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The Case of Germany in 1950-2015

Konstantin A. Kholodilin and Julien Licheron

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Macroeconomic effects of rental housing regulations
The case of Germany in 1950–2015☆

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Abstract

Despite rather skeptical attitude of economists toward state intervention in housing markets, policy makers and the general public typically support it. As a result, since World War I, in many European countries the rent and eviction controls, as well as social housing policies, are an important element of governmental economic and social policies. Nevertheless, the macroeconomic effects of such regulations are largely unknown. In this paper, we evaluate the effects of governmental rental market regulations on real house prices, price-to-rent, and price-to-income ratios, real rents, as well as new housing construction in Germany from 1950 to 2015. The regulations are measured using indices developed by one of the authors based on a thorough analysis of the legal acts issued mostly by the central government, but also by the regional authorities between 1914 and 2015.

Keywords: Housing market; government regulations; Germany; housing prices and rents; new residential construction.

JEL classification: C22; O18; R38.

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1. Introduction

As a rule, economists are rather skeptical toward the state intervention in the housing markets,[1] policy makers and the general public typically support it. Consequently, since World War I, in many European countries both rent and eviction controls, as well as social housing policies, are an important element of governmental economic and social policies. Nevertheless, the macroeconomic effects of such regulations are largely unknown. In this paper, we evaluate the effects of governmental rental market regulations on real house prices, price-to-rent ratios, price-to-income ratios, real rents, and new housing construction at the national level in Germany from 1950 to 2015. The regulations are measured using indices developed by Kholodilin (2016) and based on a thorough analysis of the legal acts issued between 1914 and 2016 by the German central government. Some legal acts by regional authorities between 1970 and 2016 are also taken into account.

In particular, we consider four types of regulations: rent control, social housing policy, and housing rationing. The common objective of all these regulations is to guarantee the affordability of housing. While rent control and housing rationing focus mainly on the rental housing, the social housing policy can foster both tenant- and owner-occupied dwellings.

Unlike the USA, where rent and eviction controls are formulated at the municipal level,[2] in Germany the national government is responsible for determining the legal framework of rental market regulations. Identical eviction protection regulations and rent controls are valid across the whole country. In some cases, it is the up to the Länder and/or municipalities to implement the national regulations concerning stricter rent controls (for the regions with acute housing shortage) and housing rationing regulations.

There is a vast and diverse literature on rental market regulations. It considers mainly various effects of rent controls on the rents in controlled and non-controlled housing sectors; mobility (Munch and Svarer 2002 and Krol and Svorny 2005); quality (especially related to the maintenance; Kutty 1996 and Sims 2007) and quantity of rental housing; efficiency of housing allocation (Glaeser and Luttmer 2003); segregation (Giffinger 1998, Glaeser 2003, and Field

[1] For example, most American economists believe that rent control leads to both lower quantities and quality of housing supply; see Alston et al. (1992) and Jenkins (2009).

[2] See, for instance, Börsch-Supan (1994), p. 132.

et al. 2008), homelessness (Grimes and Chressanthis 1997 and Early and Olsen 1998), etc. There are much fewer studies considering other forms of the rental housing market regulations: for example, the effects of social housing on the consumption of housing (Le Blanc and Laferrère 2001), the effects of housing allowances on rents (Laferrère and Le Blanc 2004), and the effects of tenant protection on the housing supply (Iwata 2002).

Below, we review studies that suggest theoretical explanations about the impact that rental market regulations exert on housing rents, and new residential construction.

Housing prices. If one part of the housing market is controlled, then the excess demand will be channeled into the uncontrolled sector, where rents and prices will be much higher than if there was no control; Needleman (1965), p. 163. Fallis and Smith (1984) showed using a simple graphical model that uncontrolled rents are likely to be higher than the rents in the absence of controls. Similarly, Hubert (1993), using a theoretical model based on the assumption of indivisibility of dwellings points out that the initial effect of introducing rent control in times of an acute housing shortage is to put an upward pressure on rents in the non-regulated market. In the long run, since the aged tenants of controlled housing were locked in, they do not move to smaller dwellings when their children grow up and move out. As a result, the life-cycle reallocation of housing, which might lead to rent decreases, is prevented by rent control. Basu and Emerson (2000) develop a model of second-generation rent control, where the landlord may set the rent freely between contracts, but is restricted within an existing contract. This is a model of asymmetric information, where the tenant types are exogenously given. The model Basu and Emerson (2000) predicts that the removal of rent controls can lead to a general lowering of rents. Moreover, the rent and eviction controls exacerbate non-payment risks related to the tenants and, hence, landlords tend to set higher rents when former tenants move out in order to cover these risks. Thus, tenants face higher rents compared to the case of no rent control.

New dwellings supply. Even if rent control covers only existing housing stock and excepts newly built dwellings, developers still tend to be cautious in building new flats since they are worried about the possible expansion of rent control; see Downs (1988). One of implications of the Basu and Emerson (2000) model is that the supply of rental housing is likely to fall as a result of rent controls. Early and Phelps (1999) claim, however, that the that more time lapses

since the introduction of rent control the less, probable is the advent of the new controls. Thus, the incentives to new construction should recover. This must be a very long-run effect. Häckner and Nyberg (2000) argue that in the short run, the increase in aggregate income due to the lower controlled rents may lead to an increase of housing construction in less attractive areas. However, in the long run, as the low rents in unattractive areas would not cover construction costs, the incentives to build will be reduced.

The next section overviews studies on the macroeconomic effects of some housing market regulations. Section 3 discusses the autoregressive distributed lag model as a method used here to estimate the regulation effects. Section 4 describes the data used in this study. In section 5, the estimation results are discussed. It is shown that rent control, housing rationing, and social housing policies do affect prices, rents, housing affordability, rental yields, and residential construction both in the short and long run. Some of these effects are intuitive. For example, rent control depresses the housing prices, while social housing policies result in more new dwellings. Other effects are less obvious. For instance, housing rationing leads to higher rents. Finally, section 6 concludes.

2. Empirical studies on the macroeconomic effects of housing market regulations

There is a small but growing literature on the effects of housing market regulations. Turner and Malpezzi (2003) provide an overview of the literature on the effects of rent control published prior to 2003. The studies they cite relate to the microevidence of individual cities. The macroeconomic effects of this policy, however, remain, largely, uninvestigated. Vandenbussche et al. (2015) examine the consequences of the introduction of macroprudential policies in 16 Central and East European countries on housing prices. They apply a panel data model with error correction and find that some macroprudential measures (especially increases in minimum capital adequacy ratio) helped to cool down increases in house prices. Hilber and Vermeulen (2016) analyze the impact of land-use regulations on housing prices in England using a panel data model that regresses real house prices in 353 UK Local Planning Authorities (LPA) between 1974 and 2008 on a set of control demand-side variables and a refusal rate. The latter variable represents those residential projects consisting of 10 or more dwellings denied permission by an LPA. Strictly speaking it is rather a measure of enforcement of land-use regulations

and not the intensity of governmental interference. Hilber and Vermeulen (2016) find that the English planning system worsens the housing affordability problems and raises the volatility of house prices.

3. Methodology

The autoregressive distributed lag model (ARDL) is a workhorse of time series analysis; see Hassler and Wolters (2006). Its big advantage is that it can accommodate both stationary and non-stationary variables, thus permitting the estimation of a possible cointegration relationship. When cointegration is found, both short- and long-term effects can be estimated. When no cointegration is found, there is still the possibility of estimating long-term effects as shown below.

The autoregressive distributed lag model of order P and Q, ARDL(P, Q) is defined as follows:

$$\Delta y_t = \sum_{p=1}^{P} \alpha_p \Delta y_{t-p} + \sum_{k=1}^{K} \sum_{q=\underline{q}_k}^{Q_k} \beta_{qk} \Delta x_{k,t-q} + \varepsilon_t \tag{1}$$

where y_t is the dependent variable in levels; x_t is a K-dimensional column vector of explanatory variables in levels; ε_t is the zero mean error term; α and β's are parameters to estimate; and $\underline{q}_k$ is the minimum variable-specific lag.

Based on the ARDL model, the long-run effects of each explanatory variable, x_k, can be computed as follows:

$$LRE_{x_k} = \frac{\sum_{q=\underline{q}_k}^{Q} \beta_{qk}}{1 - \sum_{p=1}^{P} \alpha_p} \tag{2}$$

where β_{qk} is the k-th element of the parameter vector β_q.

4. Data

The variables used in this study and their sources are reported in Table 1. The real house price, price-to-rent, and price-to-income variables are available quarterly. Therefore, all other variables, whether with higher or lower frequency, were transformed to quarterly frequency.

The annual time series were interpolated using the Forsythe, Malcolm, and Moler spline.[3] The monthly series were sampled in the last month of each quarter in order to obtain the quarterly frequency. The new housing construction (the number of completed dwellings) is only available at the annual frequency. Thus, for regressions involving it as a dependent variable all covariates were aggregated to annual frequency.

The dependent variables are shown in Figures 1 and 2. The real housing prices are clearly cyclical: between 1970 and 2016, four cycles are visible; the latest beginning in 2010. Unlike many other European countries, German housing prices do not show an upward trend since 1970. Price-to-rent and price-to-income ratios are highly correlated and follow a downward trend between 1980 and 2010, then switching to a positive trend. Together with growing real prices, the increase in both ratios highlights a housing boom, which, however, still cannot be seen as a building up speculative price bubble as shown in Kholodilin et al. (2014). In contrast, the real rents, based on the rental price subindex[4] of the consumer price index grew between 1980 and 1999. It experienced a particularly strong growth in the 1990s, in the wake of the German re-unification boom. After a protracted decline it started to grow again in 2010.

In addition, we use a set of control variables that are typically employed in the literature[5] as demand-side determinants of housing prices and construction: real GDP per capita as a proxy for the purchasing power, net migration as a proxy for housing demand, and real interest rate as a proxy for the opportunity cost of housing; see Figure 3. The quarterly real GDP series for the period between 1970:q1 and 2016:q3 was constructed of two overlapping series: GDP in West Germany in 1970:q1–1991:q4 and GDP in whole Germany in 1991:q1–2016:q3. Likewise, the annual real GDP was computed based on the four GDP series: three for West Germany from 1950–1991 and one for the whole country in 1991–2016; see Table 1. Each has different constant prices basis year, thus we chain them.

Our variables of interest are indices reflecting governmental intervention in the housing market. We use the housing market regulation indices as developed in Kholodilin (2016): rent controls, housing rationing, social housing, and overall regulation index. The indices measure

[3] See function *spline* of the statistical and graphical programming language **R**.

[4] For more details on the construction and properties of the German CPI subindex for housing services see Hoffmann and Kurz (2002), p. 12–16

[5] See, for example, the literature reviews in Algieri (2013) and Kholodilin and Ulbricht (2015).

the intensity of regulations, varying between 0 (no government intervention) and 10 (total government control). The rent control index measures the degree of restrictions imposed on rents in existing and newly negotiated contracts. The housing rationing index characterizes the degree to which the state interferes in the way the landlords dispose of their houses: sometimes, it is prohibited to convert housing to non-residential uses or even modernize it in a way that upgrades it over some existing average level. The social housing index measures the willingness of the central government to support the construction and use of social housing, which in Germany is typically provided by private landlords. Finally, the overall index is an average of individual indices. The indices presented here are updated compared to Kholodilin (2016); these updates account for changes in the regulations that occurred in 2016. In particular, during that period, rental brake was introduced in Brandenburg (active starting January 1, 2016), Thuringia (active starting April 1, 2016), and Lower Saxony (active starting December 1, 2016); additionally Lower Saxony introduced capping limits (active starting December 1, 2016). These changes affected the rent control index and the overall regulations index. The updated regulation indices are displayed in Figure 4.

All the variables were tested for unit roots using the augmented Dickey-Fuller test (ADF) and Philips-Perron test (PP). The corresponding p-values are shown in Table 2. Several variables (real prices, price-to-rent ratio, real GDP per capita, net migration, and new residential construction) are found to be integrated of order 1. The first difference of net migration appears to be non-stationary, too. However, this is related to a large surge in this variable in 2015 and 2016 caused by an unexpected inflow of migrants from the Middle East and North Africa. If these two years are dropped, then for the differenced series both tests reject the null of unit root at 5% significance level.

The possible cointegration between the variables was tested using the Pesaran et al. (2001) bounds test. It amounts to estimating the following the conditional error correction model in form of an ARDL(P, P) model:

$$\Delta y_t = \sum_{p=1}^{P} \alpha_p \Delta y_{t-p} + \sum_{k=1}^{K} \sum_{p=1}^{P} \beta_{pk} \Delta x_{k,t-p} + \lambda y_{t-1} + \sum_{k=1}^{K} \theta_k x_{t-1} + \varepsilon_t \tag{3}$$

The null hypothesis of no cointegration is formulated as H_0: $\lambda = 0$, $\theta_k = 0$, $\forall k$. Thus, it can

be tested using t- and F-statistics. While using t-statistic one tests the null of $\lambda = 0$; with the F-statistic the joint restriction is tested. Pesaran et al. (2001) supply tables of with lower and upper critical bounds. If the test F-statistic is smaller than the lower bound, then the null of cointegration is rejected. If it is above the upper bound, then the existence of cointegration is accepted. If the test F-statistic is between the lower and upper bounds, the inference is inconclusive.

We determined the optimal lag length, P, using Akaike information criterion. The maximum lag was set to 4. The optimal lag lengths and test statistics are reported in Table 3. While the first column contains the names of dependent variables, the second indicates the regulation indices and, thus, different models that are formulated for each dependent variable. Here, we have the case of an unrestricted intercept and no trend. The note below the table reports the corresponding 5% critical value bounds from Tables CI(iii) and CII(iii) of Pesaran et al. (2001). When using F-statistic the null hypothesis of no level relationship can only be rejected at 5% significance level for the three models with price-to-income ratio as dependent variable. However, when using t-statistic the null cannot be rejected for price-to-income ratio. It can only be rejected for the new residential construction, when the rent control index is in the regression. Thus, for both tests the null hypothesis of no cointegration cannot be rejected. Therefore, in what follows we estimate ARDL models without the error correction term.

5. Estimation results

ARDL models were estimated for each dependent variable and all regulation indices. The selection of lag order was carried out using the Akaike and Schwartz information criteria. Given our relatively small sample and the quarterly frequency of the data, the maximum lag length was set at 4. In addition, for the case of regulation indices, the minimum lag starts at 1, assuming that the economic agents do not react immediately to the changes in governmental policy. Moreover, this allows ruling out the issue of housing policy endogeneity. All different combinations of lag orders for the dependent variable and explanatory variables were considered. For annual data with 4 lags, 2000 permutations of variable-specific lags were considered.

The estimation results for the quarterly real housing prices, price-to-rent ratio, price-to-income ratio, and real housing rents are in Tables 4 through 7. The results for the model

of new dwelling completions estimated using annual data are reported in Table 8. Although the data on the new residential construction for whole Germany are available since 1949, we decided to use only data on West Germany, given that prior to 1990 East Germany was under a centrally planned system with a restrained housing market and a completely different set of policy instruments. This should not pose a grave problem in terms of extrapolating the results for the whole country, even at the end of the sample, since, for example, in 2015 more than 84% of new dwellings were completed in West Germany.

In order to avoid the possible multicollinearity between different regulation indices and to preserve degrees of freedom, given a rather limited sample size, we use only one regulation index in each regression.

Table 9 contains the estimated long-run effects based on equation (2). It also shows the 95% confidence interval bounds computed using a bootstrap with 1000 replicates.[6]

Short-run effects. In the short run, the rent controls and overall regulation index negatively affect the real housing prices. By capping rents, the profitability of rental housing falls, thus driving down the capitalized values of residential properties. The housing rationing policy positively affects the price-to-rent ratio. This implies a negative effect of this policy on the profitability of rental housing. Indeed, the inverse of the price-to-rent ratio can be seen as a gross rental return. The price-to-income ratio appears to be unaffected by governmental regulations. Housing rationing also appears to lead to higher rents. Although its purpose is to provide more space for housing purposes, it also diminishes the attractiveness of investing in housing. Consequently, housing supply may decrease through lack of maintenance, leading to quicker dilapidation and reduced residential construction. The resulting housing shortage leads to rising real rents. In contrast, new dwelling completions are negatively and significantly affected by rent control, housing rationing, and the overall regulation with a lag of two years, but are positively influenced by encouraging social housing policies only one year after being introduced.

Long-run effects. The real per capita GDP has no significant long-run effect on any of the housing market variables considered in this study. Net migration has a positive and significant

[6]The bootstrapping was done using the functions *boot* and *boot.ci* of the **R** package *boot*.

(both lower and upper bounds of the 95% confidence interval are positive) impact on real prices, real rents, price-to-income ratios, and construction. Indeed, it represents an increase in demand leading to an upward pressure on the housing market. The rents are especially prone to this effect, since most foreigners settle down in the cities, where rental housing dominates. Although the average long-term effect of the real interest rate is almost always negative, it is not statistically significant. By contrast, it exerts a significant positive long-run impact on the real rents. This is explained by the fact that interest and principal payments contribute to the costs of the landlords, which are transmitted to the tenants.

Rent control has a significant negative impact on the real prices. Surprisingly, it does not exert a significant impact on real rents, albeit the average long-term effect is negative. The housing rationing policy positively affects the price-to-rent ratio and the real rent. This is similar to the short-term effects of the policy. This effect seems to be contradictory, since rents enter the denominator of the ratio. Here, however, we deal with two different definitions of rents. In the price-to-rent ratio, the nominal rents for newly let dwellings are used, while the real rents indicator of Destatis covers both old and new rental contracts. Moreover, declining price-to-rent ratios imply lower rental yield, which transforms in reduced investment in housing construction, increased housing shortages, and higher rents. In the long run, social housing policies positively and significantly affect real prices. This can be explained by the construction booms triggered by such measures, which are typically accompanied by rising land and construction costs due to increasing demand by investors. Social housing incentives also exert a statistically significant negative impact on the price-to-income ratio. Provided that they positively affect real housing prices, it can only imply that their stimulating affect on the overall economy is even larger, thus, making housing more affordable. This is quite plausible, since, according to an estimate made for Germany, the investment in housing construction has a multiplier of 2.36; see Barabas et al. (2011), p. 56. In other words, a 1 million euro increase in residential investment leads to 2.36 million euro increase in the output. The overall regulation index appears to significantly and positively affect only the price-to-rent ratio.

6. Conclusion

In this paper, we demonstrated that rental housing market regulations affect real housing prices, real rents, rental yields, housing affordability, and new residential construction, both in the short and long runs.

Stricter rent controls lead to higher prices, while increased housing rationing results in higher rents and fewer dwelling completions. These negative effects are at least, in part, offset by social housing policies that spur new residential construction and improve the affordability of housing.

Given that the analysis for prices covers the period between 1970 and 2015, it implies that even more flexible second-generation rent controls can be detrimental from the macroeconomic point of view.

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Appendix

Table 1: Data sources

Code	Description	Frequency	Source	
RHPI	real house price index	quarterly	1970q1-2016q3	OECD
P2Y	price-to-income ratio	quarterly	1980q1-2016q3	OECD
P2R	price-to-rent ratio	quarterly	1970q1-2016q3	OECD
RGDP_WD	real SA GDP of West Germany	quarterly	1970q1-1991q4	Destatis
RGDP_DE	real SA GDP of whole Germany	quarterly	1991q1-2016q3	Destatis
RGDP	real SA GDP	quarterly	1970q1-2016q3	own calculations
RGDP_WD1	real calendar and SA GDP, former West Germany (without Berlin-West and Saarland)	annual	1950-1960	Destatis
RGDP_WD2	real calendar and SA GDP, former West Germany	annual	1960-1970	Destatis
RGDP_WD3	real calendar and SA GDP, former West Germany (results of the 2005 SNA revision)	annual	1970-1991	Destatis
RGDP_DE	real calendar and SA GDP, Germany	annual	1991-2016	Destatis
RGDP	real calendar and SA GDP, Germany	annual	1950-2016	own calculations
IRate_3m_Frankfurt	money market rate three-months funds (Frankfurt exchange)	monthly	1959m12-2012m05	Deutsche Bundesbank
IRate_3m_EONIA	money market rate three-months funds (EONIA)	monthly	1999m01-2016m12	Deutsche Bundesbank
IRate_3m	money market rate three-months funds	monthly	1959m12-2016m12	own calculations
New_HU_WD	completed housing in residential and non-residential buildings, West Germany	annual	1949-2015	Destatis
New_HU_DE	completed housing in residential and non-residential buildings, Germany	annual	1949-2015	Destatis
Pop_WD	population, thousand persons, West Germany	annual	1950-2015	Destatis
Pop_DE	population, thousand persons, Germany	annual	1950-2015	Destatis

. . . continued

Code	Description	Frequency	Period	Source
WAPop	working age population (population ages 15-64 as % of total)	annual	1960-2015	World Bank
Immigration	immigration to Germany	annual	1950-2015	Destatis
Emigration	emigration from Germany	annual	1950-2015	Destatis
Net_migration	net migration (immigration minus emigration)	annual	1950-2015	Destatis
	housing market regulation indices	irregular	1914-2015	Kholodilin (2016)

Notes: 1) BIS stands for Bank for International Settlements; Destatis is the German Federal Statistical Office; and OECD is the Organization for Economic Cooperation and Development. 2) SA denotes seasonal adjustment.

Table 2: Results of the unit-root tests, p-values of ADF and Philips-Perron tests

Variable	ADF	PP
Quarterly data		
LRHPI	0.325	0.989
DLRHPI	0.014	0.010
P2Y	0.036	0.990
DP2Y	0.076	0.010
P2R	0.519	0.974
DP2R	0.059	0.010
LRGDP	0.377	0.639
DLRGDP	0.010	0.010
RIRate_3m	0.116	0.010
Rent_control_index	0.105	0.052
DRent_control_index	0.010	0.010
Rationing_index	0.464	0.836
DRationing_index	0.010	0.010
SH_Foster	0.805	0.718
DSH_Foster	0.010	0.010
Regulation_index	0.010	0.109
DRegulation_index	0.010	0.010
Annual data		
LNew_HU_WD	0.657	0.079
DLNew_HU_WD	0.010	0.010
Net_migration	0.110	0.208
DNet_migration	0.022	0.010

Table 3: Results of the bounds testing for cointegration

Dependent variable	Regulation index	Optimal lag	F-statistic	t-statistic
Quarterly data				
DLRHPI	Rent_control_index	2	4.003	-2.676
DLRHPI	Rationing_index	3	2.429	-2.208
DLRHPI	SH_Foster	3	2.121	-2.064
DLRHPI	Regulation_index	2	2.856	-2.003
DLP2R	Rent_control_index	2	2.398	-1.805
DLP2R	Rationing_index	2	3.101	-2.065
DLP2R	SH_Foster	2	2.410	-1.426
DLP2R	Regulation_index	2	1.742	-1.311
DLP2Y	Rent_control_index	1	6.748	-1.296
DLP2Y	Rationing_index	1	7.506	-0.855
DLP2Y	SH_Foster	3	1.195	-0.539
DLP2Y	Regulation_index	1	6.675	-0.722
DLRRent_DE	Rent_control_index	4	1.459	-3.141
DLRRent_DE	Rationing_index	4	1.474	-3.437
DLRRent_DE	SH_Foster	4	2.109	-3.641
DLRRent_DE	Regulation_index	4	1.613	-3.276
Annual data				
DLNew_HU_WD	Rent_control_index	4	2.266	-5.680
DLNew_HU_WD	Rationing_index	4	1.621	-0.297
DLNew_HU_WD	SH_Foster	4	1.025	-0.633
DLNew_HU_WD	Regulation_index	4	1.626	-2.181

Note: Case III: unrestricted intercept and no trend. Critical value bounds of F-test for $k = 3$ and $\alpha = 0.05$ are $(3.23, 4.35)$. Critical value bounds of t-test for $k = 3$ and $\alpha = 0.05$ are $(-2.86, -3.78)$.

Table 4: Estimation results of ARDL model for real housing price

	Dependent variable:			
	real housing price			
	(1)	(2)	(3)	(4)
Constant	0.116	0.027	0.033	0.109
	(0.092)	(0.083)	(0.084)	(0.092)
DLRHPI_L1	0.368***	0.391***	0.388***	0.371***
	(0.074)	(0.074)	(0.074)	(0.074)
DLRHPI_L2	0.131*	0.117	0.117	0.141*
	(0.078)	(0.079)	(0.079)	(0.078)
DLRHPI_L3	0.208***	0.197***	0.195***	0.201***
	(0.072)	(0.073)	(0.073)	(0.072)
DLRGDP_PC	0.068	0.062	0.059	0.051
	(0.049)	(0.048)	(0.048)	(0.050)
DLRGDP_PC_L1	−0.086*	−0.067	−0.067	−0.086*
	(0.049)	(0.048)	(0.048)	(0.049)
DLRGDP_PC_L2		−0.014	−0.016	−0.030
		(0.048)	(0.048)	(0.048)
DLRGDP_PC_L3		−0.032	−0.031	−0.044
		(0.049)	(0.048)	(0.048)
DLRGDP_PC_L4		0.096**	0.100**	0.108**
		(0.047)	(0.047)	(0.047)
DNet_migration	0.020**	0.024***	0.024***	0.020**
	(0.008)	(0.009)	(0.009)	(0.009)
RIRate_3m	0.039	−0.012	−0.013	0.029
	(0.043)	(0.018)	(0.018)	(0.044)
RIRate_3m_L1	0.027			0.027
	(0.056)			(0.056)
RIRate_3m_L2	−0.085*			−0.080*
	(0.045)			(0.045)
DRent_control_index_L1	0.009			
	(0.008)			
DRent_control_index_L2	−0.017**			
	(0.008)			
DRent_control_index_L3	−0.0003			
	(0.009)			
DRent_control_index_L4	−0.018**			
	(0.008)			
DRationing_index_L1		0.0001		
		(0.066)		
DSH_Foster_L1			0.015	
			(0.020)	
DRegulation_index_L1				0.027
				(0.020)
DRegulation_index_L2				−0.041**
				(0.020)
Observations	182	182	182	182
R^2	0.546	0.523	0.524	0.546
Adjusted R^2	0.511	0.492	0.494	0.508
Residual Std. Error	0.576 (df = 168)	0.587 (df = 170)	0.586 (df = 170)	0.578 (df = 167)
F Statistic	15.569*** (df = 13; 168)	16.934*** (df = 11; 170)	17.042*** (df = 11; 170)	14.332*** (df = 14; 167)
Note:	*p<0.1; **p<0.05; ***p<0.01			

Table 5: Estimation results of ARDL model for price-to-rent ratio

	Dependent variable:			
	price-to-rent ratio			
	(1)	(2)	(3)	(4)
Constant	0.094	0.093	0.101	0.097
	(0.119)	(0.118)	(0.119)	(0.119)
DLP2R_L1	0.258***	0.294***	0.262***	0.258***
	(0.075)	(0.071)	(0.075)	(0.075)
DLP2R_L2	0.267***	0.324***	0.267***	0.268***
	(0.076)	(0.068)	(0.076)	(0.076)
DLP2R_L3	0.058		0.045	0.053
	(0.078)		(0.077)	(0.077)
DLP2R_L4	0.072		0.079	0.072
	(0.073)		(0.073)	(0.073)
DLRGDP_PC	0.040	0.055	0.047	0.038
	(0.065)	(0.065)	(0.065)	(0.065)
DNet_migration	0.022**	0.018	0.021*	0.022**
	(0.011)	(0.011)	(0.011)	(0.011)
RIRate_3m	0.134**	0.127**	0.125**	0.133**
	(0.056)	(0.056)	(0.056)	(0.056)
RIRate_3m_L1	−0.072	−0.082	−0.074	−0.068
	(0.073)	(0.075)	(0.073)	(0.073)
RIRate_3m_L2	−0.102*	−0.087	−0.091	−0.105*
	(0.057)	(0.056)	(0.056)	(0.057)
DRent_control_index_L1	0.011			
	(0.011)			
DRationing_index_L1		0.061		
		(0.087)		
DRationing_index_L2		−0.048		
		(0.089)		
DRationing_index_L3		0.008		
		(0.096)		
DRationing_index_L4		0.219**		
		(0.095)		
DSH_Foster_L1			0.007	
			(0.026)	
DRegulation_index_L1				0.029
				(0.025)
Observations	182	182	182	182
R^2	0.464	0.473	0.461	0.465
Adjusted R^2	0.433	0.439	0.429	0.433
Residual Std. Error	0.763 (df = 171)	0.759 (df = 170)	0.766 (df = 171)	0.763 (df = 171)
F Statistic	14.811*** (df = 10; 171)	13.868*** (df = 11; 170)	14.602*** (df = 10; 171)	14.842*** (df = 10; 171)
Note:	*p<0.1; **p<0.05; ***p<0.01			

Table 6: Estimation results of ARDL model for price-to-income ratio

	Dependent variable:			
	price-to-income ratio			
	(1)	(2)	(3)	(4)
Constant	0.021	0.019	−0.001	0.027
	(0.148)	(0.147)	(0.147)	(0.147)
DLP2Y_L1	−0.043	−0.045	−0.060	−0.044
	(0.086)	(0.086)	(0.086)	(0.086)
DLP2Y_L2	0.246***	0.250***	0.233***	0.246***
	(0.083)	(0.084)	(0.082)	(0.082)
DLP2Y_L3	0.297***	0.296***	0.308***	0.300***
	(0.082)	(0.082)	(0.082)	(0.082)
DLP2Y_L4	0.102	0.102	0.150	0.112
	(0.087)	(0.087)	(0.090)	(0.087)
DLRGDP_PC	−0.129	−0.132	−0.124	−0.126
	(0.087)	(0.087)	(0.086)	(0.087)
DNet_migration	0.024*	0.025*	0.024*	0.024*
	(0.014)	(0.014)	(0.014)	(0.014)
RIRate_3m	−0.026	−0.025	−0.022	−0.025
	(0.033)	(0.033)	(0.033)	(0.033)
DRent_control_index_L1	−0.002			
	(0.017)			
DRationing_index_L1		−0.027		
		(0.115)		
DSH_Foster_L1			−0.053	
			(0.033)	
DRegulation_index_L1				−0.055
				(0.061)
Observations	142	142	142	142
R^2	0.272	0.272	0.286	0.276
Adjusted R^2	0.228	0.229	0.243	0.233
Residual Std. Error (df = 133)	0.935	0.935	0.926	0.933
F Statistic (df = 8; 133)	6.220***	6.226***	6.666***	6.353***
Note:	*p<0.1; **p<0.05; ***p<0.01			

Table 7: Estimation results of ARDL model for real housing rent

	Dependent variable:			
	real housing rent			
	(1)	(2)	(3)	(4)
Constant	−0.079	−0.066	−0.079	−0.081
	(0.108)	(0.108)	(0.108)	(0.108)
DLRRent_DE_L1	−0.019	−0.039	−0.022	−0.020
	(0.075)	(0.075)	(0.075)	(0.075)
DLRRent_DE_L2	0.109	0.100	0.107	0.109
	(0.073)	(0.073)	(0.073)	(0.073)
DLRRent_DE_L3	0.059	0.040	0.050	0.057
	(0.074)	(0.072)	(0.073)	(0.073)
DLRRent_DE_L4	0.238***	0.224***	0.240***	0.239***
	(0.073)	(0.073)	(0.073)	(0.073)
DLRGDP_PC	−0.007	−0.015	−0.010	−0.006
	(0.055)	(0.055)	(0.055)	(0.056)
DLRGDP_PC_L1	−0.103*	−0.106*	−0.105*	−0.103*
	(0.056)	(0.055)	(0.055)	(0.056)
DNet_migration	0.012	0.009	0.012	0.012
	(0.010)	(0.010)	(0.009)	(0.010)
RIRate_3m	0.015	0.016	0.018	0.016
	(0.049)	(0.049)	(0.049)	(0.049)
RIRate_3m_L1	0.006	0.014	0.006	0.005
	(0.063)	(0.065)	(0.063)	(0.063)
RIRate_3m_L2	−0.102	−0.117*	−0.106*	−0.102
	(0.064)	(0.064)	(0.063)	(0.064)
RIRate_3m_L3	0.047	0.056	0.047	0.049
	(0.062)	(0.063)	(0.063)	(0.062)
RIRate_3m_L4	0.081*	0.075	0.081*	0.079*
	(0.047)	(0.047)	(0.047)	(0.047)
DRent_control_index_L1	−0.005			
	(0.009)			
DRationing_index_L1		0.020		
		(0.073)		
DRationing_index_L2		0.061		
		(0.076)		
DRationing_index_L3		0.141*		
		(0.081)		
DSH_Foster_L1			0.006	
			(0.022)	
DRegulation_index_L1				−0.011
				(0.021)
Observations	182	182	182	182
R^2	0.181	0.200	0.180	0.180
Adjusted R^2	0.117	0.127	0.116	0.117
Residual Std. Error	0.642 (df = 168)	0.639 (df = 166)	0.643 (df = 168)	0.643 (df = 168)
F Statistic	2.851*** (df = 13; 168)	2.762*** (df = 15; 166)	2.828*** (df = 13; 168)	2.846*** (df = 13; 168)
Note:	*p<0.1; **p<0.05; ***p<0.01			

Table 8: Estimation results of ARDL model for new dwelling completions

	Dependent variable:			
	new dwelling completions			
	(1)	(2)	(3)	(4)
Constant	−3.741	−3.671	−1.507	−3.998
	(3.749)	(3.963)	(4.021)	(3.769)
DLNew_HU_WD_L1	0.145	0.196	0.200	0.124
	(0.146)	(0.154)	(0.158)	(0.149)
DLNew_HU_WD_L2		−0.089	−0.099	
		(0.142)	(0.138)	
DLNew_HU_WD_L3		−0.166	−0.211	
		(0.132)	(0.134)	
DLRGDP_PC	1.450*	1.602*	0.565	1.683**
	(0.818)	(0.854)	(0.845)	(0.827)
DNet_migration	−0.218**	−0.285***	−0.204**	−0.222**
	(0.089)	(0.102)	(0.090)	(0.089)
DNet_migration_L1	0.204*	0.174	0.142	0.207*
	(0.106)	(0.109)	(0.106)	(0.106)
DNet_migration_L2	0.241**	0.227**	0.250**	0.227**
	(0.100)	(0.108)	(0.104)	(0.100)
DNet_migration_L3	0.354***	0.322***	0.309***	0.344***
	(0.100)	(0.106)	(0.101)	(0.100)
DNet_migration_L4	0.311***	0.291**	0.316***	0.324***
	(0.112)	(0.113)	(0.113)	(0.112)
RIRate_3m	−1.203	−0.856	−0.646	−1.591
	(1.036)	(0.936)	(0.906)	(1.154)
RIRate_3m_L1	−0.133	−1.044	−1.443	0.637
	(1.538)	(1.325)	(1.292)	(1.733)
RIRate_3m_L2	−1.925	−0.811	−0.652	−2.328
	(1.407)	(1.299)	(1.280)	(1.479)
RIRate_3m_L3	2.788**	2.515*	2.845**	2.748**
	(1.281)	(1.378)	(1.357)	(1.275)
RIRate_3m_L4	−0.053	−0.538	−0.727	−0.044
	(1.039)	(1.115)	(1.050)	(1.036)
DRent_control_index_L1	0.134			
	(0.104)			
DRent_control_index_L2	−0.167*			
	(0.083)			
DRationing_index_L1		1.619		
		(1.036)		
DRationing_index_L2		−1.614*		
		(0.940)		
DSH_Foster_L1			0.669*	
			(0.355)	
DSH_Foster_L2			−0.289	
			(0.370)	
DSH_Foster_L3			0.854**	
			(0.365)	
DSH_Foster_L4			−0.481	
			(0.365)	
DRegulation_index_L1				0.388
				(0.300)
DRegulation_index_L2				−0.503**
				(0.243)
D_Reunif	9.760*	12.968**	12.087**	10.412*
	(5.334)	(5.583)	(5.529)	(5.400)
Observations	49	49	49	49
R^2	0.706	0.726	0.758	0.708
Adjusted R^2	0.572	0.576	0.600	0.575
Residual Std. Error	8.368 (df = 33)	8.323 (df = 31)	8.086 (df = 29)	8.339 (df = 33)
F Statistic	5.272*** (df = 15; 33)	4.842*** (df = 17; 31)	4.792*** (df = 19; 29)	5.323*** (df = 15; 33)
Note:		*p<0.1; **p<0.05; ***p<0.01		

Table 9: Long-run effects for housing price, price ratios, rent, and new residential construction

Dependent variable	Determinant	lower bound	estimate	upper bound
DLRHPI	DLRGDP_PC	-0.836	-0.004	0.677
DLRHPI	DNet_migration	-0.012	0.071	0.173
DLRHPI	RIRate_3m	-0.255	-0.083	0.059
DLRHPI	DRent_control_index	-0.207	-0.092	-0.002
DLRHPI	DRationing_index	-0.468	0.001	0.456
DLRHPI	DSH_Foster	0.024	0.050	0.203
DLRHPI	DRegulation_index	-0.203	-0.049	0.169
DLP2R	DLRGDP_PC	-0.401	0.108	0.497
DLP2R	DNet_migration	-0.019	0.062	0.149
DLP2R	RIRate_3m	-0.468	-0.115	0.015
DLP2R	DRent_control_index	-0.005	0.033	0.109
DLP2R	DRationing_index	-0.089	0.626	2.127
DLP2R	DSH_Foster	-0.065	0.019	0.089
DLP2R	DRegulation_index	0.011	0.083	0.291
DLP2Y	DLRGDP_PC	-1.159	-0.327	0.203
DLP2Y	DNet_migration	-0.003	0.061	0.148
DLP2Y	RIRate_3m	-0.248	-0.065	0.163
DLP2Y	DRent_control_index	-0.075	-0.006	0.230
DLP2Y	DRationing_index	-0.536	-0.068	0.763
DLP2Y	DSH_Foster	-0.765	-0.144	-0.060
DLP2Y	DRegulation_index	-0.527	-0.141	0.419
DLRRent_DE	DLRGDP_PC	-0.653	-0.178	0.035
DLRRent_DE	DNet_migration	0.001	0.019	0.055
DLRRent_DE	RIRate_3m	-0.006	0.075	0.211
DLRRent_DE	DRent_control_index	-0.045	-0.008	0.009
DLRRent_DE	DRationing_index	0.055	0.329	0.804
DLRRent_DE	DSH_Foster	-0.005	0.009	0.165
DLRRent_DE	DRegulation_index	-0.095	-0.018	0.035
DLNew_HU_WD	DLRGDP_PC	-0.960	1.922	5.514
DLNew_HU_WD	DNet_migration	0.504	1.004	2.205
DLNew_HU_WD	RIRate_3m	-2.523	-0.660	2.197
DLNew_HU_WD	DRent_control_index	-1.091	-0.039	0.219
DLNew_HU_WD	DRationing_index	-5.183	0.005	4.064
DLNew_HU_WD	DSH_Foster	-3.106	0.678	7.713
DLNew_HU_WD	DRegulation_index	-2.255	-0.131	0.901

Figure 1: Dependent variables, quarterly frequency

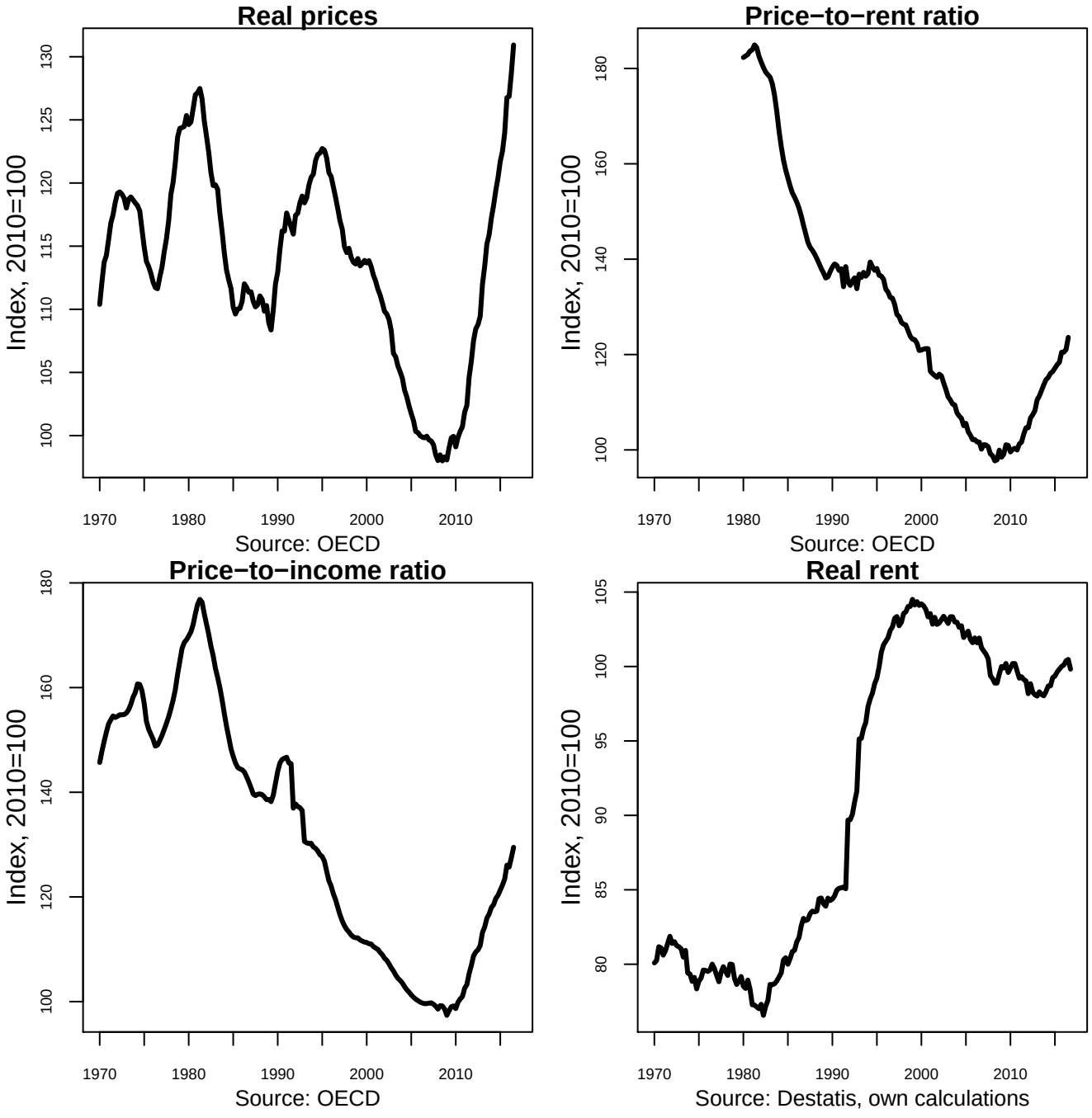

Figure 2: Dependent variables: new residential construction, annual frequency

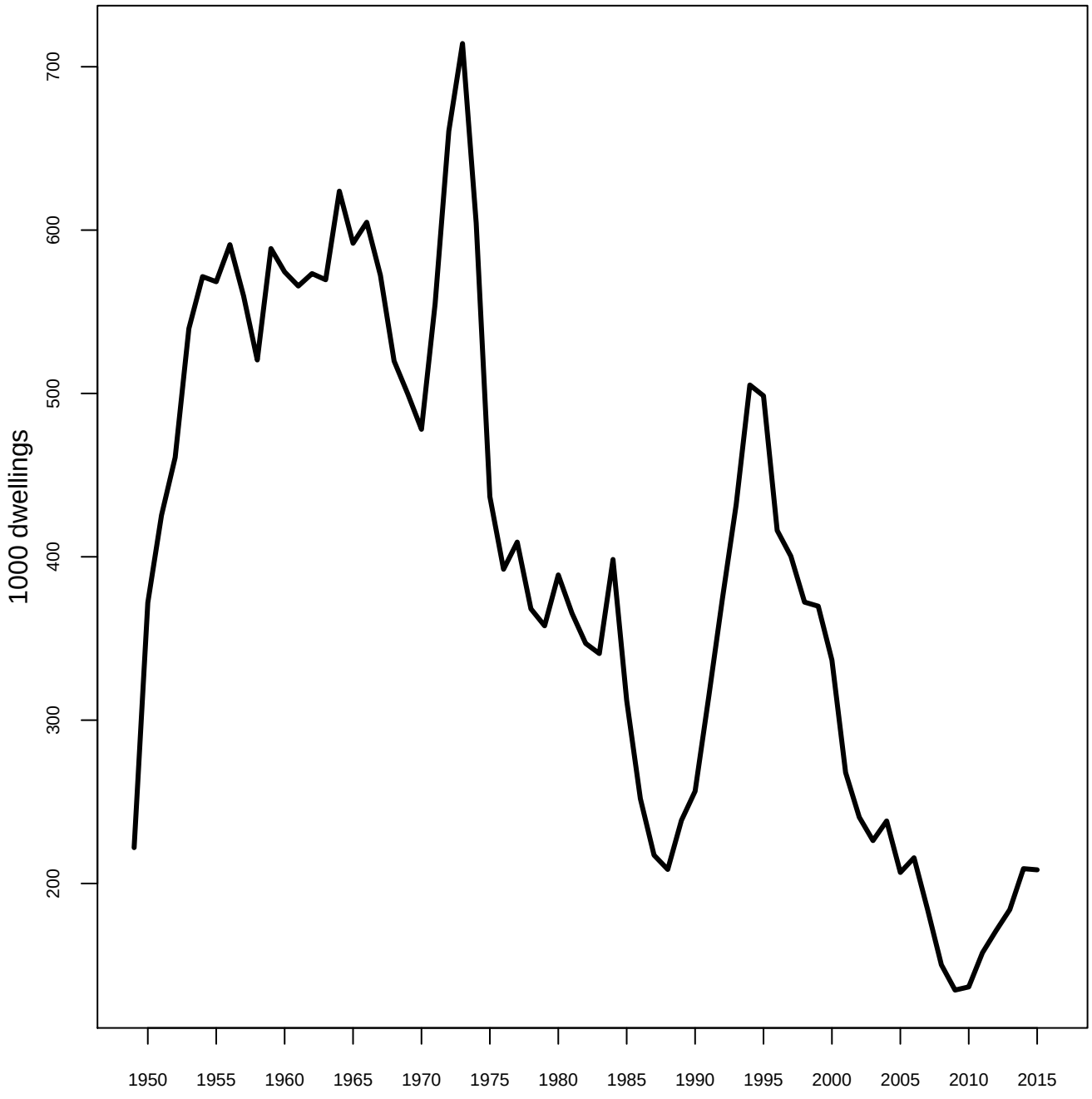

Figure 3: Control variables

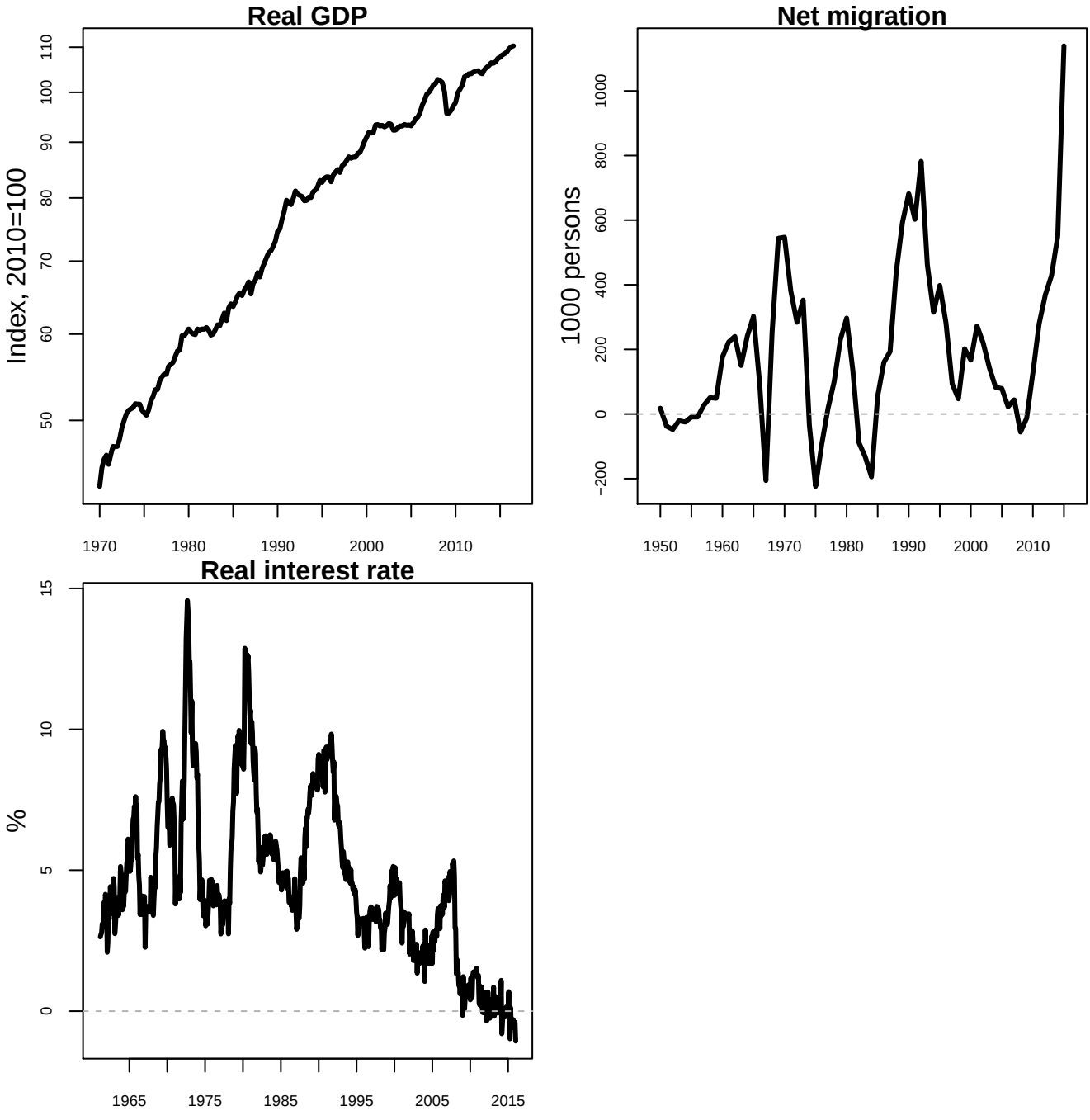

Figure 4: Regulation indices