

Key issues of government policy include providing of affordable housing, identifying the main drivers of mortgage borrowing and performance of mortgage loans. Therefore the understanding of the mortgage borrowing problems, developing optimal credit contracts and effective risk management systems, especially on the residential mortgage market, are becoming crucial.

The paper presents the demand-supply model for the Russian residential mortgage market. It was estimated on the aggregated data for the period 2008-2012 and corrects for the autocorrelation and the endogeneity problems. The lagged decision-making process of borrower's application causes serial correlation of errors. Endogeneity is generated by simultaneity in borrower's and credit organization's decisions and its affection on demand and supply factors.

The study overviews current approaches in the mortgage literature to model credit demand and supply. Many papers are aimed to estimate the demand and supply functions for housing service, but not on the mortgages. Then Vector autoregression (VAR) approach was applied to estimate dynamic demand and supply model for the mortgage market and control for possible endogeneity in demand and supply factors. It helps to understand which supply and demand factors influence the client decision to participate in the mortgage debt market, how price on this market is determined, and to predict the demand for a mortgage loan of a particular credit organization. To relay on obtained results, the set of different tests were performed for each VAR model specification like the Lagrange multiplier test, tests for normality of residuals (the Jarque-Bera test, the Skewness and the Kurtosis tests) and stability of estimates.

Obtained results provide original insights into the determinants of borrowing process on the Russian residential mortgage market and allow predicting the probability of application for mortgage. Robust estimates of demand function evidenced that decision on application for mortgage loan is lagged. It means that the probability of application depends both on the current macroeconomic situation and its dynamics in previous time periods. In long run mortgage demand correlates positively with supply shocks and consumers' income and negatively with both prices of mortgage and property.

JEL Classification: C30, R21, R31

Keywords: mortgage market, demand, supply, endogeneity, VAR

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Introduction

Key issues of government policy include providing of affordable housing, identifying the main drivers of mortgage borrowing and performance of mortgage loans. Therefore the understanding of the mortgage borrowing problems, developing optimal credit contracts and effective risk management systems, especially on the residential mortgage market, are becoming crucial.

The initial step of mortgage-borrowing process is an application of borrower to a particular credit organization. A potential borrower realizes the necessity of borrowing, chooses a credit organization and a credit program that reflects her/his preferences, fills an application form with demographic and financial characteristics. The probability of application measures the demand on the mortgage market. Econometric estimation of this model is faced with inconsistency driven by serial autocorrelation and endogeneity.

The lagged decision-making process of borrower's application causes serial correlation of errors. Endogeneity is generated by simultaneity in borrower's and credit organization's decisions and its affection on demand and supply factors. This research is aimed to avoid these challenges and to consistently estimate the demand on the Russian residential mortgage market. It helps to understand which supply and demand factors influence the client decision to participate in the mortgage debt market, how price on this market is determined, and to predict the demand for a mortgage loan of a particular credit organization.

The rest of the paper is divided into four sections. It starts with the brief literature review. The second section describes our methodology and data, which are used to obtain consistent estimates of the demand for mortgage loans. The third and fourth sections discuss the results and robustness check. The final section concludes.

Literature review

The classical dynamic economic model that describes cyclical supply and demand in a market, where the amount produced must be chosen before prices are observed, is known as the cobweb model or cobweb theory. It was firstly introduced by Tinbergen (1930) and the cobweb theory proved by Ezekiel (1938).

The functions of demand and supply on the mortgage market are:

$$Y_t^D = a - bP_t \quad (1)$$

$$Y_t^S = -c + dP_{t-1} \quad (2)$$

where

t – the time period,

Y_t^D – the function of demand at the time period t,

Y_t^S – the function of supply at the time period t,

P_t – prices for the mortgage at the time period t,

P_{t-1} – prices for the mortgage at the time period $t-1$,

a, b, c, d – constant coefficients.

The supply on the mortgage market could be measured by different variables, for example, the numbers of mortgages and mortgage volume, which are offered to clients by credit organizations. In the same way, the number of applications for mortgage, the mortgage approval or denial rate, could characterize the demand on this market. When $|b| > |d|, b \neq 0, d \neq 0$, it can be shown that long-run market price moves to the market equilibrium.

Recent developments in macroeconomic and microeconomic theories stimulated the interest to study the demand and supply of household credit. Crook (2006) reviewed and compared results of studies that had examined the credit demand and supply across the countries. Studies which were aimed to explain inter-household differences in demand and the characteristics of the households that are most likely to be credit constrained showed considerable variation in the determinants of demand and in marginal effects within the countries as well as between them. Most of them have been published for Italy and the US markets.

Some papers on aggregated supply and demand on mortgage market, for example (Goetzmann et al., 2012; Xu, Zhang, 2012), take into account not only pricing factors, but other supply factors (loan-to-income ratio and loan-to-value ratio of issued loans) and demand factors (income per capita, unemployment rate, education rate, rate of retired residents) in order to control time and space variation.

Goetzmann et al. (2012) showed that demand (the number of mortgage applications and volume) should be included in supply equation (the mortgage approval rate) and vice versa to obtain efficient estimates. The approval rate was measured by both the percentage of loans and the percentage of applications that had been approved. In addition, they empirically found that both subprime borrowers and lenders considered past housing returns as a factor in a home purchase process and underwriting – perhaps extrapolating the recent past as a forecast of future home values.

Xu and Zhang (2012) analyzed the demand for nonlocal mortgages. They had shown that such demand factors as the share of out-of-state nonlocal mortgages issued should be modeled as endogenous because of their dependence on the supply (the denial mortgage rate). This paper provides evidence that the demand for nonlocal mortgages is higher in the neighborhoods where local banks tend more likely to deny mortgage applications, suggesting that borrowers of nonlocal mortgages are less creditworthy.

Magri (2002, 2007) found the statistical significance of households' socio-demographic characteristics such as age, current and future households' income, self-employment, education, residence in the demand for a loan in Italy. For example, the uncertainty of income reduces the demand for loans, except-self-employed workers, who are nevertheless subject to very rigid evaluation by lenders. Another evidence is that age plays a very important role, essentially in the demand side.

Cauley and Pavlov (2002) studied the demand function in housing market. Using the Los Angeles single-family dwellings data for 1985 - 1997, they founded strong evidence of lagged decision-making in house-buying process and necessity of using lagged explanatory variables to predict the demand response to demand shocks. The asymmetric response of real estate markets to positive and negative demand shocks could be partly explained by the option value of the owner's interest.

The causal relationships in the American housing market were studied by Clayton et al. (2010). The structure of causality in price-volume process in housing market was modeled by vector autoregression model (VAR) and tested by Granger test. It was shown that endogenous variables – home price and trading volume should be modeled jointly by system of dynamic simultaneous equations. Both variables are affected by the labor market conditions, the mortgage and stock markets, and the effects differ across the markets. Authors find empirical evidence that home prices Granger cause trading volume, but decreasing of price reduces trading volume, and price increases have no effect. Moreover, trading volume also Granger causes home prices, but only in markets with inelastic supply.

Empirical studies of Russian mortgage market are limited mostly due to the lack of statistics. Polterovich and Starkov (2007) discussed strategies of developing the mortgage market in Russia and presented the model calculations for the strategy of creating mass mortgage in Russia, based on the transplantation of modified construction and bank savings.

There is extensive literature on the demand and supply for housing service, but not on the mortgages. In this paper we follow VAR approach to estimate dynamic demand and supply model for the mortgage market and control for possible endogeneity in demand and supply factors.

Methodology and Data

To estimate demand on the mortgage market, the following structural model was used:

$$\begin{cases} D = f_1(S, D_f), \\ S = f_2(D, S_f). \end{cases} \quad (3)$$

where

D – demand function,

S – supply function,

D_f – demand factors,

S_f – supply factors.

The data set contains monthly aggregated regional data of the Agency of Home Mortgage Lending (AHML) branch performance, regional mortgage market characteristics and regional macroeconomic variables for 01/08/2008 – 31/08/2012. The data on mortgage market and macroeconomic variables is publicly available. The data on the AHML regional branch performance provided by itself and cannot be disclosed.

The AHML is state-owned provider of government-insured loans, which helps to implement government housing policy and to support mortgage lending in Russia. It uses two-level system of lending. On the first stage banks and non-credit organizations provide mortgage loans to households according to the common AHML standards. The second step is refinancing (redemption) of mortgage receivables by the AHML. The AHML develops special mortgage programs and refinances risks from its regional branches and commercial banks, which operate such programs. The list of programs contains "Young researchers", "Young teachers", "Mortgage for Soldiers", "Mothers' capital" and the other social and subprime programs. All of them have relatively high risk that is secured by the government.

The description of variables and summary statistics are presented in Table 1.

Table 1

Summary statistics

Variables	Description	Mean	Std. Dev.	Min	Max
prob	The amount of applications to AHML divided by the amount of households in the region	–	–	–	–
mean_LTV	Average Loan-to-value ratio (LTV) in the region, %	58.24	3.40	47.9	64.9
median_maturity	Median maturity for mortgage in the region, in months	201.64	12.7	173	222.2
median_rate	Median contract rate for mortgage in the region, %	13.1	0.82	12	14,3
mean_DTI	Average Debt-to-income ratio (DTI) in the region, %	34.81	0.7	33.44	36.68
lodging_coef_in_years	Housing price to income ratio, years	3.48	0.68	2.57	4.65
mortgage_amount	Total amount of issued mortgages in the region	896.57	528.89	134	2112

Demand on the mortgage market D is represented by the function for the probability of application, which is calculated as number of applications in month *t* divided by the amount of households. Amount of issued mortgages characterizes supply S on this market. The other variables can be divided into two groups: demand-side factors D_f that characterize consumer's willingness to borrow, and supply-side factors S_f that characterize bank's willingness to lend.

$$D_f = (mean\_DTI, lodging\_coef\_in\_years) \quad (4)$$

$$S_f = (mean\_LTV, median\_rate, median\_maturity) \quad (5)$$

It is essential to take into account that variables have time dimension *t*, in this paper we adopt a vector autoregressive model (VAR) (4) for the system of dynamic simultaneous equations for demand and supply (3).

$$Y_t^s = a_0^s + a_1 Y_{t-1} + a_2 Y_{t-2} + ... + a_m Y_{t-m} + b_1 X_{t-1} + b_2 X_{t-2} + ... + b_k X_{t-k} + e_t^s, s = 1,...,n$$
$$E(e_t \mid Y_{t-1}, Y_{t-2},...) = 0, \qquad (6)$$
$$E[e^s e^{s}{'}] = \Sigma, E[e^s e^{\tau}{'}] = 0 \text{ if } s \neq \tau$$

where

$t = 1,...,T, T$ – the set of time moments,

$Y_t = (Y_t^1,...,Y_t^n)$ – the vector of dependent variables at time t,

$Y_{t-1},...,Y_{t-m}$ – lagged values of dependent variables,

m – a maximum lag of dependent variables,

$a_0, a_1,..., a_m$ – constant coefficients,

$e_t = (e_t^1,...,e_t^n)$ – vector of error terms.

X_t – the vector of independent variables at time t,

$X_{t-1},..., X_{t-k}$ – lagged values of independent variables,

k – a maximum lag of independent variables,

$b_1,...,b_k$ – constant coefficients.

If the variables are non-stationary and are cointegrated in the same order, the correct method to estimate the VAR model is the VAR in first-differences with the addition of a vector of cointegrating residuals, which is called Vector Error Correction Model (VECM). The proper specification, considering possible non-stationarity and cointegration, will be tested by Johansen approach (Johansen, 1988).

Stability of VAR estimates requires that the moduli of the eigenvalues of the dynamic matrix to lie within the unit circle. As there is more than one lag in the VAR, it is likely that complex eigenvalues, leading to cycles, will be encountered.

The supply-demand relationship on the mortgage market and its determinants sometimes are ambiguous and there is ongoing debate in this area. To test causal relationship the Granger causality test was conducted. It allows determination whether one time series is useful in forecasting another (Granger, 1969).

Suppose we have the vector autoregressive model (VAR):

$$Y_t^s = a_0^s + a_1 Y_{t-1} + a_2 Y_{t-2} + ... + a_m Y_{t-m} + b_1 X_{t-1} + b_2 X_{t-2} + ... + b_k X_{t-k} + e_t^s, s = 1,...,n$$
$$E(e_t \mid Y_{t-1}, Y_{t-2},...) = 0 \qquad (7)$$
$$E[e^s e^{s}{'}] = \Sigma, E[e^s e^{\tau}{'}] = 0 \text{ if } s \neq \tau$$

where

$t = 1,...,T, T$ – the set of time moments,

Y_t – the vector of dependent variable at time t,

$Y_{t-1},...,Y_{t-m}$ – lagged values of dependent variable,

m – a maximum lag of Y,

$a_0, a_1, ..., a_m$ – constant coefficients,

e_t – the vector of error terms.

To test the null hypothesis that *X* does not Granger cause *Y*, we add in (7) lagged values of *X*.

$$Y_t = a_0 + a_1 Y_{t-1} + a_2 Y_{t-2} + ... + a_m Y_{t-m} + b_1 X_{t-1} + b_2 X_{t-2} + ... + b_k X_{t-k} + e_t \quad (8)$$

where

X_t – the vector of independent variable at time *t*,

$X_{t-1}, ..., X_{t-k}$ – lagged values of X,

k – lag of X,

$b_1, ..., b_k$ – constant coefficients.

In regression (8) we remain all the lagged values of *X* that are individually significant. If the *F*-test shows that lagged *X* collectively add explanatory power to the regression, then the null hypothesis that *X* does not Granger cause *Y* is not rejected.

In addition, the Granger causality test allows determining endogenous variables, which leads to inconsistent estimates of parameters in (3). In case of a functional relationship:

$$Y = f(X) \quad (9)$$

if *Y* Granger cause *X* is accepted, it means that *X* is endogenous variable in the equation (9) and is needed to be instrumented.

Results

On the first step endogenous and exogenous variables from supply S_f and demand D_f factors were determined. The results of the Granger causality test are presented in Tables 2 and 3.

Table 2

p-value for Tests of Granger Causality Based on VAR (supply factors S_f)

Dependent Variable	Probability of application	Mean LTV	Median rate	Median maturity	all
Probability of application	–	0.039	0.495	0.071	*0.010*
Mean LTV	*0.849*	–	0.004	0.138	0.017
Median rate	*0.849*	0.675	–	0.094	0.186
Median maturity	*0.146*	0.450	0.421	–	0.352

All supply factors do Granger cause the probability of application (*p*-value=0.010). The probability of application is statistically insignificant in specifications for all supply variables such as mean LTV, median rate and median maturity. The last result indicates that supply factors have to be exogenous in the model (3) for demand equation. In addition, this finding supports that supply factors can be used as instruments for demand estimation. In other words, covariance between supply factors and error term in the demand equation equals to zero.

From the demand side, mean DTI has to be exogenous in the model (3) for supply equation, while lodging coefficient in years – endogenous. It is confirmed by results of the Granger-Causality tests in Table 3.

Table 3

p–value for Tests of Granger-Causality Based on VAR (demand factors D_f)

Dependent Variable	Probability of application	Mean DTI	Lodging coefficient in years	all
Probability of application	–	0.004	0.072	*0.001*

DMean DTI	0.362	–	0.489	0.257
DLodging coefficient in years	*0.000*	*0.001*	–	0.000

Note: D – the first-difference.

Based on the above-mentioned results, the econometric model for demand is the following:

$$\begin{cases} D_t = f_1(D_{t-1},...,D_{t-m}, D^{end}_{f,t-1},...,D^{end}_{f,t-m}, D^{ex}_f, S^{ex}_f) \\ D^{end}_{f,t} = f_2(D_{t-1},...,D_{t-m}, D^{end}_{f,t-1},...,D^{end}_{f,t-m}, D^{ex}_f, S^{ex}_f) \end{cases} \quad (10)$$

where

D – demand on the mortgage market (the probability of application),

D^{end}_f – endogenous demand factors (first difference of lodging coefficient in years),

D^{ex}_f – exogenous demand factors (first difference of mean DTI),

S^{ex}_f – exogenous supply factors (mean LTV, median rate and first difference of median maturity),

m – a maximum lag of dependent variables.

Mean DTI, mean LTV, median rate and median maturity are the instruments for demand function because they are exogenous, according to the results of the Granger causality tests. However, demand is the function not only from demand factors, but from the supply ones too, which can be endogenous in the model (3). It is confirmed by results of the Granger causality tests in the Table 4.

Table 4

p–value for Tests of Granger Causality Based on VAR (supply S)

Dependent Variable	Probability of application	DLn mortgage amount	DLodging coefficient in years	all
Probability of application	–	0.276	0.037	0.132
DLn mortgage amount	0.164	–	0.000	0.000
DLodging coefficient in years	0.001	0.441	–	0.006

Note: D – the first-difference.

The first difference of lodging coefficient in years does Granger cause the first difference of the natural logarithm of mortgage amount. It means that supply influences the endogenous demand factor. This finding proves that supply is endogenous. The extended econometric model for demand should be the following:

$$\begin{cases} D_t = f_1(D_{t-1},...,D_{t-m}, D^{end}_{f,t-1},...,D^{end}_{f,t-m}, S_{t-1},...,S_{t-m}, D^{ex}_{f,t}, S^{ex}_{f,t}) \\ D^{end}_{f,t} = f_2(D_{t-1},...,D_{t-m}, D^{end}_{f,t-1},...,D^{end}_{f,t-m}, S_{t-1},...,S_{t-m}, D^{ex}_{f,t}, S^{ex}_{f,t}) \\ S_t = f_3(D_{t-1},...,D_{t-m}, D^{end}_{f,t-1},...,D^{end}_{f,t-m}, S_{t-1},...,S_{t-m}, D^{ex}_f, S^{ex}_f) \end{cases} \quad (11)$$

To check the stability of coefficients we follow Cauley and Pavlov (2002) and include lagged exogenous variables considering decision-making process on application as lagged. Thus, the model is the following:

$$\begin{cases} D_t = f_1(D_{t-1},...,D_{t-m}, D^{end}_{f,t-1},...,D^{end}_{f,t-m}, S_{t-1},...,S_{t-m}, D^{ex}_{f,t},...,D^{ex}_{f,t-k}, S^{ex}_{f,t},...,S^{ex}_{f,t-k}) \\ D^{end}_{f,t} = f_2(D_{t-1},...,D_{t-m}, D^{end}_{f,t-1},...,D^{end}_{f,t-m}, S_{t-1},...,S_{t-m}, D^{ex}_{f,t},...,D^{ex}_{f,t-k}, S^{ex}_{f,t},...,S^{ex}_{f,t-k}) \\ S_t = f_3(D_{t-1},...,D_{t-m}, D^{end}_{f,t-1},...,D^{end}_{f,t-m}, S_{t-1},...,S_{t-m}, D^{ex}_{f,t},...,D^{ex}_{f,t-k}, S^{ex}_{f,t},...,S^{ex}_{f,t-k}) \end{cases} \quad (12)$$

Estimated parameters of demand in models (10)–(12) are presented in columns (1)–(3) in Table 5, correspondingly. Standard errors of parameters are in parenthesis.

In all model specifications for the demand equation estimated coefficients remain the signs and statistical significance, but the third model has also significant coefficients behind lagged exogenous variables. However, in terms of adjusted R^2 and log likelihood, the model specification, which includes endogenous supply and lagged independent variables, fits data better. The demand on the residential Russian mortgage market is mostly determined by the demand in the previous period of time, the demand factors and the supply. From the demand side, the lagged probability of application (with lags equals to one and two) and Dlodging_coef_in_years$_{t-2}$ are highly statistically significant. Significant coefficients are also behind such exogenous variables as mean maturity (and its first lag) and mean LTV. These findings provide evidence for a lagged borrowing decision process and follow the results of Cauley and Pavlov (2002). Thus, a potential borrower makes a time lagged decision, which is based not on the macroeconomic situation in the current time period, but on its dynamics in previous periods.

Interpretation of signs of significant coefficients is strictly intuitive. Probability of application positively correlated with income (negative sign behind lodging coefficient and DTI ratio), negatively correlated with flat value (negative signs behind lodging coefficient and positive ones behind LTV), positively linked with extension of maturity and not affected by interest rate (the last two points jointly were revealed in numerous papers dedicated to analysis of credit constrained borrowers' demand for mortgage).

More clear interpretation of estimated VAR parameters can be shown by impulse response (IRF) and dynamic multiplier (DMF) functions for endogenous and exogenous variables respectively. With IRF and DMF it is possible to measure dynamic effects of change in endogenous variables, as well as the effects of change in endogenous variables by shocks in exogenous ones through the other endogenous variables. Thus, Fig.1 shows dynamic responses of mortgage demand to shocks in exogenous variables through DMF. Fig.2 demonstrates responses of demand to shocks in endogenous variables using orthogonal IRF.

Interpreting all the responses is similar to interpretation of coefficient signs, except for changes in rate. Thus, increase of mean DTI by one standard error gains the highest response of demand (up to a half of standard error of demand in each period, $\sigma_{prob} = 3\ .3$) . Along with negative response of demand to shock of lodging coefficient it gives strong evidence of positive correlation between demand and consumers' income. Supply shocks positively impact the demand which corresponds with the equilibrium theory.

Median rate variable has no significant influence on demand change directly. However, it influences the supply and as a consequence, the demand for mortgages. Long-run dynamics of demand change by shock of rate shows negative impact of rate increase on demand for mortgage. Along with negative response to shock of DTI and positive response to shock of maturity it gives evidence of negative correlation between demand and price-of-mortgage indicators. Positive responses of demand for mortgage to a shock of LTV reflect negative correlation between demand and price of property.

Table 5

Estimated parameters for the probability of application equation

	Model (1)	Model (2)	Model (3)
prob$_{t-1}$	0.754***	0.754***	0.488***
	(0.153)	(0.162)	(0.144)
prob$_{t-2}$	0.104	0.034	0.336**
	(0.166)	(0.177)	(0.153)
prob$_{t-3}$	–	–	0.085
			(0.144)
prob$_{t-4}$	0.013	0.018	0.048
	(0.132)	(0.127)	(0.115)
Dlodging_coef_in_years$_{t-1}$	31.223	45.984	–27.681
	(38.104)	(39.026)	(33.734)
Dlodging_coef_in_years$_{t-2}$	–57.841*	–103.802***	–74.464*

	Model (1)	Model (2)	Model (3)
	(31.660)	(38.703)	(39.282)
Dlodging_coef_in_years$_{t-3}$	–	–	58.698
			(42.227)
Dlodging_coef_in_years$_{t-4}$	–36.060	–11.087	–58.153*
	(35.949)	(37.202)	(33.305)
Dmean_dti	–9.183	–5.966	–7.984
	(7.696)	(7.859)	(6.449)
Dmean_dti$_{t-1}$	–	–	–19.352***
			(6.341)
mean_ltv	1.826	1.321	4.056***
	(1.530)	(1.543)	(1.439)
mean_ltv$_{t-1}$	–	–	–2.097
			(1.891)
mean_ltv$_{t-2}$	–	–	–0.452
			(1.517)
median_rate	–8.181	–8.274	8.529
	(5.917)	(5.780)	(6.893)
Dmedian_maturity	1.195	0.773	1.388*
	(0.944)	(0.975)	(0.720)
Dmedian_maturity$_{t-1}$	–	–	1.479**
			(0.698)
Dln_ma$_{t-1}$	–	–13.390*	0.373
		(7.376)	(7.632)
Dln_ma$_{t-2}$	–	–10.741	23.400***
		(6.933)	(7.265)
Dln_ma$_{t-3}$	–	–	15.524***
			(5.894)
Dln_ma$_{t-4}$	–	–0.578	–8.527
		(5.201)	(5.451)
Constant	3.875	37.191	–398.091***
	(65.650)	(65.911)	(132.815)
Log likelihood	–194.629	–192.772	–174.245
Adjusted R^2	0.615	0.646	0.845

Note: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

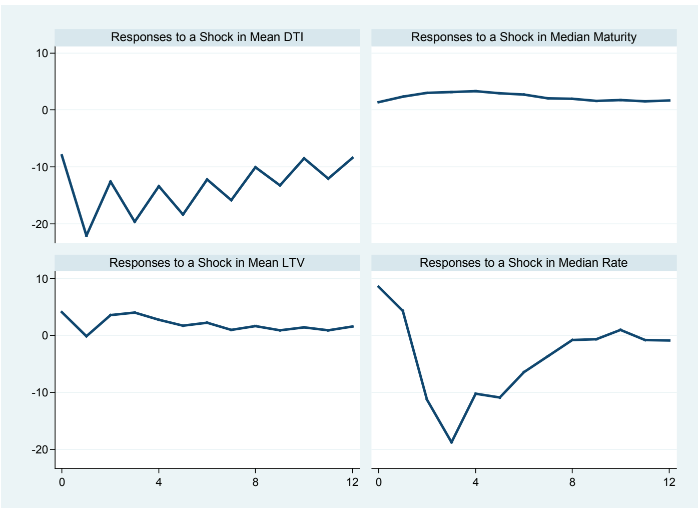

Fig.1. Responses of demand to shocks in endogenous variables

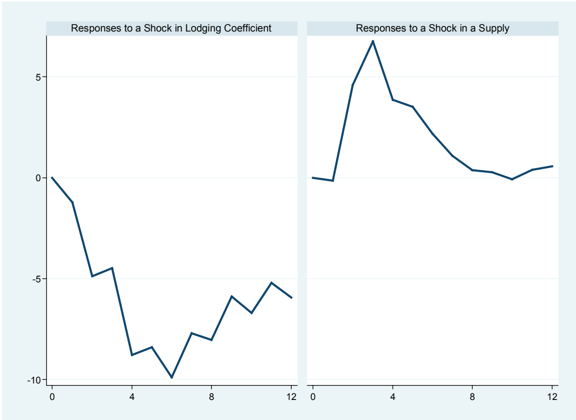

Fig.2. Responses of demand to shocks in exogenous variables

Robustness Checks

To relay on obtained results, the set of different tests were performed for each VAR model specification. Based on the statistical significance of lagged variables in the Wald test, variables with corresponding lags were used. Observation of all the VAR models revealed the absence of autocorrelation in error terms, the normal distribution of error terms, and the absence of unit roots. To this purpose the Lagrange multiplier test, the Jarque-Bera test, and the test of VAR estimates for stability condition were performed correspondingly. The results of these tests applied to the three specifications of application probability model are presented in Table 6–7.

Table 6

p–value for Tests of the Lagrange Multiplier Based on VAR models

lag	Model (1)	Model (2)	Model (3)
1	0.45668	0.22008	0.33127
2	0.38255	0.51196	0.87268

Table 7

p–value for Tests of the Jarque-Bera, the Skewness test, and the Kurtosis test Based on VAR models

Test	Model (1)	Model (2)	Model (3)
the Jarque-Bera test	0.29198	0.47653	0.46312
the Skewness test	0.27432	0.28061	0.27436
the Kurtosis test	0.32865	0.63413	0.62144

In addition, for all specifications of application probability model all the eigenvalues lie inside the unit circle, which is reported in Table 8. It means the absence of unit roots and that VAR models satisfy stability condition.

Table 8

Test for the unit roots on VAR for the Probability of Application

Model (1)			Model (2)			Model (3)		
Eigenvalue		Modulus	Eigenvalue		Modulus	Eigenvalue		Modulus
0.4703276	0.7342361i	0.871958	0.8962194		0.896219	0.964999		0.964999
0.4703276	–0.7342361i	0.871958	0.3845592	0.7185519i	0.814986	–0.942299		0.942299
–0.8580232		0.858023	0.3845592	–0.7185519i	0.814986	0.4287639	0.80291i	0.910022
–0.617194	0.4774606i	0.780319	–0.5251282	0.5179861i	0.73761	0.4287639	–0.80291i	0.910022
–0.617194	–0.4774606i	0.780319	–0.5251282	–0.5179861i	0.73761	0.6912427	0.39293i	0.795124
0.4804812	0.4765577i	0.676734	–0.6721792		0.672179	0.6912427	–0.39293i	0.795124
0.4804812	–0.4765577i	0.676734	0.6158586	0.1335075i	0.630164	–0.341006	0.52124i	0.622864
0.07134631	0.5604926i	0.565015	0.6158586	–0.1335075i	0.630164	–0.341006	–0.52124i	0.622864

0.07134631	−0.5604926i	0.565015	0.09614097	0.5665891i	0.574688	−0.408289		0.408289
−0.3016162	0.4701563i	0.558587	0.09614097	−0.5665891i	0.574688	0.3808256		0.380826
−0.3016162	−0.4701563i	0.558587	−0.04656162	0.1857423i	0.191489	0.0259851	0.36049i	0.361428
0.5292138		0.529214	−0.04656162	−0.1857423i	0.191489	0.0259851	−0.36049i	0.361428

The Johansen test for cointegration gives the evidence of no cointegration among the dependent variables, so the VAR in form of (9) is consistent and there is no necessity of VECM estimation.

Conclusion

This paper provides original insights into the determinants of borrowing process on the Russian residential mortgage market. Using monthly aggregated regional mortgage data for 2008-2012, we estimate the dynamic demand-supply model that allows predicting the probability of application. It controls possible endogeneity of demand and supply factors and autocorrelation in error disturbance process. Firstly, the results show that all supply side and demand side variables Granger cause the probability of application. Secondly, we empirically established that borrowing decision process is lagged. In other words, the probability of application depends both on the current macroeconomic situation and its dynamics in previous time periods. In long run mortgage demand correlates positively with supply shocks and consumers' income and negatively with both prices of mortgage and property. The further research may reveal how different demographic variables such as gender, age, education level, unemployment rate and etc. may affect demand and supply on the mortgage market. However, for this purpose micro-level or cross-regional aggregated data is required.

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