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Modelling of mortgage debt´s determinants: the case of the Czech Republic

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Abstract

This paper deals with the Czech household mortgage debt and its determinants in the 1Q2005 – 2Q2021 period. Our analysis focuses on variables determining the level of mortgage debt from short run and long run perspective. Our contribution is two-fold. First, we examine the relationship between selected variables within cross-correlation analysis. The results confirm positive dependency of household mortgage debt and real GDP, real gross average income and level of house prices. Contrary, negative relation was identified for real interest rates, unemployment rate and inflation rate. Second, we explore ARDL model and identify one cointegration relationship. Our results show that mortgage debt is positively affected by house prices in long run perspective. However, wider range of variables plays the role in short run, such as house prices, real gross average income, inflation and long-term interest rates.

AMS/JEL classification: C01, C22, G51

Keywords: Mortgage debt; Household debt; Cointegration; ARDL model

1. Introduction

During last decade, the mortgage market has gained relatively strong growth in the Czech Republic and in many European countries. The cumulative change of households´ mortgage debt between 2010 and 2020 reached 122% according to Czech National Bank (CNB) statistics. Low level of interest rates, easing of credit standards and upward trend of house prices have been considered as the main drivers of this rapid growth. CNB (2018) also emphasized that the enormous increase of credit for house purchases was faster than average income growth. The central bank considered this development as the potential risk for financial stability.

As a response, the CNB has activated macroprudential policy measures targeted at borrowers in order to reduce the increase of systemic risk associated with exposures secured by real estate (Fiala and Teplý, 2021; CNB, 2020). The measures activation has been explained in line with the development of macroeconomic and financial variables, which have been considered as the main drivers of growing demand for mortgages.

In the light of the global financial crisis (GFC) impacts on financial system and real economy, household indebtedness has started to be strictly observed as the leading indicator of potential risk for financial stability. The crisis showed that high level of household indebtedness can cause financial and economic

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imbalances. Large part of research activity has been focused on the role of credit in the economy and its impact on real economy and financial sector due to GFC negative consequences. The household debt has been examined in line with risk associated with mortgage debt because of link between the financial and real sector. Relatively less attention has been payed to the demand for credit, i.e. the factors determining the level of indebtedness and influencing households´ behaviour when making decision to draw the loans.

This article focuses on the determinants of the mortgage debt in the Czech Republic. The aim is to provide empirical evidence based on econometric analysis of selected variable (of macroeconomic and financial nature) determining the level of mortgage debt which makes up the majority of total household debt.

The reminder of the paper is as follows. The second chapter provides literature review with the main conclusions of research in the field of credit demand. Another part (3.1) presents examined datasets and used methodology. In chapter 3.2, we present the results of cross-correlation analysis. Another part (3.3) concludes econometric analysis based on the Autoregressive Distributed Lag model (ARDL) and error correction model (EC). The fourth chapter is dedicated to results and discussion. Finally, we discuss our main conclusions.

2. Literature review

The household indebtedness has already been analysed in different dimensions. In context of the GFC, the research has been focused on the debts´ impacts on economic growth (for example Mian and Sufi, 2010; Lombardi, 2017; or Alter et al., 2018). Furthermore, a certain part of research has examined the risk associated with the household indebtedness and financial crisis occurrence (for example Jorda et al., 2015 and 2016). As mentioned, relatively less research activity has been focused on the factors determining the households´ demand for credit, especially mortgage credit.

The key factors influencing the development of mortgage credit have been analysed by Kearl, Rosen and Smith (1974), who present the level of interest rates as the key demand factor. The interest rate increase is considered to affect the demand in negative way through the expectation channel. In line with this, the borrowers expecting the decline of interest rates lower their demand for loans in short run until the rates slump. Moreover, the negative effect of interest rate growth is explained by increase of debt service causing the decline of demand. This study, besides others, mentions house prices as another variable strongly affecting the level of mortgage debt.

Stockhammer and Wildauer (2018) present the empirical analysis of household debt determinants in 13 OECD countries. The results of research are based on testing the following hypotheses. The first one – housing boom hypothesis – deals with the house prices as the key driver of demand. The second hypothesis – low interest rate hypothesis – is aimed at the role of low level of the interest rates for future household indebtedness. Besides these two main hypotheses, the role of deregulation and the attitude of wealthy households to drawing the credit are discussed. The results confirmed the prices of residential real estates as the key variable determining the level of household indebtedness. House prices caused between 25 and 39 per cent of total 54 per cent of the debt growth. These finding are in line with other research, for example Borio (2012) or Bezemer et al. (2017). The research also proved level of interest rate as statistically significant variable due to the fact that the contribution to total household debt increase ranged between 2 and 14 per cent depending on the selected estimator.

Basten and Koch (2016) discuss the importance of the house prices as the debt determinant. The authors analyse this effect within causal effect analysis and emphasize the demand channel, i.e. higher house prices fuel the mortgage supply. The analysis is targeted at the Swiss market and the results,

however, confirm that the high level of house prices (i.e. high collaterals value) do not lead to higher effort of banking sector to easing of credit standards when granting the loans or lowering the interest rates.

Everaert et al. (2015) present the key role of house prices as well. The authors also present the growing demand for loans in line with the strong economic growth and low level of interest rates. Contrary, the model of demand is based on the total volume of granted loans, which does not reflect the differences between sectors drawing the loans. Very similar findings have been concluded by Philbrick and Gustafsson (2010) within the co-integration analysis in case of variables determining the indebtedness of Australian households. From the long run perspective, the debt is mostly affected by house prices (positive relationship) and interest rates (negative relationship). The authors clarify two ways of interest rates impact. The first one deals with the income effect, which explains the increase of incomes associated with higher returns of assets hold when the interest rates go up. The second one describes the role of substitutional effect resulting in lowering consumption in case of higher interest rates that scale up debt service.

Calza, Gartner and Sousa (2001) proved the negative relationship between interest rates and loans to private sector in Euro area (covering household debt and non-financial sector). The results confirmed negative relationship between the level of debt and short-term interest rate (3M interbank rate) and long-term interest rate (10Y government bond yields). The authors also pointed out the positive influence of real GDP. The role of real economic growth is explained in two opposite hypotheses. The first one assumes the positive impact of real GDP growth on the credit growth due to higher investment returns in economic expansion, which leads to credit growth financing the investments. The second hypothesis, on the other hand, assumes the negative relationship, which is explained by different behaviour of households and companies in expansion and recession periods. While the companies and households are more likely to use their incomes in the expansion phase of economic cycle, they replace the incomes by drawing the loans in the recession, which leads to higher demand for credit, i.e. countercyclical approach.

Jacobsen et al. (2004) also confirm the key role of house prices explaining the level of indebtedness. This result is based on the Norwegian household sector analysis. From the long-run perspective, the authors point out positive relationship between household debt and house prices, which is caused by wealth effect[2]. The higher demand for credit, i.e. growing indebtedness, is caused by increasing level of collateral prices and low level of interest rates. Very similar findings are presented by OECD (2017) or André (2016) in case of the house prices. Jacobsen et al. (2004) also highlight other variables influencing the debt development, such as wages growth (positive relationship) causing higher ability to service the debt payments. Otherwise, there is proved the negative relationship between the debt level and unemployment rate associated with lowering level of income and expectations of their uncertainty.

Davenport (2003) analyses factors influencing the demand for owner-occupied housing in the USA. The model confirms positive effect of income growth, which can serve as a proxy to demand for loans financing the housing needs. Contrary, increasing unemployment rate signals the lower affordability of housing through lower income levels.

Samad et al. (2020) explain the household debt development in 19 emerging economies within correlation analysis and panel regression analysis. The results of the correlation analysis prove the

[2] The wealth effect causes the growing demand for real estates, which are financed by loans. The increasing level of house prices leads to higher demand for credit due to households´ expectations of real estates as more valuable property (i.e. wealth).

negative relationship of household debt and unemployment and interest rates, whereas GDP per capita increase leads to growth of the debt level. On the other hand, panel regression shows different results in case of interest rates. The positive relationship between household debt and interest rates is explained in line with strong demand for loans and low consumers´ sensitivity to interest rates increase. Mian and Sufi (2008) emphasize that this causality can be explained by different borrowers´ creditworthiness. The creditworthy applicant can draw the loan with standard level of interest rate. On the other hand, the applicants with poor history, i.e. riskier borrowers, are more likely to get subprime mortgages with higher interest rates associated with higher risk premium.

Nieto (2007) presents demand factors analysis in the short and long run via Johansen methodology in case of Spain. The research proves the long-term positive relationship between household debt and real consumption and wealth and negative link to unemployment and costs of credit (negative). From short-run perspective, the demand for household debt is influenced by changes in unemployment and long-term interest rates.

With respect to the literature review, we are going to analyse how house prices, real GDP, real interest rates and level of average income influence the level of Czech household mortgage debt, i.e. how the demand for mortgage debt is affected by the development of these variables. The research is based on the following two hypotheses:

Hypothesis 1:

We assume a positive relationship between household mortgage debt and level of house prices, real GDP, inflation rate and level of gross average income.

Hypothesis 2:

We suppose a negative relationship between household mortgage debt and level of real interest rates and unemployment rate.

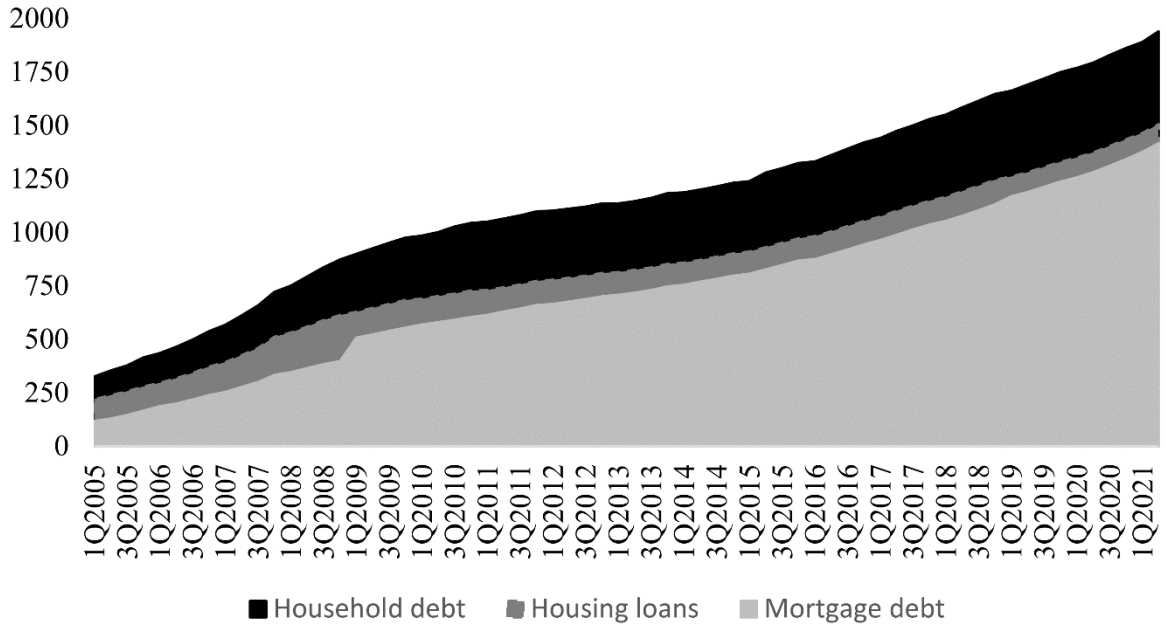
3. Empirical analysis

3.1. Data and methodology

This part provides detailed information about data and methodology of our research. As Figure 1 displays, the majority of the Czech household debt is made up by housing loans covering secured and unsecured debt. The figure also shows that large part of the household debt regards to mortgage debt, i.e. the outstanding of the mortgage loans granted to households.

From the perspective of our analysis, we aim to analyse the determinants of the mortgage debt because of two reasons. The first one is to capture the variables determining the major part of the household debt in the Czech Republic and the second one is to analyse only secured debt due to potential different household behaviour when drawing unsecured loans (especially consumer loans granting for other than house purchase purposes).

Figure 1: The household debt structure (CZK bln.)



Data source: Czech National Bank (2021)

We use data about real mortgage loans to household sector, real long-term interest rates, real GDP, real wages, inflation and house prices. Real mortgage loans are measured as logged quarterly averages of the outstanding amounts at the end of the month granted to household sector (seasonally adjusted and deflated by GDP deflator). Real long-term interest rates are given by quarterly averages of 10Y government bond yields deflated by GDP deflator. Real GDP and real wages are counted as logs of their nominal values on quarterly basis (deflated by GDP deflator and seasonally adjusted). Real wages are measured as logged quarterly averages of monthly gross wages presented by the Czech Statistical Office. Unemployment rate is given by logged quarterly averages from monthly data. House prices correspond to quarterly index of flats´ offered prices published by the Czech Statistical Office and transformed to logarithms. Inflation is given as harmonised index of consumer prices published by the Czech Statistical Office. The information about dataset used within the econometric analysis is summarized in the Table 1 and more detailed features about each variable are concluded in Table 2. The developments of the variables are presented in the Appendix 1.

Table 1: Information about dataset

Variable		Source	Time period and frequency
The volume of mortgage loans (CZK mil)	*LOANS*	Czech National Bank database	1Q2005 – 2Q2021; monthly
Inflation rate (level of consumer prices)	*HICP*	Czech Statistical Office	1Q2005 – 2Q2021; monthly
10Y government bond yields	*RIR*	Czech National Bank database	1Q2005 – 2Q2021; monthly
Average gross wage	*rWAGES*	Czech Statistical Office	1Q2005 – 2Q2021; quarterly
House prices	*HP*	Czech Statistical Office	1Q2005 – 2Q2021; quarterly
GDP	*rGDP*	Czech Statistical Office	1Q2005 – 2Q2021; quarterly
Unemployment	*UNEM*	Czech Statistical Office	1Q2005 – 2Q2021; monthly
GDP deflator	-	Czech Statistical Office	1Q2005 – 2Q2021; quarterly

Data source: Czech National Bank (2021), Czech Statistical Office (2021)

Table 2: Descriptive statistics of time series

Variable	House prices	Real mortgage loans	Real GDP	Real wages	Real interest rate	UNEM	HICP
Mean	110.95	706 703.2	1 096 536	25 819.51	2.55	5.26	2.10
Median	102.00	701 415.7	1 044 324	24 705.43	2.22	5.77	2.00
Maximum	175.10	134 8681.0	1 471 870	37 183.14	5.13	8.13	7.57
Minimum	65.80	116 615.8	744 899.4	16 808.93	0.30	1.93	0.13
Std. Dev.	28.58	341 049.3	185 556.2	4 998.31	1.46	1.99	1.56
Observations	66	66	66	66	66	66	66

Data source: Authorial computation based on Eviews

In the first step, we run cross-correlation analysis in order to test the relation between selected variables. Further, we test the stationarity (unit roots) of time series by using the Augumented Dickey-Fuller test (ADF) and Phillip-Peron test (PP) and observe the existence of cointegration between selected variables within Eagel - Granger cointegration test. Following these results, we build up the ARDL model and specify the long and short run relationships of tested variables by transformation to the error correction model. When specifying the long run relation, we use Eagel-Granger test and Bounds test. The robustness of the model is examined by following test of residuals: Jarque-Berra test (normality), Breusch-Godfrey (serial correlation) and Arch test (heteroscedasticity).

3.2. Cross-correlation analysis

As the first step, we run the cross-correlation analysis showing the dependency between analysed variables. Table 3 concludes the results of the analysis. All gained outcomes are significant on 1% confidence level (rejection the null hypothesis expecting no linear relationship).

Table 3: Cross-correlation analysis

	LOANS	HP	rGDP	RIR	UNEM	rWAGES	HICP
LOANS	**1.0**						
HP	0.92	**1.0**					
rGDP	0.96	0.97	**1.0**				
RIR	-0.76	-0.56	-0.70	**1.0**			
UNEM	-0.76	-0.88	-0.88	0.56	**1.0**		
rWAGES	0.98	0.96	0.98	-0.68	-0.81	**1.0**	
HICP	-0.08	0.15	0.04	0.31	-0.27	0.02	**1.0**

Data source: Authorial computation based on Eviews

The correlation coefficients show the negative relationship between mortgage debt and real interest rates. From the perspective of the strength of relationship, the coefficient (-0.76) shows relatively high degree of negative linear dependency. This can be explained by lowering the demand for loans as the reaction to higher price of loans, which is fuelled by growing interest rates or (and) by risk premiums. The negative relation was also proved in case of the unemployment rate. The correlation coefficient reached the same level, i.e. -0.76. Higher level of unemployment indicates the decrease of households´ income, which implies lower probability to repay the debt as a result of lowering households´ incomes.

In this context, the credit institutions are more prudent when granting the loans. The affordability of the household loans decreases. These results have been confirmed by other research mentioned in literature review (for example Davenport, 2003) and are also in line with the first hypothesis.

However, the negative relation has been proved for inflation rate (-0.08). This outcome is not in line with our hypothesis, which is based on the following assumption. In the environment of higher level of inflation, rational consumer is more willing to draw the loan due to decrease of the real value of the debt which is in line with the theory of time value of money. Moreover, the increasing inflation can be caused by the growth of nominal wages, which are the key parameter when households decide about the debt. On the other hand, the inflation rise is usually followed by the growth of central banks´ monetary policy interest rates causing the increase of loans interest rates. The total effect of inflation on the household (mortgage) debt therefore depends on the approach of central bank which is expected to tighten monetary policy if the prices tend to faster growth on the monetary policy horizon.

Contrary, the positive relationship has been identified for the rest of tested variables, i.e. house prices (0.92), real GDP (0.96) and real wages (0.98). The increase of real wages can be understood as the factor improving the probability to repay the debt. In this context, this signals higher affordability of the loan. Positive impact of growing house prices can be explained in line with wealth effect mentioned in literature review.

The role of real GDP has been also explained within other research presented in literature review. Calza, Gartner and Sousa (2001) prove positive impact of economic growth to level of credit as the result of higher investment returns. This hypothesis is based on the used dataset, which covers not only household debt but also debt of non-financial corporation. In our case, the positive influence of economic growth can be explained as follows. In the upward phase of economic cycle, households expect increase of their incomes and therefore they are more likely to draw the loans financing their needs (in our study we observe mortgages, so the needs are connected mostly with house purchase). This behaviour fuels the demand for loans financing real estates. Moreover, good times (economic growth) are mostly connected with lower level of unemployment and risk premiums (i.e. lower interest rates), which makes credit more accessible.

On the other hand, cross-correlation analysis does not take into account the long run and short run development. In order to examine the behaviour of mortgage debt in different perspectives, we examine the existence of cointegration between variables and build up the Autoregressive Distributed Lag (ARDL) model in the following part of this paper.

3.3. Cointegration analysis

The cointegration analysis is based on testing the following equation, which also shows the assumed relationship as we stated in the above-mentioned hypotheses.

$$LOANS = f(HP, rGDP, rWAGES, RIR, UNEM, HICP) \quad (1)$$

$$+ \quad + \quad + \quad - \quad - \quad +$$

First, we test the stationarity of time series via unit root tests (Augumented Dickey-Fuller test and Phillip-Peron test). In case of real wages, we used KPSS test in order to confirming the stationarity of the first difference due to different results of ADF and PP tests. PP test, however, indicated stationarity of HICP on 10% confidence level. We treat this variable as I(1) regarding to the statistical significance

of first difference on 1% level confidence level. The results are concluded in Table 4 and suggest that time series are integrated of order one (I(1)).

Table 4: The results of ADF and PP unit root tests

		HP	LOANS	rGDP	rWAGES	RIR	UNEM	HICP
Level	ADF p-value	0.94	0.99	0.86	0.99	0.77	0.53	0.19
	(t-statistic)	*(-0.13)*	*(0.74)*	*(0.96)*	*(0.93)*	*(-0.95)*	*(-1.49)*	*(-2.27)*
	PP p-value	0.99	0.99	0.86	0.99	0.74	0.60	0.07*
	(t-statistic)	*(0.57)*	*(0.63)*	*(-1.11)*	*(-0.31)*	*(-1.02)*	*(-1.35)*	*(-2.77)*
1st diff	ADF p-value	0.04**	0.00***	0.00***	0.69	0.00***	0.01**	0.00***
	(t-statistic)	*(-2.97)*	*(-7.51)*	*(-2.19)*	*(-1.14)*	*(-6.84)*	*(-3.68)*	*(-5.99)*
	PP p-value	0.04**	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
	(t-statistic)	*(-3.04)*	*(-7.57)*	*(-20.61)*	*(-21.79)*	*(-6.84)*	*(-3.79)*	*(-5.42)*
Order of integration		**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**

Data source: Authorial computation based on Eviews

Note: Null hypothesis: existence of unit root. ***, **, * indicate statistical significance at the 1%, 5% and 10% respectively.

In line with the objective of this article to test the long and short run relationship between observed variables, we use the ARDL model to test the presence of the cointegration, i.e. potential long-run relation. The ARDL model is expressed as equation 2. Further, this model is transformed to long run (cointegration) relationship (equation 3) and short-run relation (equation 4) following the results of cointegration tests which are provided below.

$$\begin{aligned}\Delta\ln(LOANS)_t = {} & \alpha_0 + \sum_{i=1}^{n}\alpha_{1,i}\Delta ln(LOANS)_{t-i} + \sum_{i=1}^{n}\alpha_{2,i}\Delta lnHP_{t-i} + \sum_{i=1}^{n}\alpha_{3,i}\Delta HICP_{t-i} \\ & + \sum_{i=1}^{n}\alpha_{4,i}\Delta lnrGDP_{t-i} + \sum_{i=1}^{n}\alpha_{5,i}\Delta lnrWAGES_{t-i} + \sum_{i=1}^{n}\alpha_{6,i}\Delta RIR_{t-i} \\ & + \sum_{i=1}^{n}\alpha_{7,i}\Delta lnUNEM_{t-i} + \Psi_1\ln(LOANS)_{t-1} + \Psi_2\ln(HP)_{t-1} + \Psi_3(HICP)_{t-1} \\ & + \Psi_4\ln(rGDP)_{t-1} + \Psi_5\ln(rWAGES)_{t-1} + \Psi_6(RIR)_{t-1} + \Psi_7\ln(UNEM)_{t-1} + \varepsilon_t\end{aligned} \tag{2}$$

where α and Ψ refer to long and short run parameters; ε is assumed to be IID.

$$\begin{aligned}\Delta\ln(LOANS)_t = {} & \gamma_1 + \sum_{i=1}^{n}\gamma_{1,i}\Delta ln(LOANS)_{t-i} + \sum_{i=1}^{n}\gamma_{12,i}\Delta lnHP_{t-i} + \sum_{i=1}^{n}\gamma_{13,i}\Delta HICP_{t-i} \\ & + \sum_{i=1}^{n}\gamma_{14,i}\Delta lnrGDP_{t-i} + \sum_{i=1}^{n}\gamma_{15,i}\Delta lnrWAGES_{t-i} + \sum_{i=1}^{n}\gamma_{16,i}\Delta RIR_{t-i} \\ & + \sum_{i=1}^{n}\gamma_{17,i}\Delta lnUNEM_{t-i} + \varepsilon_{2t}\end{aligned} \tag{3}$$

$$\Delta \ln(LOANS)_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1,i} \Delta ln(LOANS)_{t-i} + \sum_{i=1}^{n} \alpha_{2,i} \Delta lnHP_{t-i} + \sum_{i=1}^{n} \alpha_{3,i} \Delta HICP_{t-i} + \sum_{i=1}^{n} \alpha_{4,i} \Delta lnrGDP_{t-i} + \sum_{i=1}^{n} \alpha_{5,i} \Delta lnrWAGES_{t-i} + \sum_{i=1}^{n} \alpha_{6,i} \Delta RIR_{t-i} + \sum_{i=1}^{n} \alpha_{7,i} \Delta lnUNEM_{t-i} + \phi ECT_{t-1} + \varepsilon_{3t} \quad (4)$$

where Φ refers to coefficient of the error correction term (ECT_{t-1}). The error correction term can be written as follows (equation 5):

$$\mathrm{ECT}_{t-1} = \varepsilon_{2t} = \ln(LOANS)_t - \gamma_1 + \sum_{i=1}^{n} \gamma_{1,i} \Delta ln(LOANS)_{t-i} + \sum_{i=1}^{n} \gamma_{12,i} \Delta lnHP_{t-i} + \sum_{i=1}^{n} \gamma_{13,i} \Delta HICP_{t-i} + \sum_{i=1}^{n} \gamma_{14,i} \Delta lnrGDP_{t-i} + \sum_{i=1}^{n} \gamma_{15,i} \Delta lnrWAGES_{t-i} + \sum_{i=1}^{n} \gamma_{16,i} \Delta RIR_{t-i} + \sum_{i=1}^{n} \gamma_{17,i} \Delta lnUNEM_{t-i} \quad (5)$$

In this paper, the econometric model formally written by equations above (eqs. 3 – 5) refers to Model 1. In order to confirm the presence of cointegration relation (long run equilibrium), we run the cointegration Bounds test. The null hypothesis of this test is stated as follows: $\Phi_1 = \Phi_2 = \Phi_3 = \Phi_4 = \Phi_5 = \Phi_6 = \Phi_7 = 0$, i.e. no cointegration. In order to refuse the null hypothesis we need the F-statistic to be higher than upper Bounds critical value (F-stat > I(1) critical value). The results of the test are summarized in Table 3 in Appendix 2.

Although Eagel-Granger test indicates no cointegration between underlying variables for mortgage debt as the dependent variable (Table 2 in Appendix 2), the Bounds test confirm the presence of cointegrating relation on 1% confidence level. Therefore, we accept the results of the Bounds test indicating the long-term relationship. The estimates are concluded in Table 5 and Table 6. Other statistics regarding the models are concluded in tables in Appendix 2.

Table 5: ARDL models estimation – long run relationships

Variable	**Model 1**		**Model 2**		**Model 3**	
Long-run relationship	coefficients	t-stats	coefficients	t-stats	coefficients	t-stats
$\Delta \ln(HP)_{t-1}$	**1.613**	**3.299*** **	**1.238**	**2.904*** **	**1.669**	**3.135*** **
Δ $(HICP)_{t-1}$	-0.014	-0.887	-0.006	-0.391	-0.013	-0.845
$\Delta \ln(rGDP)_{t-1}$	0.424	0.773	-0.245	-0.616		
$\Delta \ln(UNEM)_{t-1}$	0.161	1.427	0.128	1.220		
$\Delta \ln(rWAGES)_{t-1}$	**-2.302**	**-2.155** **			**-3.027**	**-2.118** **
Δ $(RIR)_{t-1}$	0.009	0.317	-0.002	-0.079	0.013	0.435
C	**0.026**	**2.646** **	0.013	1.467	**0.032**	**2.418** **

Data source: Authorial computation based on Eviews

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% respectively.

Table 6: ARDL models estimation – short run relationships

Variable	Model 1		Model 2		Model 3	
Short-run relationship	coefficients	t-stats	coefficients	t-stats	coefficients	t-stats
$\Delta ln(LOANS)_{t-1}$	**-0.788**	**-6.563*** **	**-0.671**	**-5.714*** **	**-0.832**	**-6.533*** **
$\Delta ln(LOANS)_{t-2}$	**-0.294**	**-2.519** **	**-0.205**	**-1.781***	**-0.441**	**-2.735*** **
$\Delta ln(LOANS)_{t-3}$					-0.207	-1.439
$\Delta ln(LOANS)_{t-4}$					**-0.181**	**-1.956***
$\Delta ln(HP)_{t}$	**-0.428**	**-1.743***	-0.368	-1.461	**-0.452**	**-2.012***
$\Delta ln(HP)_{t-1}$	**-1.016**	**-3.608*** **	**-1.150**	**-4.666*** **	**-1.010**	**-3.081*** **
$\Delta ln(HP)_{t-2}$	**-0.596**	**-2.126** **			-0.397	-1.320
$\Delta ln(HP)_{t-3}$	0.264	1.296				
Δ $(HICP)_{t}$	0.003	0.723	0.005	1.232	-0.0001	-0.029
Δ $(HICP)_{t-1}$	-0.006	-1.337	**-0.011**	**-2.648** **	**-0.008**	**-1.758***
Δ $(HICP)_{t-2}$	**0.015**	**3.253*** **	**0.017**	**3.869*** **	**0.014**	**3.162*** **
Δ $(HICP)_{t-3}$			-0.006	-1.398		
$\Delta ln(rGDP)_{t}$	0.179	0.794	-0.109	-0.622		
$\Delta ln(UNEM)_{t}$	0.068	1.452	0.057	1.201		
Δ $(RIR)_{t}$	**0.025**	**2.675** **	**0.027**	**2.763*** **	**0.028**	**2.919*** **
$\Delta ln(rWAGES)_{t}$	**-0.459**	**-1.805***			-0.187	-0.902
$\Delta ln(rWAGES)_{t-1}$					0.171	0.898
$\Delta ln(rWAGES)_{t-2}$					**0.377**	**2.001***
ECM_{t-1}	**-0.421**	**-4.466*** **	**-0.445**	**-4.706*** **	**-0.391**	**-3.743*** **

Data source: Authorial computation based on Eviews

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% respectively.

The estimate of the Model 1 shows insignificance of certain parameter (both short and long run). Moreover, the Jarque-Berra test confirms that distribution of residual is not normal on 5% confidence level. Adjusted R squared of Model 1 reached relatively high level (approximately 69 %), however, the model does not take into account multicollinearity, which is visible from cross-correlation matrix. This problem was also checked via Variance inflation factor (VIF).

In order to eliminate above mentioned errors, we build up another two models. The estimates are also summarized in the tables in above. The second model does not use real wages as the exogenous variable. This variable was removed due to high degree of linear dependency with endogenous (dependent) variable, which has been confirmed within correlation analysis. Nevertheless, Model 2 also suffers some errors. The tests of residual indicate heteroscedasticity problem and also adjusted R squared reached lower level in comparison to the first model. The results of VIF still indicate presence of multicollinearity.

Following these outcomes, we explore the third model by reducing number of exogenous variables. Model 3 excludes real GDP and unemployment but in comparison to Model 2 real wages are included as exogenous variable. Figure 1 in Appendix 1 shows that real GDP and real wages go hand in hand in

the observed period which was also proved by correlation analysis. Removing one of these two variables as exogenous variable was therefore a step to reduce multicollinearity of model.

In the third model, we also do not take into account unemployment due to insignificance of the parameters of this variable in the first and second model. The tests of residuals produced by Model 3 confirmed their normal distribution, no serial correlation and presence of heteroscedasticity was refused. From the perspective of multicollinearity, house prices are the only variable with higher VIF value. On the other hand, our estimates confirmed that elimination of this variable would lead to worsening of the model (lower R squared, insignificance parameters, multicollinearity caused by other variables, negative impact on residuals). Thus, we consider house prices as important exogenous variable despite certain level of multicollinearity. Finally, Model 3 reached the highest value of adjusted R squared and lowest level of information criteria. Imposed residual tests also confirmed normal distribution, homoscedasticity and no serial correlation.

As mentioned above, all models indicate cointegration relationship of underlying variables. The results of our analysis are presented in line with Model 3 which has been built up by elimination of Model 1 and 2 errors. As the estimates in show, there is positive relationship between house prices and real mortgage debt in the long-run perspective, which is in line with the assumption in the first hypothesis. This parameter is significant on 1% confidence level that also corresponds to results of other research, such as Stockhammer and Wildauer (2018), Philbrick and Gustafsson (2010) or Jacobsen et al. (2004). Thus, growth of house prices leads to higher volume of loans which implies total mortgage debt increase. In addition, higher values of collateral may cause the debt more affordable. The negative relation in case of real wages we consider as statistical omission in spite of statistical significance of the parameter. Positive influence has been proved for example by Jacobsen et al. (2004) or Davenport (2003). With regard to statistical insignificance of the rest of variables within cointegration equation, we confirm house prices as the key variable determining the level household mortgage debt in the long run period.

From the short-run perspective, the estimated model shows that level of mortgage debt is determined by own lags of endogenous variable (LOANS), house prices, inflation rate, real interest rates and real wages. The short-term contribution of endogenous variable lags seems to be negative. This result may correspond to fact, that household with certain level of their debt cannot increase their indebtedness in short run. The causality can be described as follows. The growth of household indebtedness resulting from drawing mortgage loans determines certain level of total indebtedness. This debt usually serves to house purchase which indicates relatively high volume of these loans and its long-term maturity. In this context, growing mortgage debt implies limits to draw another loans caused by inability to cover increased debt service caused newly drawn loan and (or) increasing borrowers riskiness to repay their debt. On the other hand, Figure 1 shows relatively high year-on-year growth of total household debt in the Czech Republic (mostly determined by mortgage debt). Then, above mentioned causality will depend on the absorption capacity of newly issued debt by household sector.

Contrary to the long-term relation, there was identified positive contribution of real wages in the short-run perspective, which is in line with literature review and our assumption. With regard to real interest rates, there was confirmed relatively weak positive relation. This finding, however, does not correspond to our assumption and stated hypothesis. On the other hand, positive relation can be explained by households´ expectation about rise of interest rates in future, which leads to preference of drawing loans in short-term horizon.

From the short-run perspective, there was also confirmed weak positive contribution of inflation. As mentioned above, the rise of inflation rate can be caused by the growth of wages, i.e. households´ income, which makes mortgage loans more accessible. Moreover, increasing prices in the economy

(measured by inflation rate) implies restrictive monetary policy conducted by central bank targeting inflation. In line with this, rational households tend to increase their indebtedness in order to protect against inflation. Potential rise of interest rates caused by tightening monetary policy indirectly confirms positive relation of interest rates and real mortgage debt.

Despite positive contribution of house prices in long-term period, we identified negative relations between mortgage debt and level of house prices in short-run horizon. The rise of house price may reduce affordability of mortgage loans in short-term period, especially when the growth is higher than income increase. Higher prices determine the volume of loans with negative impact on granting new mortgages.

4. Results and Discussion

The main objective of this paper was to conduct the analysis of variables determining the level of household mortgage debt in the Czech Republic. Firstly, we run cross-correlation analysis, which confirm our two hypotheses. The correlation coefficients show the positive influence of the real GDP, house prices, and real wages. Contrary, the negative relationship is identified in case of long-term real interest rates, unemployment rate and level of inflation. The results of the correlation analysis show relatively high degree of the linear dependency (positive or negative). The opposite relationship has been obtained in case of inflation. This result may be caused by some weaknesses of the correlation analysis and potential different behaviour of household sector when making the decision about increasing their indebtedness and also country specific situation. Thus, we do not refuse stated hypotheses.

Secondly, we explore ARDL model in order to separate the long and short run relationship of underlying variables. We identify one cointegrating relationship determining the long run equilibrium. In the long run, the level of household mortgage debt seems to be determined by house prices (positive influence). Our findings confirm the results of mentioned research such as Stockhammer and Wildauer (2018), Basten and Koch (2016) or Philbrick and Gustafsson (2010). On the other hand, we identified negative relationship between level of debt and real wages. This outcome, nevertheless, we consider to be statistical misalignment in comparison to our opposite assumption and results of other research presented in literature review (for example Jacobsen et al., 2004; Davenport, 2003).

From the short-run perspective, the estimated model shows that level of mortgage debt is determined by own lags of endogenous variable, house prices real wages, real interest rates and level of inflation. In case of real wages, the results confirm the assumed relationship, i.e. positive. Real interest rates and inflation rate seem to contribute positively in short-term period, whereas house prices tend to affect mortgage debt negatively in short-run perspective. These findings are particularly different in comparison to cross-correlation analysis and our hypothesis. In this context, we particularly refuse the first hypothesis. Our model signals the opposite relationship between level of debt and interest rates and unemployment rate was excluded from exogenous variables. This outcome leads us to refuse the second hypothesis.

Nevertheless, our model can be scaled up by adding new exogenous variables, which would contribute to valuable results. For example, bank lending rates, number and volumes of newly issued loans or borrower-based measures may play important role when determining level of mortgage debt and can be implemented into model as dummy variables. Testing other variables as debt determinants are considered to be assumption to further research.

5. Conclusion

This paper focuses on the determinants of the Czech household mortgage debt. The main aim of our analysis is to examine the role of real GDP, house prices, real interest rates, inflation, unemployment and real wages and their impact on household mortgage debt. Our study is based on the correlation analysis and cointegration analysis. The contribution is two-fold.

First, we test two hypotheses about the expected relationship between observed variables within cross-correlation analysis. The results confirm negative dependency on interest rates, unemployment rate and also inflation. Contrary, real GDP, real wages and house prices contribute positively to the mortgage debt growth. The outcomes are in line with our hypotheses excluding the expected relation between debt and inflation.

Second, we examine the long run relationship of variables within cointegration analysis based on ARDL model and the results are further exploited to build up the EC model in order to divide the short- and long-term behaviour of mortgage debt. From the long-term perspective, the mortgage debt is determined by house prices which were confirmed to contribute positively. The short run deviation from the equilibrium state is caused by own lags of the endogenous variable, real wages, level of house prices, interest rates and inflation. Our estimates show different relationships in short- and long-term period in comparison to our assumption in tested hypotheses.

This analysis also provides the basis for further research, which can be based on other exogenous variables that would scale up the model. Testing more exogenous variables can bring valuable results about variables that are responsible for mortgage debt development. We suppose that mentioned macroprudential regulation may play significant role when determining level of mortgage debt. Moreover, conducting impulse response analysis would allow evaluation the impact of this regulation, which was very often discussed. In this context, our objective is therefore scale up our model in order to improve the outcomes of our research.

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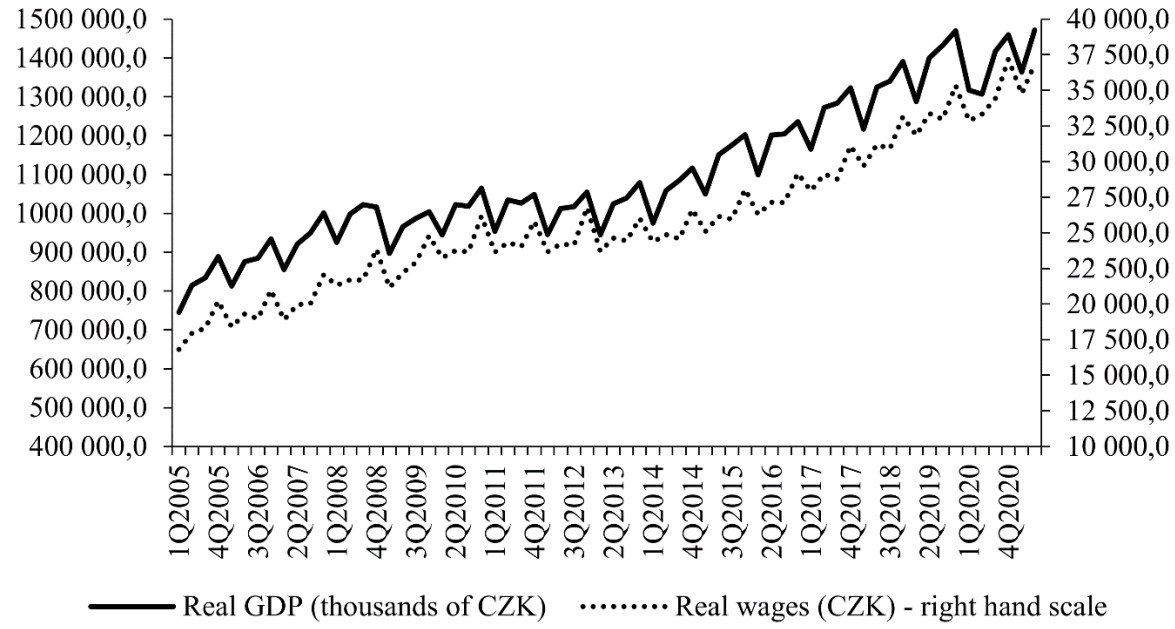
7. Appendices

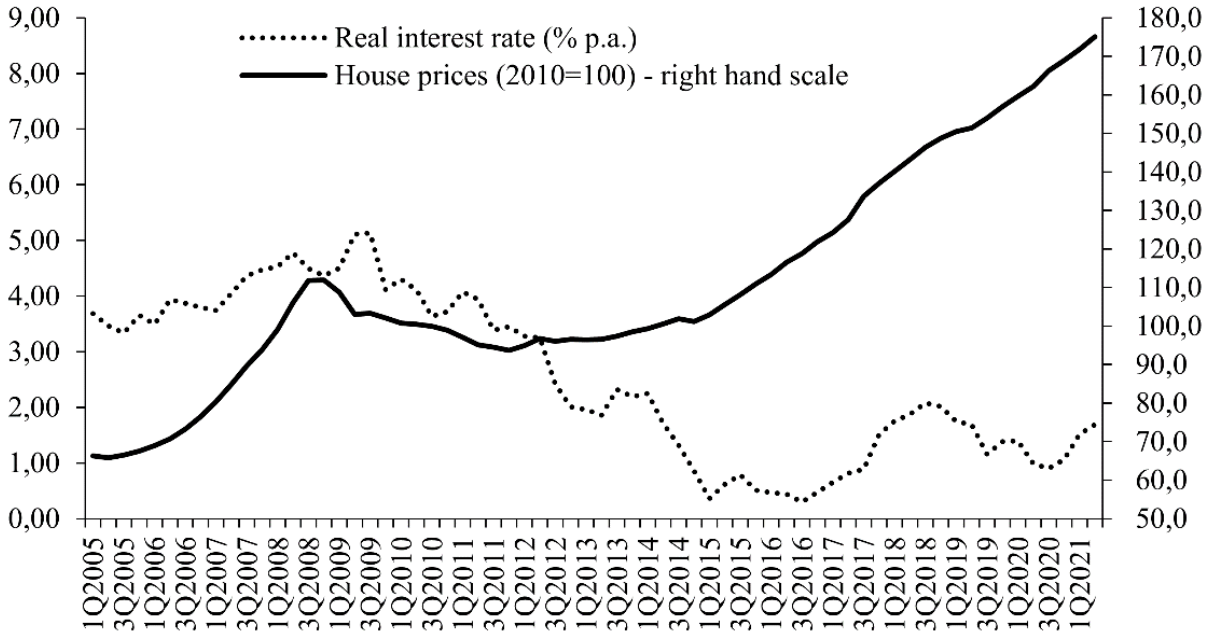
7.1. Appendix 1: Development of variables used within econometric analysis

Figure 2: The development of real GDP and real average gross wages



Data source: Czech Statistical Office (2021), authorial computation

Figure 3: The development of unemployment, real interest rate and house prices



Data source: Czech Statistical Office (2021), Czech National Bank (2021), authorial computation

7.2. Appendix 2: Estimates of ARDL models

Table 7: Descriptive statistics of estimated ARDL models

	Model 1	Model 2	Model 3
R^2	0.784	0.744	0.798
Adj R^2	0.692	0.658	0.702
S.E. of regression	0.018	0.019	0.018
Sum squared resid	0.014	0.017	0.013
F-statistic	8.490	8.711	8.299
Prob(F-statistic)	0.000	0.000	0.000
AIC	-4.901	-4.827	-4.939
SIC	-4.243	-4.273	-4.241
HQC	-4.643	-4.610	-4.666
DW stat	2.011	2.078	2.003

Data source: Authorial computation based on Eviews

Table 8: Eagel-Granger cointegration test

Dependent variable	Tau-stat	Prob.	Z-stat	Prob.
lnLOANS	-1.723	0.996	-8.598	0.992
lnHP	-2.662	0.933	-12.521	0.951
HICP	-2.937	0.871	-35.105	0.098
lnrGDP	-4.379	0.254	-30.624	0.221
lnUNEM	-1.996	0.991	-11.557	0.966
lnWAGES	-3.363	0.717	-18.424	0.768
RIR	-3.276	0.753	-17.323	0.814

Data source: Authorial computation based on Eviews

Table 9: Summary of Bounds test results

	Model 1	Model 2	Model 3
F - statistic	***4.74***	***4.52***	***5,76***
I(1) Bound critical value (10% significance)	3.23	3.35	3.52
I(1) Bound critical value (5% significance)	3.61	3.79	4.1
I(1) Bound critical value (2.5% significance)	3.99	***4.18***	4.49
I(1) Bound critical value (1% significance)	***4.43***	4.68	***5.6***

Data source: Authorial computation based on Eviews

Table 10: Summary of residual diagnostic tests

Test	Model 1 t-stat *(p-value)*	Model 2 t-stat *(p-value)*	Model 3 t-stat *(p-value)*
Jarque - Berra	8,40 *(0,015)*	3,88 *(0,143)*	3,03 *(0,220)*
Breush – Godfrey (LM test)	1,02 *(0,371)*	0,57 *(0,569)*	1,51 *(0,235)*
Arch test	0,382 *(0,539)*	7,925 *(0,007)*	0,02 (0,875)

Data source: Authorial computation based on Eviews

Note: Jarque-Berra test indicates the normality of residuals, Breush-Godfrey test is conducted for serial correlation of residuals and Arch test for testing the heteroscedasticity.

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