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Housing Price Bubbles and their Determinants in the Czech Republic and its Regions

Michal Hlaváček and Luboš Komárek*

Abstract

This working paper, based on an empirical analysis, discusses factors affecting property prices and tries to identify periods of property price overvaluation by three approaches: using simple ratios related to house prices (price-to-income and price-to-rent), using time series analysis for the Czech Republic as a whole, and using panel regression for the Czech regions. The time series analysis and the simple indicators of housing price sustainability identified overvalued property prices in 2002/2003 and partly also in 2007/2008. According to the time series analysis, however, the size of the housing price overvaluation in 2007/2008 was relatively low, as the rise in property prices in this period was largely explainable by fundamentals. From the regional perspective, there is a higher degree of overvaluation in regions with higher property prices. The exception is Prague, which seems to be a "specific" region.

JEL Codes: R21, R31, C23.

Keywords: Asset price bubbles, Czech Republic and its regions, housing prices, panel regression.

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Nontechnical Summary

An understanding of housing price determinants is of crucial importance for central banks. Historical experience shows that housing price busts have much stronger effects on the economy than those when stock market bubbles burst. Housing market bubbles pose an important threat to the financial stability of a country, especially when mortgage loans account for a large proportion of total loans. Housing price busts might also negatively influence the balance sheets of the banking sector via an increase of the *Probability of Default (PD)* and *Loss Given Default (LGD)* both for housing loans and for loans to the construction industry and to developers. Consequently, housing market bubbles might negatively influence private consumption (via the wealth channel), the mobility of the labour force and thus the flexibility of the supply side of the economy. These affects have propagated themselves during recent financial crises in many countries (the USA, the UK, Ireland and others). A natural question arises whether the recent quick housing price growth in the Czech Republic will lead to similar threats.

The main objective of this paper is to explain the determinants of housing prices in the Czech Republic and to identify periods when housing prices diverged from their fundamentals. Furthermore, the paper describes different sources of real estate data for the Czech Republic in order to choose an appropriate index for the description of housing market developments. Additionally, the paper discusses supply and demand factors determining property prices.

The empirical analysis covers basically three ways of assessing the divergence of housing prices from their fundamental values. The first, simple, approach uses the price-to-income and rental yield indicators. A further, more advanced, analysis includes two alternative econometric models for determining equilibrium housing prices. The first econometric model uses time series regression analysis, which explains the growth in property prices in the Czech Republic as a whole and in Prague as its capital city with the “price leader” effect (based on quarterly data from 1998 Q1 to 2009 Q2). The second econometric model uses panel regression analysis in the individual Czech regions (with and without Prague) with housing transfer prices as the dependent variable.

From all three strands of the analysis we identified property price bubbles in 2002/2003 and 2007/2008. However, the time series regression analysis showed that the level of overvaluation in 2007/2008 was lower than in the first period, even though the increases in prices in the two periods were similar. This is due to the fact that in the second period the rapid house price dynamics were in line with the development of the economy and demographic trends. In the panel regression analysis we found that the level of overvaluation of apartment prices in individual regions is positively related to the apartment price level, with the exception of apartment prices in Prague.

As for the relevance of individual housing price determinants, similarly to previous studies we found that housing prices in the Czech Republic are driven mainly by demand factors. Those include especially wages, rents, unemployment and natural population growth and partly also other factors (migration, divorce rate). One surprising result was that neither mortgage credit growth nor the credit conditions (represented by interest rates) were among the significant factors of apartment prices. However, recent developments show that the link between housing credit and housing prices might have been restored.

Nevertheless, due to relatively short data samples we were forced to use relatively simple types of analysis and we were not able to account for some problems connected with this analysis (e.g. the inclusion of bubble periods that might have influenced the estimated equilibrium housing prices, and the problem of endogeneity of some explanatory variables). Therefore, our results should be taken with caution.

1. Introduction

Housing prices proved to be a very important factor during the recent financial crisis. Their explosive growth and busts in combination with the mispricing of subprime mortgage loans are usually mentioned among the most important factors of this crisis (see, for example, Calomiris et al., 2008). Therefore, an understanding of housing price determinants is of crucial importance for central banks. Housing price busts might negatively influence the balance sheets of the banking sector via an increase of the *Probability of Default (PD)* and *Loss Given Default (LGD)* both for housing loans and for loans to the construction industry and to developers. They might negatively influence private consumption via the wealth channel; a change in the situation on the housing market might influence the mobility of the labour force and thus the flexibility of the supply side.

This paper sets out to explain the determinants of housing prices and then to identify periods when housing prices diverged from their fundamentals. Despite its imperfections, given mainly by short time data series, the results might be used as an input for the prediction of housing prices under different stress testing scenarios related to housing prices (see Czech National Bank, 2009). It could also shed some additional light on the discussion of the role of housing prices in monetary policy making (see, for example, Frait and Komárek, 2007). Moreover, due to the link of housing prices to PD and LGD, understanding the determinants of housing prices might help to improve the stress testing framework, which is one of the crucial methodologies for assessing financial stability in the Czech Republic.[1]

Property prices surged in the Czech Republic in 2007. The rise continued in 2008 and 2009 despite the fact that the global financial crisis had already led to major falls in property prices in countries where such prices had surged in the previous decade. This is illustrated in Chart 1. A simple comparison of property prices in the Czech Republic and in other countries raises questions about whether the Czech Republic, too, faces such a property price bust and whether the recent growth is a sign of a "bubble" which, if it bursts, might have grave macroeconomic and social consequences.

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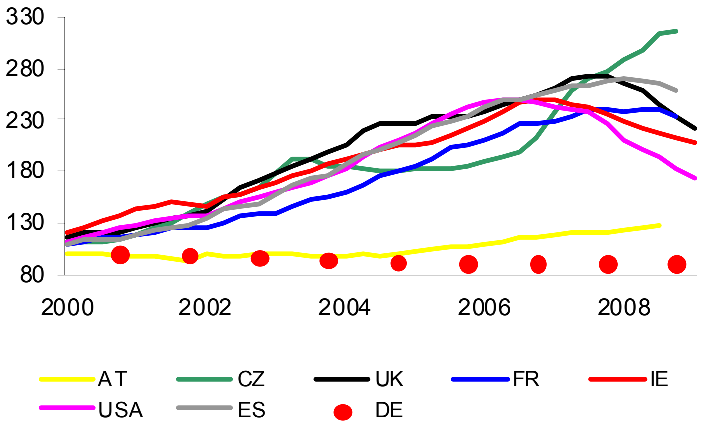
[1] For an overview and the outcomes of stress testing as applied to the Czech economy, see, for example, CNB (2008), CNB (2009) and Čihák et al. (2007). Our model might be used, for example, as a basis for some satellite model linking the stress testing scenarios for major macroeconomic variables with apartment price developments and then with the housing loan PDs and LGDs that enter the bank's balance sheet estimations. However, one has to keep in mind that our estimates are pretty rough and therefore they are not very useful for predicting future housing price developments.

Chart 1: International Comparisons of Property Prices in Selected Countries (apartment prices; 1999 Q1=100)



Note: AT – Austria, CZ – Czech Republic, UK – United Kingdom, FR – France, IE – Ireland, USA – United States, ES – Estonia, DE – Germany.
***Source*:** BIS, CZSO, Case and Shiller (US) and Nationwide (UK)

Historical experience shows that the effects when housing market bubbles suddenly burst are accompanied by larger output losses and last longer on average (4 years) than those when stock market bubbles burst (1.5 years). Housing market bubbles pose a greater threat to the financial stability of a country/region if mortgage loans account for a large proportion of total loans (see, for example, Helbling and Terrones, 2003a,b, Bordo and Jeanne, 2002, or Reinhart and Rogoff 2009).

The effect of asset price bubbles on the functioning of the economy can distort the economic and investment decisions of individual economic agents. Their impact can pass through to the housing market via: (i) household consumption through the wealth channel (growth in the prices of property and financial assets held by households is perceived as growth in wealth and consumption financing sources); (ii) the banking sector balance sheet (property prices often serve as collateral in lending operations).[2] These effects differ in strength over time and across economies, but they affect the real economy all the same.[3] What is more, the economic literature does not offer clear recommendations regarding the degree of activity and preventiveness of central bank action – see, for example, Roubini (2006) and Posen (2006) and, for an application to transition economies, Frait and Komárek (2007).

Whether it is possible to identify excessive growth in past and present property prices in the Czech Republic depends to a large extent on whether this growth can be explained using standard demand and supply mechanisms and macroeconomic and demographic indicators and/or various structural characteristics of the housing stock. We define an asset price bubble as an explosive and asymmetrical deviation of the market price of a housing asset from its fundamental value that has the potential to correct suddenly and sharply.[4] Therefore, in our analysis we understand a bubble to be the residual of housing price growth that cannot be explained by the aforementioned "standard" factors. This approach, however, has some significant flaws that have to be taken into account. Firstly, it is quite sensitive to the inclusion of all relevant variables; if a significant variable is missing, this will lead to a change in the estimated "bubble" (the absolute value of the bubble will most probably be higher). Secondly, if, on the other hand, we include among the explanatory variables a variable that has its own bubble component that correlates with the bubble in housing prices, our approach will most probably identify housing prices as being in equilibrium even in those bubble periods. Thirdly, if we include the bubble periods in our sample, this could bias the estimation of equilibrium housing prices, which could, in turn, decrease the absolute size of the estimated bubble.

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[2] If property prices rise, the probable loss from selling the collateral on a mortgage loan decreases, which, in turn, notionally increases the bank's capital and allows it to expand its investments and loans. However, a slump in property prices can lead to credit constraints, a credit crunch and a negative impact on economic activity.

[3] According to many studies (e.g. Bordo and Jeanne, 2002, and Borio and Lowe, 2002), credit booms and asset price busts have had grave financial and economic consequences leading to financial crises in emerging markets.

In addition to the usual difficulties relating to the heterogeneity of property as an asset, such an assessment is complicated by the transformation nature of the Czech economy, where property prices were probably "undervalued" at the beginning of the transformation period. Hence, part of the observed increase in property prices can be attributed to (i) a process of catching-up with the usual level in developed economies combined with macroeconomic convergence, (ii) a correction in relative prices, (iii) the development of the Czech housing market and (iv) the constantly expanding mortgage market in the Czech Republic. Analysis of property prices for the Czech Republic as a developing economy is also complicated by the relatively low liquidity of its housing market, particularly at the start of the transformation process, by comparatively large changes in housing quality, which price indices are unable to identify, and by the distorting effects of the persisting regulation of rents. The Czech housing market has also been subject to numerous shocks that complicate the situation further. Such shocks include speculation on price growth prior to the entry of the Czech Republic into the European Union in 2004, speculation related to an increase in value added tax on housing in early 2008, and sales of regulated apartments owned by municipalities to their tenants at prices far below market prices.

In this working paper, we apply three alternative approaches to determining "equilibrium prices" or periods with housing price overvaluation. In the first approach, we apply simple indicators of housing price sustainability – the price-to-income and price-to-rent ratios. In the second approach, we try to explain the "equilibrium price" by time series regression analysis for the growth in property prices in the Czech Republic as a whole and in Prague as its capital city, which can be expected to show a different trend than the rest of the country and to display a "price leader" effect. For this analysis, we use quarterly property transfer price index data for the period 1998 Q1–2009 Q2, the figures for 2009 being estimated from supply prices. In the third approach, we apply panel regression analysis on annual data for 1998–2008, with property transfer prices in the individual Czech regions as the dependent variable.[5] Most of the explanatory variables in the panel regression were also obtained in a regional breakdown. Due to a relatively short data sample we were forced to use relatively simple types of analysis, so our results should be taken with caution. We treat them rather as an attempt to describe the relative importance of real property price determinants in the past and as a tool for predicting future housing prices.

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[4] Asset price bubbles are often caused by psychologically and behaviourally determined factors, self-fulfilling expectations and suchlike. This makes them difficult to identify from both the ex-ante and ex-post perspective.

[5] Égert and Mihaljek (2008) performed a similar analysis across the countries of the Central European region.

The working paper is organised as follows. Section 2 briefly discusses the relevant theoretical and empirical literature. In Section 3 we compare different sources of real estate data for the Czech Republic in order to choose an appropriate index for describing housing market developments. In Section 4 we list the factors influencing house prices that were included in the regression as explanatory variables together with their possible transmission mechanisms into apartment prices. Then we describe our estimation methodology in Section 5 and discuss the results of both variants of the regression in Sections 6.1 and 6.2. Section 7 concludes.

2. Related Literature

Housing price booms in recent years as well as the surge of interest in financial stability have led to an increase in the number of studies on this topic for developed countries. The relationship between asset price bubbles and monetary policy has been addressed in a book edited by Hunter, Kaufman and Pomerleano (2003), in Iacoviello (2005) and in Calza, Monacelli and Stracca (2007), and in Frait and Komárek (2007) for the new EU Member States. The theories of the housing market are, however, different to those for both standard goods and financial assets, as housing goods have the dual nature of commodities and investment assets. Housing goods are also specific due to their durability, their fixation to a specific location and heterogeneity, the relatively high down payment related to the purchase of a house (implying that the buyer's liquidity and liquidity constraints play a role here) and the existence of a secondary market (see Miles, 1995). Therefore, the housing market is usually viewed as being segmented into different connected markets.

The theoretical models of the housing market usually suppose that it consists of two markets – one for the stock of existing houses, which determines the price of houses, and another for the flow of new construction, which determines the level of new investment. A widely used model by Poterba (1984) (which uses the assumption of efficient markets) models equilibrium in the market for existing owner-occupied houses (assuming the same return on housing investments as on other assets) by the equation: $R_H / P_H = \left[(1-\Theta)(i+\tau_p) + \delta + \alpha + m - \pi^e\right]$, where R_H denotes the marginal value of the rental per period on owner-occupied homes, P_H the price of existing houses, Θ the investor's marginal tax rate, i the nominal interest rate, τ_p the property tax rate as a proportion of house value, δ the depreciation rate on housing capital, α the risk premium on assets with the risk characteristics of housing, m the maintenance cost per unit value, and π^e the investor's expected rate of nominal house appreciation. The flow of net new construction is then according to Poterba (1984) given by $H_t - H_{t-1} = \phi(P_{Ht} / C_t) - \delta H_{t-1}$ (where C_t depicts construction costs; this approach is similar to Tobin's q theory of investment adjusted for external adjustment costs).

In addition to determining fluctuations on the housing market, the model by Stein (1993) tries to address the question of why there is fall in trading activity on falling markets. The different liquidity constraints on different types of households related to their down payments when purchasing a house makes up a major assumption of the model. The financial constraints in this model magnify the effects from the standard "efficient market" model. The model also generates multiple equilibria and within-equilibrium multipliers, resulting in higher price volatility. The model predicts that the trading volume should be correlated with changes in prices. An extension of the basic model to include search and matching technology predicts a negative correlation of time-to-sell and housing starts with housing prices.

As far as empirical research on housing prices and their relation to the macroeconomy is concerned, the research is relatively extensive for developed countries. A nice overview of empirical studies is given in Girouard, Kennedy, Noord and André (2006). Some of the studies use a structural vector autoregression framework (for example Tsatsaronis and Zhu, 2004). Similarly, Iacoviello (2000) uses structural VAR analysis with a five-dimensional VAR with $X_t = [y; mp; hp; i; \pi]$ (y depicts real income, mp real money balances, hp the real housing price index, i the short-term nominal interest rate and π consumer price inflation) for six European countries. Adalid and Detken (2007) use a panel housing price model for 18 OECD countries to analyse the relation of housing prices during boom periods and money growth. They provide evidence for regime shift during boom periods. Noord (2006) tries to calculate the probability of a peak in housing prices in reaction to an increase in interest rates for 17 OECD countries using PROBIT analysis for the period 1970–2005. Girouard, Kennedy, Noord and André (2006) and McCarthy and Peach (2004) try to evaluate the fundamental price from price-to-income and price-to-rent ratios. Rae and Noord (2006) use a relatively simple two-equation approach (one equation for the market for new houses, the second for the market in "second-hand" houses) for the case of Ireland. A similar approach is applied by Hakfoort and Matysiak (1997) for the case of the Netherlands. Girouard and Blondal (2001) try to relate the development of housing prices to household consumption (the wealth effect).

Contrary to the developed countries, research for the new EU Member States remains thin on the ground. For the Czech Republic, an analysis of price-to-income and price-to-rent ratios is conducted in the CNB's Financial Stability Reports (CNB, 2009). Čadil (2009) applied the price-to-income ratio and then used VAR analysis to identify the possibility of a bubble on the Czech housing market for the period 1998–2006 for both apartment and family house prices. Zemčík (2009) applied the present value model and panel Granger causality techniques to information on prices and rents to identify bubbles. Hlaváček and Komárek (2009) applied both price-to-income and price-to-rent ratios, supplementing them with econometric analysis in order to identify the equilibrium path of the Czech housing market. Lux and Sunega (2003) try to assess the equilibrium rent for the case of rent deregulation and try to simulate the effects of this deregulation mainly on the social costs of the state. ARTN (2008) gives an interesting discussion of commercial property prices and related variables and also gives some description of the residential property segment especially in relation to housing construction. Nevertheless, the discussion of property price determinants in this report is mainly verbal. An interesting description of developments in the residential market is also given by King Sturge in its "Czech Republic Residential Report" (King Sturge, 2009), which describes developments in Prague in detail and also distinguishes between new and used apartments.

3. Sources of Real Estate Data in the Czech Republic

Any considerations about the equilibrium growth of housing prices and about possible negative shocks to them are necessarily influenced by the data source selected. Compared to “standard” markets the real estate market is rather specific, as real estate is to a large extent a heterogeneous type of good. The price of individual real estate depends on a number of characteristics, such as its type (apartments compared to family houses), its size (larger apartments are of course more expensive, but for the price per m^2 the relationship between price and size might be non-linear), its age and quality, its equipment, what floor the apartment is on, the view from the apartment and other similar characteristics that are difficult to measure. A specific feature of the real estate market is the virtual impossibility of transferring a property from one location to another, coupled with highly inelastic supply (the number of newly constructed apartments is just a small fraction of the overall housing stock[6]). Real estate prices are thus often determined regionally; within a given region other location characteristics are of high importance (e.g. city centre relative to suburb). This extreme heterogeneity of the real estate market of course makes construction of the housing price indicator complicated, while different data sources might lead to different conclusions.

In the Czech Republic there are several possible sources of data series on real estate prices. The main data sources are listed in the table in Appendix 1. Generally, one can distinguish two types of real estate prices – transfer prices and supply prices.[7] Real estate transfer prices are the closest to actual market prices in terms of methodology. The only available source of real property transfer prices in the Czech Republic is the Czech Statistical Office (see CZSO, 2009), which uses Ministry of Finance statistics from property transfer tax returns (for the evolution of these prices see Chart 2).

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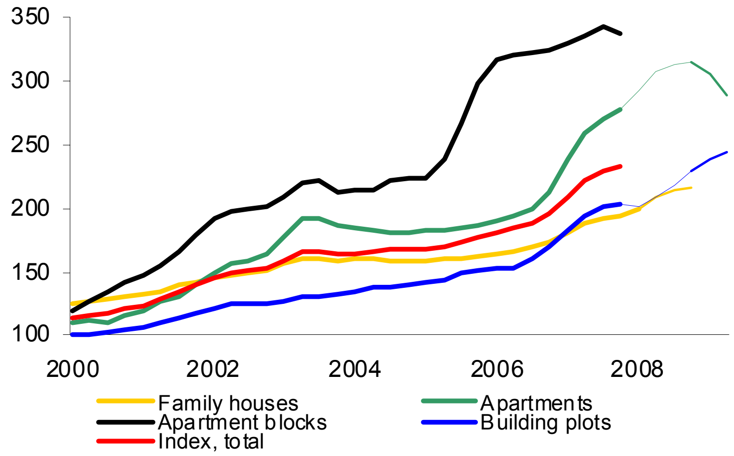
[6] Even in 2007, when the number of completions recorded its highest level since the early 1990s, the ratio of the number of newly constructed apartments to the total housing stock was only 1%. There are massive regional differences in the intensity of housing construction (higher construction in Prague and in Central Bohemia, for which the number of completions per 1,000 inhabitants is more than two and a half times that in the rest of the Czech Republic). However, even for the regions with the highest construction the numbers of completed apartments do not exceed 2% of the housing stock.

[7] For the sake of completeness we should also mention “property purchase prices”, which are provided by the Czech Statistical Office (see CZSO, 2008). The property purchase price reflects the total investment cost of building new property (at least the amount stated on planning permission application documents, i.e. the tentative costs of the build, including equipment). The property purchase price does not include expenditures on the building plot. The property purchase price is, however, often distant from the real market price and is usually lower. Its variability across regions is much lower compared to the other types of prices. We use this price rather as an explanatory variable (see Section 6.1). Another possible source of prices is price maps. These are available for quite a detailed breakdown (according to individual properties), but are not usable for our analysis as they are updated only rarely. Moreover, the basic source of the data is similar to that of the property transfer prices we use in the analysis.

Chart 2: Real Property Prices – Transfer Prices (absolute index, 1999 Q1=100)



Source: CZSO, CNB calculation.
Note: 2008 and 2009 data preliminary or calculated from supply prices (for prices of apartments and building plots.

The advantage of this source is its completeness – all transfers of used real property against payment are subject to tax. These statistics cover all major districts. The data are also classified according size of municipality and age of the given real estate. Another advantage is its relatively wide coverage according types of real estate (apartments, family houses, apartment blocks, building plots and garages) using a comparable methodology and structure. Another advantage is that the real property transfer prices have been published since 1998 and form the longest time series of all the available data sources. However, a big disadvantage of this data source is its long delay to publication of final data (almost one year[8]). Tax optimisation by the respondents might also influence the prices reported. Another disadvantage is that this index only includes information on the prices of transfers of already existing real estate. Information on the prices of new houses or apartments is not included, as they are not subject to property transfer tax (they are subject to value added tax).

The second type of apartment prices available is “supply prices”. These prices are usually based on the bid prices of estate agencies. Consequently, they are supposed to be higher than transfer prices. The advantage of this source of data is the swiftness of their publication (a minimal time lag). The obvious disadvantage is that the visible evolution of apartment prices might only reflect changes in the margins of real estate agencies.[9] These bid prices might also be biased by older advertisements with unrealistically high prices that survive in the list of advertisements for a longer time than advertisements with prices that are actually traded.

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[8] For apartment prices and family house prices, however, the Czech Statistical Office publishes estimates that are continuously updated with a lag of approximately one quarter. The final data, however, are often quite distant from those estimates.

[9] For individual advertisements it is often not clear whether or not the price bid includes the real estate agency’s commission. This might significantly influence the level and dynamics of prices, as these margins could have a significant cyclical component. The final price might differ from the advertised price due to different discounts, promotions, etc.

The longest data series of supply prices in the Czech Republic has been published by the Institute for Regional Information (IRI) since 2000 (until 2006 only yearly data; starting from 2007 quarterly data). The IRI uses the prices of a "standard apartment", i.e. it limits itself to prices of "1st category" apartments that are either cooperative or owner-occupied with a floor space of 68 m^2 and amortisation of approximately 40% in a conventional and not suburban location.[10] On the one hand, this enables us to avoid problems with changes in the structure of the housing stock and the need to change weighting schemes. On the other hand, one loses information about price developments outside this relatively thin market segment. For this reason this index often shows different dynamics compared to alternative indexes (see Charts 3 and 4 below). The advantage of IRI supply prices is that the IRI also publishes supply market rents. This enables us to construct an apartment rental yield index or price-to-rent indexes, which are the basic indicators of the sustainability of housing prices.[11] Another disadvantage is that even the data on IRI apartment prices can be obtained from various sources (websites, newspapers) and the database is not officially public.[12]

Another important primary source of real estate supply prices is the indexes constructed by the team around Professor Dolanský, which, starting from 2002, are published at monthly frequency in the journal "Realit". This source covers apartment prices, family house prices and building plot prices. Since 2007 it has also been publishing market rents. Apartment prices are classified in detail for different districts of Prague. The data for apartment prices outside Prague are not complete (some regional capitals are missing). Apartment prices from this database are also the primary source for the apartment supply prices published quarterly by the CZSO since 2004. An interesting source of apartment prices that was the first to signal the fall in apartment prices is the "Czech Republic Residential Report" published by the real estate advisory company King Sturge (see King Sturge, 2009). This source of data looks in detail at apartments as well as family houses in Prague and its districts. However, data on other regions of the Czech Republic are limited. These data also differentiate between used and new real estate.

Besides the above-mentioned sources of real estate supply prices there are several other data published that are discussed in the press. These cover, for example, data from real estate agencies themselves (AAA byty or Lexxus). Nevertheless, these data are usually available only to a limited extent. There is no long time series for them and related commentaries cover just the latest information. Therefore, they could not be used for our analysis.

The dynamics of apartment prices over the last five years are depicted in Charts 3 and 4. From these charts one can clearly see a stagnation of apartment prices in 2004–2005 (and according to some sources even until 2006 H1), followed by accelerating growth of apartment prices until the end of 2007. The maximum year-on-year growth rates of apartment prices were between 21% and 37%. During 2008, housing prices gradually decelerated (to begin with mainly because of a high base). In 2009 this slowdown turned into year-on-year decreases in line with the worsening general economic situation.

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[10] See http://www.kiseb.cz/zrcadlo/def_standard.asp.

[11] For a deeper analysis see Cimburek, Hlaváček and Komárek (2008) or CNB (2008).

[12] Archive data from the website http://cenybytu.idnes.cz/ are always overwritten by the actual data.

Chart 3: Apartment Prices – Prague (year-on-year indexes)

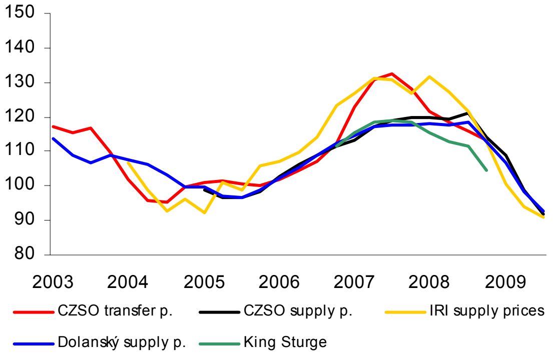
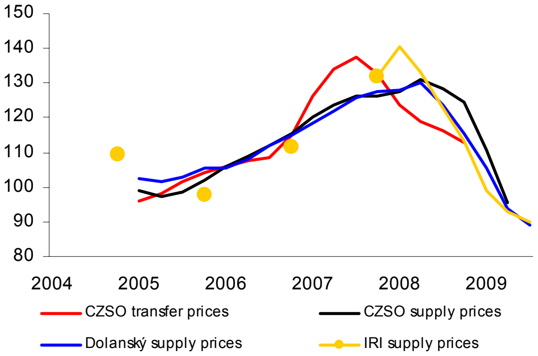


Chart 4: Apartment Prices –Rrest of Czech Rep. (year-on-year indexes)



Source: CZSO, IRI, Realit, King Sturge

The growth in apartment prices shows similar tendencies across the different sources (correlation coefficients between 0.85 and 0.99 – see Appendix 2). Comparing the two charts one can conclude that the size of the year-on-year drop in prices in 2009 according to a given source is negatively linked to the previous growth of prices according to this source in 2006–2008. In other words, the sources that reported the highest price growth for apartments are now reporting the highest price drops in 2009. This is visible, for example, from a comparison of IRI and CZSO supply prices.[13] This might be due to the fact that the IRI covers only a relatively narrow part of the apartment market with lower prices that are more sensitive to changes in the economic situation.

Comparing the CZSO transfer price and supply price dynamics it seems that the reaction of transfer prices is somehow quicker (see also Appendix 2 for lagged correlations that illustrate this as well). This might indicate some counter-cyclicality of the margins between supply and transfer prices, with margins shrinking during massive growth in prices (i.e. transfer prices rising quicker than supply prices) and widening during large declines in prices. Comparing Charts 3 and 4 one can see that during the last period of high price growth there was some convergence tendency for apartment prices between Prague and the rest of the Czech Republic, as prices grew faster in the rest of the Czech Republic than in Prague according to both transfer prices and supply prices. On the other hand, the lagged correlations indicate that Prague is, at least to some extent, the price leader for the rest of the Czech Republic.

These stylised facts from Charts 3 and 4 in combination with the lead/lag correlation matrix from different data sources (see Appendix 2) show that CZSO transfer prices often lead the prices from the other data sources. Due to the long time lag of publication by this source this advantage of course disappears. However, given its combination of the most detailed regional coverage and the clearest methodology we decided to use this data source primarily. For the newest data (2009), as well as for some additional information (e.g. rents), we also used the other data sources. We decided to conduct our analysis only for apartment prices and not for the other types of real estate (e.g. family houses and apartment blocks; we used building plot prices only as an explanatory variable – see Section 4.2). The reasons were threefold. Firstly, apartment prices are the most

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[13] Or Dolanský supply prices, which correlate strongly with the CZSO ones as the former are the primary data source for the latter.

widely covered by the alternative data sources. This allows us to check the consistency of their price developments and to prolong the data series for supply prices to include the latest data. Secondly, as one can see from Chart 2, apartment prices show the most interesting price dynamics and therefore a price bubble is most likely to be identified for them.[14] Thirdly, apartments should be more "homogeneous" than, for example, family houses. This makes the analysis of apartment prices more likely to be successful. However, one has to keep in mind that we describe only part of the real estate market and that we do not opt for analysis of the other segments (e.g. family houses). For example, for the period 2005–2007 the number of used apartment transfers formed only 56% of all transfers of used residential units (apartments and family houses). Their share in the volume of transactions was 49% owing to a higher price per unit for family houses.[15]

4. Factors Determining Property Prices

The fundamental factors determining property prices in the Czech Republic on which the quantitative analysis below is performed can traditionally be divided into supply and demand factors (see, for example, HM Treasury, 2003, or Égert and Mihaljek, 2008). Compared to the other studies applied to the Czech Republic's housing market (Čadil, 2009, and Zemčík, 2009) we opted to include as wide a set of explanatory variables that might be linked to house prices as possible. This was motivated by the nature of the real estate bubble discussed in Section 1. As we define a housing bubble as being the part of house prices that cannot be explained by macroeconomic fundamentals, the omission of some potentially significant factor of housing prices could lead to a bubble being identified even in a situation where prices could easily be explained by this factor.

4.1 Supply Factors

Supply on the housing market is generally driven primarily by the profitability of the construction business and is regarded as sticky in the short run (see, for example, Poterba, 1984). The housing market is often divided into two segments: the segment of existing housing with inelastic supply, where the price is already fixed, and the segment of new housing construction, where the price determines the amount of new construction. Supply in the existing housing market can be proxied using the saturation of housing needs (the number of apartments per 1,000 inhabitants) or the dynamics thereof (the number of newly completed apartments). Higher saturation of housing needs should lead, ceteris paribus, to lower upward pressure on apartment prices.

The supply factors also include the majority of cost factors, such as building plot prices, average apartment acquisition amounts and building construction costs. Building construction costs can proxied using "apartment construction prices", which aggregate the total projected construction investment costs excluding building plot prices. Another possibility is to use the construction output price index.[16] A rise in the costs of acquiring a new apartment should, at a given level of demand, lead to a rise in the value of existing apartments. Supply factors often pass through to property prices with a long lag, due to the long time it takes to prepare and actually implement a construction project.

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[14] The prices of apartment blocks recorded even higher growth than apartment prices. However, the number of transfers is low compared to the other types of real estate (with a much higher price per transfer).

[15] There were also significant regional differences for these shares. For example, in Prague apartments form 94.6% of all transactions and 89.4% of their volume, while the respective numbers for Central Bohemia are 45% and 33%.

4.2 Demand Factors

Demand for property is determined primarily by households' disposable income, the main component of which is wages and salaries. They affect both the accumulation of savings and wealth by households and the availability and riskiness of housing loans. Other labour market factors that can influence property prices include the unemployment rate, the economic activity rate of the population and the number of vacancies. These factors mostly affect disposable incomes either directly (lower unemployment and a higher economic activity rate of the population mean higher disposable income of households at any given wage level) or indirectly via labour force mobility (migration in search of work). With the exception of unemployment, growth in labour market factors should lead to growth in apartment prices.

Apartment prices can also be affected by various demographic factors: linked with the aforementioned labour market factors is population growth due to migration; natural population growth should act in the same direction. Property price growth should also be fostered by a higher divorce rate, as most divorces turn one household into two, thus giving rise to a need for a new dwelling. The marriage rate can act in the same direction, as a wedding often establishes a completely new household. Demand for housing can also be affected by the age structure of the population (people of productive age should usually form the majority of demand for new housing), which, however, is reflected in the economic activity rate of the population.

The major factors of property price growth have recently also included the development of the financial market. This is being reflected primarily in growth in housing loans and is reducing the liquidity constraints on households when acquiring their own housing and should therefore be pushing property prices upwards. The mortgage interest rate (proxied by the one-year money market rate) acts in the opposite direction, as growth in the mortgage rate makes loan financing of property purchases less attractive and increases households' repayments of existing loans.[17] Demand from abroad can affect demand for housing quite strongly.

Demand for property can also be affected by market rents, growth of which tends to lead to rising apartment prices. This factor reflects substitution between rental and ownership housing, as rising rents motivate households to buy a flat of their own and therefore increase demand for owner occupied housing. The level of rents also affects investment in housing for speculative reasons, as growth in rents ceteris paribus increases the returns on such investment and leads to rising demand for apartments. The dependence between apartment prices and market rents can go in either direction, of course. The aforementioned substitution between rents and home ownership may therefore mean that, conversely, a rise in apartment prices will lead to a rise in market rents (home ownership will become less affordable, causing demand for rented accommodation to rise). Besides that, one needs to take into account the decisions of owners of rental properties as to whether to continue renting the property or whether to sell it (as happened in the past with many municipal flats with regulated rents). Given the limited length of the time series, however, we do not examine the direction of the causality between apartment prices and other variables in our analysis.

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[16] The advantage of the construction output price index compared to apartment construction prices is its higher frequency (monthly compared to yearly). On the other hand, the construction output price index is not available in regional coverage, unlike apartment construction prices. Therefore, we used the construction output price index in the quarterly time series analysis (see Section 7.1) and apartment construction costs for the yearly regional panel analysis (see Section 7.2).

[17] Unfortunately for the Czech mortgage market there is no indicator of the credit market conditions going beyond the simple interpretation of interest rates (such as the IMF Mortgage Market Indicator). Moreover, even the data on interest rates on housing loans are available only from 2004 onwards and therefore we had to use just the money market rate, which does not include information on the spread of housing loans.

Descriptive statistics of the supply and demand factors for the average Czech region, based on annual data, are given in Table 1 (simple averages among 14 regions). Except for the housing loan volume (CNB figures combined with Ministry of Regional Development data) and the estimate of market rent (IRI), all the other data came from the CZSO as well. Among other things, Table 1 confirms the assumption that the variability of apartment prices and their individual determinants is in most cases higher – sometimes quite a lot higher – across regions than over time. Therefore, panel data analysis among regions should be the natural type of analysis for housing prices. Table 1 also identifies variables with too little variance both over time and across regions, which would not be significant factors of housing prices (e.g. apartment construction prices, number of apartments per 1,000 inhabitants, marriages and economic activity rate).

Table 1: Descriptive Statistics (figures for average region; annual data for 1998-2008)

	Variable	Unit	Mean	Median	Variability over time (%) [b]	Variability across regions (%) [b]
	Apartment prices [a]	Kč/m^2	13 000	12 128	27.4	37.6
Supply factors	Building plot prices [a]	Kč/m^2	1 338	1 090	15.5	66.5
	Apartment construction prices [a]	Kč/m^2	23 369	22 756	4.5	10.3
	Completed apartments (without family houses)	% of hous. stock	0.32	0.31	27.5	59.2
	No. of apartments per 1,000 inhabitants	number	428.7	429.6	2.0	5.9
Demand factors	Marriages	% of MYP	0.52	0.51	5.0	6.2
	Divorces	% of MYP	0.30	0.30	9.3	14.3
	Natural population growth	% of MYP	-0.05	-0.08	238.0	166.9
	Net migration	% of MYP	0.14	0.07	194.3	607.0
	Unemployment rate	%	7.30	6.59	19.7	38.5
	Economic activity rate of population	%	59.7	59.5	1.7	2.4
	Vacancies/labour force	%	0.35	0.29	48.9	37.3
	Average monthly wage [a]	CZK	13 458	13 385	13.0	11.0
	Rent per month [a]	CZK/m^2	75.0	72.6	14.2	27.5
	Loans [a]	CZK millions	15 235	8 354	82.9	112.1

Source: CZSO, CNB, IRI

Notes: [a] In 1998 prices

[b] Variability computed as standard deviation in % of mean

MYP denotes mid-year population

A comparison of the evolution of the quarterly explanatory variables for the Czech Republic as a whole and for Prague with the dynamics of apartment prices is given in the charts in Appendix 3. The development of the explanatory variables at yearly frequency across regions is then available in Appendix 4. From those charts it can be seen that the building plot price dynamics correlate fairly well with apartment price growth, although they are less volatile and this link has weakened somewhat recently. Both apartment prices and building plot prices are much higher in Prague than in the rest of the Czech Republic.

The correlation of apartment prices with construction prices is weak and in some periods even negative. Their variance across regions is also much smaller. There is no visible link between apartment prices and saturation of housing needs as expressed both by the number of apartments per 1,000 inhabitants and by completions. For both variables the saturation of housing needs seems to be higher in Prague than in the rest of the Czech Republic.

As far as demographic variables are concerned, there is some weak link between apartment prices and the marriage rate and migration. The divorce rate seems to be relatively stable. Natural population growth was relatively stable and negative until 2005 then accelerated in all regions. Until 2004 natural population growth in Prague was much lower than in the rest of the regions, but its speed-up since 2004 has been much quicker. Prague also reports much higher net migration.

Of the labour market factors there seems to be quite a strong link between apartment price dynamics and unemployment and wages, with unemployment being the lowest and wages the highest in Prague compared to the other regions. The link between apartment prices and the economic activity rate of the population seems to be weak. The number of vacancies seems to be relevant only in the most recent period. For both indicators the rates for Prague are relatively high compared to the other regions.

The link between apartment price dynamics and the dynamics of rents was relatively strong until 2005, with the highest rents reported for Prague and the lowest for regions with the lowest apartment prices (Ústí nad Labem – U, and Ostrava – T). The link to the dynamics of housing credit was relatively weak, as housing credit was growing strongly irrespective of housing market developments. The only link appeared during the recent financial crisis. The relative size of housing credit was again the highest in Prague. The link to the interest rate was relatively weak.

For some of the aforementioned explanatory variables we can expect strong endogeneity within the model of apartment prices, which may be due to causality in the opposite direction. For example, the aforementioned substitution between rents and home ownership may run in either direction (i.e. a rise in apartment prices may lead to upward pressure on rents), higher prices may lead to greater housing construction, and so on. In addition, a common factor may be acting on some explanatory variables, one which is unobserved and which might be the cause of a bubble. For instance, irrational and self-fulfilling expectations regarding future price growth will very probably give rise to a bubble both on the housing market and on the building plot and rental markets. If we include these variables in the apartment price model, the estimated price bubble will be smaller than in reality.

5. Simple Indicators of Housing Price Sustainability

Following OECD (2005) one can quickly visualise the excessiveness of housing prices using simple price-to-income or rental return[18] ratios. These ratios for the Czech Republic are regularly analysed in the CNB's Financial Stability Reports (see CNB, 2009). The rental return is implicitly used in the present value model for the Czech real estate market applied by Zemčík (2009) and the price-to-income ratio is used for identification of bubbles in that market by Čadil (2009). The two ratios are depicted in Charts 5 and 6. From Chart 5 one can deduce that for the majority of the Czech regions the rental return ratio was constantly worsening between 2000 and 2008 H1. Until 2005 this worsening was in line with the drop in interest rates, but starting from 2006 the rental return declined further despite rising government bond yields and housing loan interest rates. Thus, the growth in prices in 2006–2008 might have some bubble component according the rental return indicator. A drop in prices in 2009 resulted in an improvement of the rental return indicator for the majority of regions, but for the majority of them it remains below the relevant interest rates.

Similarly, the price-to-income ratio (Chart 6) indicates two potential apartment price bubble periods, namely the start of 2003 and late 2007/early 2008. These periods are those with high price growth (see Charts 2, 3 and 4). For the period 2004–2006 one can see that the housing price bubble might ease relatively easily from the point of view of the price-to-income ratio. During this period, apartment prices were more or less stable and the improvement in the price-to-income ratio was due to wage growth. However, a question arises as to whether this can be repeated in the generally less favourable macroeconomic conditions of the world financial crisis. The improvement in the price-to-income ratio in 2009 was mainly due to apartment price drops. The ratio remains at relatively high levels.

From both the price-to-income and rental return ratios one can also work out which regions are "more risky" from the point of view of these indicators. Looking at the cross-regional dimension of those indicators (Charts 5 and 6) it is evident that the worst values are reported for regions with relatively high absolute prices (Prague) and the most favourable values for regions with relatively low absolute prices (northern Bohemia – Ústí nad Labem, and northern Moravia – Ostrava).

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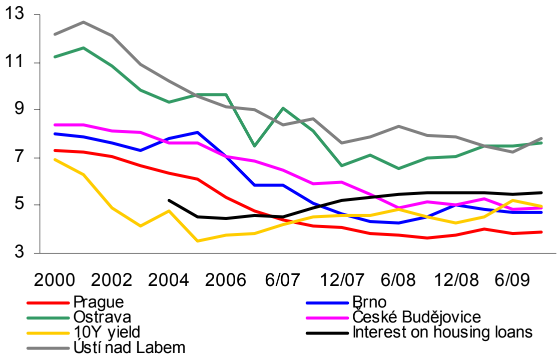
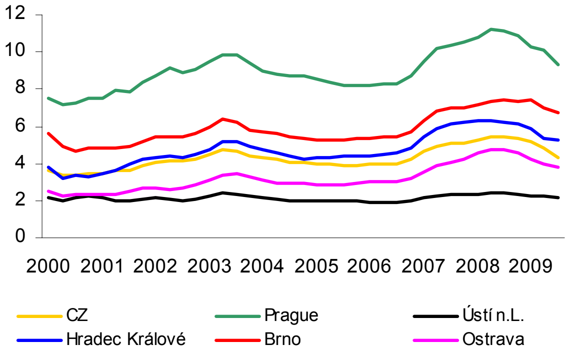
[18] The rental return ratio is the inverse of the alternatively used price-to-rent ratio. Its advantage is that it can be compared directly with interest rates in the economy.

Chart 5: Rental Returns (averages for period in %; comparison with yields on 10Y government bond and housing purchase loan rates)



Source: IRI, CNB, data for 2009 preliminary

Chart 6: Price-to-income Ratios (ratio of price of 68 m2 apartment to wage for last 4 quarters)



Source: CZSO transfer prices, CNB calculation
Note: 2008/09 data preliminary or calculated from supply prices.

6. Empirical Methodology

Panel data models allow us to develop and test situations which (in comparison with time series or cross-sectional models) better reflect reality. In econometrics, panel data is data observed over at least two dimensions[19] (typically time and cross-sections), which means that we observe several objects over the given period of time. The cross-sectional component is denoted by the subscript $i = 1,..., N$, for monitoring N objects (for example countries, regions, individuals, etc.). Similarly, the time series component is denoted by the subscript $t = 1, ..., T$, for monitoring every object in T time periods.[20]

In general, it is possible to introduce several variants of panel data models, which arise from the application of various model assumptions (especially concerning the model parameters) characterising the cross-sectional and time component. The dependent (endogenous) variable y is expressed by the vector of independent (exogenous) variables X in the form where: (i) the slope is constant and the intercept is changing for particular objects, but is not changing over time – equation 1, (ii) the slope is constant and the intercept varies for individual objects as well as in time – equation 2, (iii) both coefficients are changing for individual objects, but not in time – equation 3, and (iv) all coefficients are changing for individual objects as well as in time – equation 4; i.e. expressed mathematically [21]:

$$y_{it} = \alpha_i + \sum_{k=1}^{K} \beta_k X_{kit} + u_{it} \qquad i = 1,..., N; \quad t = 1,...T \qquad (1)$$

$$y_{it} = \alpha_i + \lambda_t + \sum_{k=1}^{K} \beta_k X_{kit} + u_{it} \qquad i = 1,..., N; \quad t = 1,...T \qquad (2)$$

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[19] A panel data set is termed "multidimensional" when the phenomenon is observed over three or more dimensions.

[20] Baltagi (2001) discusses the major advantages and limitations of using panel data.

[21] The models with constant slope, i.e. models (1) and (2), are applied most frequently.

$$y_{it} = \alpha_i + \sum_{k=1}^{K} \beta_{ki} X_{kit} + u_{it} \qquad i = 1,...,N; \quad t = 1,...T \tag{3}$$

$$y_{it} = \alpha_{it} + \sum_{k=1}^{K} \beta_{kit} X_{kit} + u_{it} \qquad i = 1,...,N; \quad t = 1,...T\,. \tag{4}$$

An important element is whether or not coefficient α_i is correlated with the regressors (Greene, 2003, p. 285). When α_i is uncorrelated with the regressors, we conceive a model with random effects; and when there is a correlation, we conceive a fixed-effects model. Essentially the difference between these two model categories centres on whether α_i feature as part of the regressors (fixed-effects models) or as part of the error term (random-effects models). Random-effects models are applied when the panel data comprise *N* objects drawn randomly from a large population, i.e. α_i are randomly distributed across cross-sectional units. Similarly, fixed-effects models are more appropriate when focusing on a specific set of *N* objects that are not randomly selected from some large population. The decision about which model type to apply (fixed-effects versus random-effects models) is often not trivial (parameter β in models with fixed effects is different from that in models with random effects). It depends on the economic logic of the problem to be solved, the size of *N*, and other specific information.[22]

In our empirical analysis of property price determinants in the Czech regions we employed panel data models with fixed effects (due to the relatively small number of *N*)[23], which can be formalised as follows (see, for example, Baltagi, 2002, Hsiao, 2003, or Wooldridge, 2002):

$$y_{it} = \beta' x_{it} + \varepsilon_{it} \qquad i = 1,...,N; \quad t = 1,...T \tag{5}$$ [24]

The value of the endogenous variable y_{it} (of region i at time t) is dependent on K exogenous variables $x'_{it} = (x_{1it}, x_{2it}, ...x_{Kit})$, which vary over different Czech regions and time. The error term ε_{it} can be theoretically separated into three components, i.e.: $\varepsilon_{it} = \alpha_{it} + \gamma_t + \omega_{it.}$. We can assume for simplicity that $\gamma_t = 0$, α_i is constant (because of the application of the fixed-effects model) and $E\varepsilon_{it} = \alpha_i$, $\mathrm{E}\omega_{\mathrm{it}}\omega_{\mathrm{pr}} = \sigma_\varepsilon^2 \quad \text{if i = p, t = r; and } \mathrm{E}\omega_{\mathrm{it}}\omega_{\mathrm{pr}} = 0 \text{ otherwise}$.

7. Results

The empirical analysis was conducted by means of (i) aggregate regression analysis of time series for the Czech Republic and Prague on quarterly data for the period January 1998–June 2009, and (ii) panel regression across the Czech regions (including and excluding Prague) on annual data for 1998–2008. The explained variable was apartment price growth (aggregate regression) or the apartment price level (panel regression), in real terms in both cases.[25] The explanatory variables used are listed in Table 1. In both empirical calculations we work with unlagged exogenous variables (owing to the short length of the time series used). In both analyses we also conducted an estimate based on a narrower set of explanatory variables owing to the possible existence of endogeneity of some explanatory variables (see the end of Section 4). Due to the low number of observations we were not able to capture this endogeneity analytically other than by removing variables suspected of endogeneity from the regression. By comparing different versions of the regression we also get some idea of the stability and robustness of our results.

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[22] In the case where *N* is large relative to *T*, consistent estimation of fixed-effects models may be difficult, especially in non-linear models.

[23] The empirical proof for the proper application of the model with fixed or random effects is given by the Hausman test.

[24] This model is alternatively denoted as the least square dummy variable model.

[25] Hlaváček and Komárek (2009) present a similar analysis for nominal apartment prices.

7.1 Time Series Analysis for the Czech Republic and Prague

The results of the regression analysis for Prague and the Czech Republic as a whole (see Table 2, CZ – Estimate A[26]) show that the apartment price growth can be explained mainly by rising prices of building plots, rising vacancies/labour force, rising average monthly real wages and rising monthly real rents. A weak effect is also observed for rising net migration. In the narrower estimation for the Czech Republic (CZ – Estimate B), natural population growth (in addition to vacancies/labour force and real monthly rent) was another significant factor, along with natural population growth and partly also the marriage rate in the case of the narrower estimate. The growth in apartment prices in Prague (Prague – Estimate B) is mainly explained by movements in the unemployment rate, economic activity and natural population growth. The other variables used were not significant at the required level of significance.[27] This was particularly surprising for growth of housing credit and its conditions (estimated by interest rates), which are often mentioned as important drivers of housing prices. This might be due to the fact that housing credit grew exponentially, with relatively low variation in its growth level. Another reason might be that the housing credit level was growing from very low levels in the first part of the period analysed. Therefore, it cannot be assumed to be significant factor of apartment price development until 2002.

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[26] Estimate B does not include the evolution of land prices and real monthly rents, which could be endogenous. Some of the variables included in the model are used in levels rather than in growth (e.g. the unemployment rate or Pribor). This mainly reflected the stationarity of different data series (see Appendix 5). However, it means that these variables could have a permanent effect on prices.

[27] Tests of the residuals ruled out the occurrence of autocorrelation and non-normality at the usual level of significance. Moreover, tests of the stability of the coefficients by recursive estimation demonstrated relatively satisfactory stability.

Table 2: Results of Regression for Prague and the Czech Republic

Variable	CZ - Estimate A		CZ - Estimate B		Prague - Estimate B	
Apartment prices ^{a}	Coefficient	Std. dev. ^{b}	Coefficient	Std. dev. ^{b}	Coefficient	Std. dev. ^{b}
Building plot prices ^{a}	0.481*	0.240	-	-	-	-
Construction output price index ^{a}	-0.576	0.504	0.764	0.492	0.263	0.685
Completed apartments ^{a,c}	0.000	0.000	0.000	0.000	0.000	0.000
No. of apartments per 1,000 inhabitants	0.000	0.001	0.001	0.001	0.001	0.001
Marriages ^{c}	0.963	0.968	0.650	1.228	1.249	0.886
Divorces	0.120	0.496	0.107	0.575	0.147	0.661
Natural population growth ^{c}	0.665	0.528	0.703**	0.335	0.599*	0.320
Net migration	0.100*	0.057	0.068	0.095	0.011	0.019
Unemployment rate	0.004	0.006	0.001	0.006	-0.0385*	0.021
Economic activity	-0.0055	0.006	-0.007	0.005	-0.0087*	0.005
Vacancies/labour force	0.101**	0.049	0.132**	0.050	-0.016	0.042
Average monthly wage ^{a,c}	1.215***	0.424	1.239*	0.641	0.398	1.393
Rent per month ^{a}	0.459**	0.195	-	-	-	-
Loans ^{a}	0.048	0.061	0.006	0.080	0.099	0.209
1Y Pribor	0.003	0.003	0.003	0.005	0.000	0.006
Adjusted R^2	0.54		0.19		0.07	
Durbin-Watson statistic	1.78		1.22		1.23	

Source: CZSO, CNB, IRI

Notes: Cells in yellow highlight coefficients significant at least at 10% level
*** significant at 1%, ** at 5% and * at 10% level of significance
$^{a)}$ differences, $^{b)}$ Newey-West HAC standard deviations, $^{c)}$ seasonally adjusted

The above estimate A for the Czech Republic[28] can be used to broadly identify periods when property prices were overvalued and also to identify the magnitude of such overvaluation. The estimates of equilibrium property prices and the gaps between actual and equilibrium property prices are shown in Charts 5 and 6. These estimates were then compared with the “naive” equilibrium estimate obtained by applying the Hodrick-Prescott (HP) filter. Like the HP filter, our regression identifies two possible periods of property price overvaluation (bubbles), namely the start of 2003 and late 2007/early 2008. The one-quarter to one-half level of overvaluation resulting from the model compared to the HP filter is not surprising.[29] One difference between these two periods might be that the growth in prices in 2002/2003 was driven mainly by speculation linked with the Czech Republic’s accession to the EU, whereas the recent surge in 2007/2008 is due primarily to improved fundamentals (wage growth, higher population growth, lower unemployment, etc.).[30] Analogously, the results of the HP filter for the recent period, which identify strong undervaluation of current property prices in the Czech Republic, are not credible from our point of view. This is mainly due to the well known end-point-bias problem of the HP filter, especially during changes of trend. The HP filter also does not account for the strong worsening of the macroeconomic situation in the Czech Republic at the end of 2009 linked to the world financial crisis.

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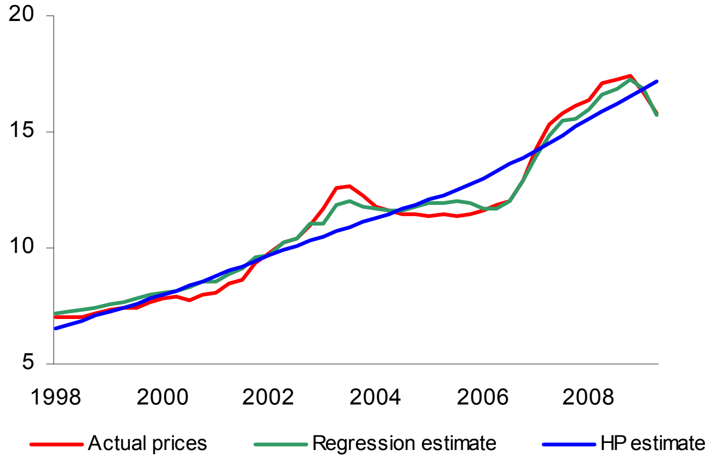
[28] As our regression estimates the equilibrium quarter-on-quarter growth in property prices, the equilibrium absolute prices were computed from the estimated quarter-on-quarter increases.

[29] The fact that the regression-based estimate fits the actual data more closely than the HP filter is due to the additional effect of a relatively high number of explanatory variables. When the version of the model with endogenous variables excluded is used, the result lies somewhere between the HP filter and the model containing all the explanatory variables in Table 1.

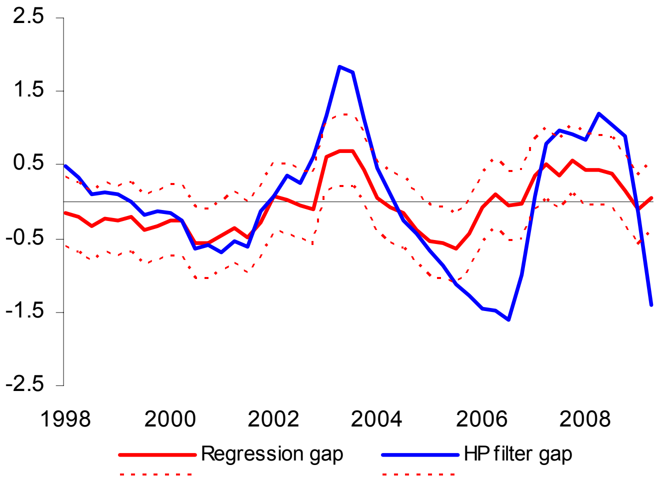
[30] This outcome is also linked with the nature of the data, i.e. with the different cyclical component in the individual variables in the regression, which to some extent prevents a bubble from manifesting itself.

Chart 7 Apartment Prices in the Czech Republic (CZK thousands per m^2)



Source: CZSO, CNB calculation

Chart 8 Gap in Prices in the Czech Republic (deviation of actual prices from estimate in CZK thousands per m^2)



Source: CZSO, CNB calculation
Note: positive values overvaluation, negative values undervaluation; dashed lines indicate 10% confidence interval

7.2 The Czech Republic by Regions

In order to capture analytically the aforementioned heterogeneity of houses as an asset at least partially, we estimated a panel regression for apartment prices covering the individual Czech regions.[31] The results are summarised in Tables 3 and 4. We also included three versions of the regression in Table 3, keeping in mind the potential endogeneity of some explanatory variables. Therefore, in the second and third columns (CZ – estimate A) we included the full set of variables, while in the fourth and fifth columns (CZ – estimate B) building plot prices and monthly rents were excluded from the regression. Both specifications reported a similar list of significant variables as well as similar signs on those variables. This indicates that endogeneity has not the broken relationships between housing prices and their determinants completely. In the last two columns (CZ excluding Prague – estimate B) we tried to capture the specific nature of Prague as the capital city by removing it from the sample as an outlier. Again, the results of the regression changed only slightly.

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[31] The statistical tests indicated that it was appropriate to use a panel regression with fixed effects. We tested the panel data for non-stationarity using the Hadri panel unit root test, which tests for stationarity in so-called heterogeneous panels. For the outcomes of these tests see Appendix 5. For some variables we had to use their first differences to make them stationary.

To capture the differences in property prices between regions, we used absolute prices in CZK per m2.[32] However, to eliminate non-stationarity of the residuals, we used two alternative approaches. In the first one, denoted OLS, we used the differences of the apartment prices that are stationary (see Appendix 5). By doing this we eliminated fixed effects and therefore we could use just simple ordinary least squares regression.[33] In the second approach (marked PR) we used panel regression with fixed effects on the level of prices and we incorporated apartment prices lagged by one year in the explanatory variables. Not surprisingly, they turned out to be statistically significant, indicating some persistence in apartment prices.[34]

Compared to our previous analysis (see Hlaváček and Komárek, 2009) we opted to explain real housing prices (expressed in 1998 prices) instead of nominal prices. We also recalculated the nominal explanatory variables into real ones. This change did not have any influence on the weights of the different nominal variables, as it just involved dividing prices by the same number. However, it did slightly change our results regarding the relative importance of variables that were included as nominal ones in our original model (e.g. building plot prices, wages and housing credit) and variables calculated as real ones even in the original regression (e.g. demographic factors, unemployment and other labour market variables). This change generally led to an increase in the significance of some variables that were treated as real even in the original regression. Generally, the model with real variables seems to be more robust than the one with a combination of nominal and real ones. The only problem we found was a loss of significance of housing loans.

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[32] The use of absolute prices, however, precludes a simple comparison of the magnitudes of the resulting coefficients between Tables 2 and 3. In the first case the coefficients reflect the impact on price growth, whereas in the second they reflect the impacts on the price level. Moreover, the significance of the coefficients from the panel regression may differ from the results of the regression in Section 6.1. Some of the variables may have insufficient variability over time (and so cannot explain the growth in prices) but sufficient variability across regions (which may lead to them being significant in the panel regression).

[33] Another possibility would be to use fixed-effects regression for apartment prices expressed in differences. However, such regression would have a slightly different interpretation than, for example, regression with fixed effects on housing price levels. Here, the fixed effects would show some systematic differences in apartment price dynamics across regions. However, a quick look at the first chart in Appendix 4 or at Chart 3 and comparing the dynamics of housing prices gives the intuitive result that the fixed effects propagate themselves rather through regional differences and are not so important for the dynamics. Therefore, the panel regression with fixed effects on housing price differences gives broadly same results as the panel regression in levels with lagged apartment prices among the explanatory variables.

[34] The estimated coefficient here is less than one, so the estimated relation should converge.

Table 3: Results of Panel Regression by Czech Regions

Variable	CZ - Estimate A		CZ - Estimate B		CZ excl. Prague - Estimate B	
Apartment prices	OLS	PR	OLS	PR	OLS	PR
Apartment prices ^{a}	x	0.938*** *0.074*	x	0.776*** *0.088*	x	0.859*** *0.093*
Building plot prices ^{b}	0.633 *0.675*	1.223* *0.715*	x	x	x	x
Apartment construction prices ^{b}	0.016 *0.062*	0.007 *0.064*	0.012 *0.079*	0.001 *0.080*	0.014 *0.082*	0.019 *0.081*
Completed apartments	-1.158 *7.704*	0.402 *9.290*	-16.161 *9.580*	-0.598	-11.456 *9.546*	5.813 *11.649*
No. of apartments per 1,000 inhabitants	-0.148*** *0.059*	-0.031 *0.281*	-0.297*** *0.072*	-0.155 *0.348*	-0.295*** *0.070*	-0.411 *0.404*
Marriages	-0.504 *32.597*	3.006 *46.382*	1.178 *41.270*	-66.890 *56.564*	-3.932 *38.936*	-49.907 *56.277*
Divorces	50.739** *27.595*	82.321** *42.100*	76.245*** *35.077*	75.974 *52.351*	68.843** *34.432*	71.099 *48.059*
Natural population growth	38.941*** *12.261*	70.323*** *22.430*	16.269 *15.306*	56.733** *27.863*	34.292** *15.238*	78.167*** *28.195*
Net migration	3.902 *4.727*	6.983 *5.796*	9.540* *5.978*	15.395** *7.088*	9.479 *6.313*	9.995 *7.594*
Unemployment rate	-1.407*** *0.444*	-2.155*** *0.802*	-2.675*** *0.537*	-4.406*** *0.922*	-2.487*** *0.507*	-4.106*** *0.841*
Economic activity rate of population	-1.005 *0.785*	0.880 *1.291*	-0.512 *0.991*	1.220 *1.602*	-0.636 *1.098*	1.342 *1.582*
Vacancies/labour force	11.958** *5.866*	3.985 *6.952*	13.444* *7.488*	7.303 *8.617*	8.127 *7.310*	2.086 *8.411*
Average monthly wage ^{b}	1.807*** *0.592*	2.001*** *0.662*	2.756*** *0.741*	3.017*** *0.807*	2.499*** *0.726*	3.179*** *0.776*
Rent per month ^{b}	102.285*** *12.322*	95.205*** *13.453*	x	x	x	x
Loans ^{b}	0.048* *0.027*	-0.011 *0.039*	0.071** *0.032*	0.013 *0.043*	0.095 *0.075*	0.044 *0.115*
1Y Pribor	1.515 *1.060*	1.958 *1.250*	2.066 *1.354*	1.311 *1.551*	2.693 *1.378*	1.899 *1.476*

Source: CZSO, CNB, IRI

Notes: Cells in yellow highlight coefficients significant at least at 10% level
*** significant at 1%, ** at 5% and * at 10% level of significance
PR - panel regression; OLS -ordinary least squares regression. Standard errors in italics.
^{a}) variable lagged by1Q, b) differences

The regression results showed that supply side effects are not an important factor of apartment price growth. The only exception was the influence of the saturation of housing needs in the OLS regressions, which was significant with the correct sign in all three versions of the regression. In the panel regression the effect of a rise in building plot prices had the correct positive sign and was insignificant at the 10% level. Nevertheless, in the case of building plot prices, one can also discuss the direction of the implication between apartment prices and building plot prices or their substitutive relationship with apartment prices as assets. The regression implicitly considers this cost effect, as higher building plot prices lead to higher costs of new apartment construction and higher prices of new apartments. However, one can also consider the opposite effect, where high apartment prices lead to more intensive apartment construction, reflected, in turn, in higher demand for building plots, which, given its low price elasticity, leads to rising prices of building plots. The second component of apartment-building costs, "apartment construction prices", which reflect the costs of building, turned out to be insignificant even though they had the correct sign. This is probably because this price shows little variability between regions as well as over time.

Of the other supply factors, the number of newly completed apartments also proved to be insignificant. This factor had the expected sign only in four specifications (higher completions and higher housing saturation should lead, ceteris paribus, to lower prices). The explanation here may again be the opposite implication, with higher apartment prices – given relatively stable construction costs across regions – leading to higher apartment construction and, in turn, to a higher number of apartments.

Of the demographic factors, the divorce rate proved significant (it was insignificant in only two of the six alternative specifications, and even then it was at the border of the 10% significance level). The sign on it is consistent with intuition, as a higher divorce rate leads to a greater need for housing (a divorce usually gives rise to a new household). A similar effect can be expected for the marriage rate, although it turned out to be statistically insignificant. This might be due to the fact that marriages nowadays take place only if the couple has already solved its housing needs. As for population growth, net migration was significant for two specifications and natural population growth was significant for five cases. Both variables had the expected signs in all specifications; in specification "CZ-B" they shared significance partly.

The majority of the variables relating to the labour market (economic activity and number of vacancies) proved to be statistically insignificant (vacancies were significant in only two versions of the OLS, with 5% and 10% significance levels respectively). This may reflect the generally low labour mobility within the Czech Republic, as relatively few people move in search of work. Labour market imbalances thus tend to be resolved rather by commuting or by the employment of foreign casual workers, whose demand for home ownership is low. The only significant labour market variable, which appeared in the regressions with the logical negative sign, was the rate of unemployment. This might relate also to the lower disposable income of households in regions with higher unemployment rates.

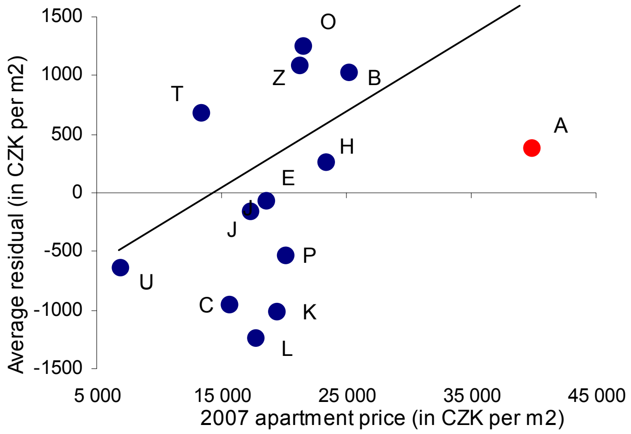
Of the other demand factors, growth in market rent proved significant, reflecting substitution between renting and home ownership. The significance of the coefficient meanwhile confirms the role of the price-to-rent ratio as an important indicator of the stability of apartment price growth. The significance of the price-to-wage ratio was also confirmed, as the coefficient on wage growth was significant at the 1% level with the expected sign. The expected role of housing loans as a major demand mechanism of property price growth was surprisingly not confirmed, as they were significant in only two specifications at the 10% level. This might be due to the "exponential nature" of housing loans in 2002–2008, when they recorded approximately 30% yearly growth irrespective of developments on the housing market (see Appendix 3). However, the recent developments might indicate that the standard relationship will be restored.

Interest rates, which were used for all regions the same, were not significant in any of our regressions and recorded the opposite sign than expected. The statistical insignificance of interest rates may be due to the fact that we used the interest rate on the interbank market, whereas interest rates on new housing loans would have been economically more meaningful (and the spread between these two rates can change quite significantly over time). Unfortunately, however, we did not have housing loan rates available for the whole time period (figures are only available from 2004 onwards).

The overall statistical properties of the panel regression seem fairly good (see Table 4). We succeeded in explaining the variability of prices across regions better than their variability over time, but the difference was not large. The statistics confirm the appropriateness of using the fixed-effects model. The F-test of equality of the constants for fixed effects rejects the hypothesis of equality at the 21% level of significance, which at least partly confirms the hypothesis that some regions are specific in nature. For example, one can assume that apartment prices in Prague are, ceteris paribus, higher than in other regions, because Prague is the capital city.

The specific nature of property prices in Prague is confirmed by Chart 3, which compares the residuals of the panel regression by regions with prices in those regions. This chart shows that it generally holds that apartment prices in regions with lower prices are undervalued (negative residuals), whereas those in regions with higher prices are somewhat overvalued (positive residuals). But in Prague (labelled A in the chart), apartment prices diverge from this positive relationship between the price and the degree of overvaluation, as they were overpriced only marginally despite being approximately two times higher than apartment prices in the rest of the Czech Republic. This relative undervaluation, however, may be partly due to the properties of the estimation technique. If prices in Prague were systematically higher than in the rest of the Czech Republic in the past (as the data show), the panel regression will assign them the highest fixed effect in absolute terms compared to the other regions. This may mean that the conclusion that apartment prices in Prague are undervalued is based on explanatory variables which are not necessary equilibrium variables themselves. For illustration, there are roughly 14% more houses per 1,000 inhabitants in Prague compared to the average region, while wages are 38% higher, unemployment is around 50% lower, net migration is 4.5 times higher and lending for housing purposes per person is roughly 2.5 times higher (see also Appendix 4). Given the still relatively short length of the available time series, there is thus a question as to whether the resulting “undervaluation” is in fact real. The conclusion that apartment prices in Prague are undervalued compared to the other Czech regions is also inconsistent with the comparison of the price-to-income and price-to-rent ratios between regions, which indicate that Prague is, on the contrary, the highest-risk region (see Section 5 above). For the evolution of the under/overvaluation of apartment prices in different regions, refer to Appendix 3. This appendix shows that apartments were overpriced for the whole period under consideration in Olomouc (O), Ostrava (T) and Zlín (Z) and systematically underpriced in České Budějovice (C), Liberec (L) and Karlovy Vary (K). In Ústí nad Labem (U) and in Plzeň (P) apartments were overpriced at the beginning of the period under scrutiny and underpriced at the end. The opposite was true for Brno (B), Hradec Králové (H) and Prague (A). Prices in Jihlava (J) and Pardubice (E) were generally near their equilibrium over the whole period. These results are in line with those of Zemčík (2009), who finds bubbles in Prague, Olomouc and Hradec Králové.

Chart 9 Apartment Price Overvaluation Relative to Apartment Price (average residual for 1998–2008)



Source: CZSO, IRI, CNB, CNB calculation
Note: A – Prague, B – Brno, C – České Budějovice, E – Pardubice, H – Hradec Králové, J – Jihlava, K – Karlovy Vary, L – Liberec, P – Plzeň, O – Olomouc, T – Ostrava, Z – Zlín.

Table 4 Results of Panel Regression by Czech regions, Estimate A

Statistic	Value	Statistic	Value
No. of observations	130	No. of groups (regions)	13
R^2- within (between regions)	0.954	R^2- between (over time)	0.974
R^2- overall	0.966	rho	0.471
F(17, 100)	121.27	Prob > F	0.000
F test of equality of constants for regions (FE)			
F(12, 87)	1.33	Prob > F	0.214

8. Conclusions

In this paper we focused on analysing property price determinants using three alternative approaches – an approach based on simple indicators of housing price sustainability (price-to-income and rental returns) and two simple econometric models (a time series model and panel regression). To the best of our knowledge, this is one of the first applications of econometric techniques to property prices in the Czech Republic and using information from regional data.[35] For this reason, and also because of difficulties associated with the properties of the analytical methods applied and with the relatively short time series used, the results of the analysis should be interpreted with caution.

That said, a number of conclusions can be drawn. Similarly to Čadil (2009) we found that housing prices in the Czech Republic are driven mainly by demand factors. The effects of supply factors were mixed: both analyses showed building plot prices to be significant. In some specifications of the second regression the number of apartments per 1,000 inhabitants was also significant. Of the demographic factors, both regressions confirmed a positive effect of natural population growth on property prices. This is in line with the results of Čadil (2009).[36] For some specifications net migration and the divorce rate were also significant. The unemployment rate and wage growth turned out to be significant among the labour market-related demand factors in both regressions (in line with Égert and Mihaljek, 2008). In addition, the economic activity rate and the number of vacancies were significant in the time series analysis. Rents also proved to be an important factor of housing price growth, confirming the possibility of rental and owner-occupied housing substitution. This is in line with the outcomes of Zemčík (2009), who used rents as the main variable explaining apartment prices. However, potential endogeneity and the influence of housing market sentiment should be taken into account for apartment prices and for building plot prices. An interesting result was that neither mortgage credit growth nor the credit conditions (represented by interest rates) were among the significant factors of apartment prices. This is different to the results of Égert and Mihaljek (2009), who applied panel regression to cross-country CEEC data. This might be because the differences in financial market developments are substantial across different countries but not very important in the cross-regional dimension within one state. On the other hand, the link between credit growth and apartment price dynamics in the Czech Republic seems to have been restored in the last 1.5 years.

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[35] Notable exceptions are papers by Čadil (2009), Zemčík (2009), Égert and Mihaljek (2008) and Hlaváček and Komárek (2009).

[36] Čadil used the size of the population aged 20–39 as the explanatory variable, which is correlated with natural population growth.

Another outcome of our analysis is the identification of periods when property prices were overvalued. As expected, our models and simple indicators identified property price bubbles in 2002/2003 and 2007/2008. However, the level of overvaluation in 2007/2008 was lower than in the first period, even though the increases in prices in the two periods were similar. This might be due to the fact that much of the rise in prices in 2007/2008 can be explained by fundamentals and the bubble is not as large as it might appear at first glance. The influence of the recent financial crisis on apartment prices confirmed the appropriateness of our approach as compared to the "naive" Hodrick-Prescott filter, which identifies strong undervaluation of apartment prices in the first half of 2009. Our approach generally identifies the recent decline in apartment prices as a return to equilibrium. A further worsening of the impacts of the world financial crisis on the Czech economy could eventually lead to renewed inflation of the bubble "from below" via worsening fundamentals.

Looking at the individual regions, we found that the level of overvaluation of apartment prices in individual regions is positively related to the apartment price level (in regions where apartment prices are higher, they are also more likely to be overvalued). Apartment prices in Prague are the exception to this rule, as the level of overvaluation is one of the lowest despite the fact that Prague has the highest absolute prices. This outcome is therefore not wholly consistent with the outcomes of the price-to-income and rental-return indicators, which see Prague as the most risky region as far as housing price bubbles are concerned. It may be due to the properties of the estimation technique and may thus not be entirely robust. However, it confirms that the property market in Prague is specific in nature compared to the other Czech regions.

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Appendix 1: Sources of Data on Apartment Prices

	Time coverage (June 2009)	Periodicity	Published	Regional coverage	Source of data	Further info	Advantages	Disadvantages
Transfer prices (CZSO)	1998–2Q 08	quarterly	yearly, estimates quarterly	Districts (“Kraje”)	Publication “Ceny sledovaných druhů nemovitostí” (in Czech only) http://www.czso.cz/csu/2008edicniplan.nsf/p/7009-08	Prices of family houses, building plots, apartment blocks and garages.	- wide coverage according to types of real estate (apartments, family houses, apartment blocks, building plots and garages) using comparable methodology and structure -data cover all transfers of used real property against payment - statistics cover all major districts - classification according size of municipality and age of given real estate	- large time lag of publication (almost one year) - tax optimisation by respondents might influence reported prices - includes only information on prices of transfers of already existing real estate. Information on prices of new apartments is not included as they are not subject to property transfer tax
Supply prices (CZSO)	2004–1Q09	quarterly	quarterly	Prague vs. Rest of CZ	http://www.czso.cz/csu/redakce.nsf/i/ceny_bytu (in Czech)		- official source, methodology should be comparable to transfer prices - small time lag of publication	- low regional coverage (only Prague vs. rest of Czech Republic) - time series available only from 2004
Supply prices (Institute for Regional Information – IRI)	2000–5/09	until 2006 yearly, from 2007 quarterly; Prague monthly starting from 3/04	quarterly	Regional capitals + other major towns (77 towns/cities in all)	Closed database, current prices available at http://bydleni.idnes.cz/ See also IRI (http://www.iri.name/)	Market and regulated rents	- longest data series of supply prices in Czech Republic (from 2000) - wide regional coverage - uses prices of “standard apartment” and so is not influenced by problems with changes in structure of housing stock - also publishes supply market rents using same methodology	- loses information on prices outside relatively thin market segment of “standard apartment” - database is not officially public
Supply prices (Dolanský)	2002–4/09	monthly	monthly	Selected towns (22)	Journal Realit (ISSN 1210-8308)	Prices of building plots and family houses, market rents (from 2007)	- published regularly starting from 2002 (at monthly frequency) - detailed classification for Prague - primary source for apartment supply prices published quarterly by CZSO	- some regional capitals are missing from database - regional coverage differs according to type of real property
Supply prices (King Sturge)	2005 – present	monthly	yearly report	Selected towns + Prague in detail	Czech Residential Market report (www.kingsturge,cz)	Prices of family houses and apartments. Differentiates between prices of new and used apartments. Includes prediction for one year horizon.	- study available in English. In addition to data includes analysis and prediction of future developments. - division of used and new apartments, analysis of different types of real property. - detailed analysis of Prague	- base study published only once a year (more detailed studies can be prepared on commercial basis) - only partial regional coverage

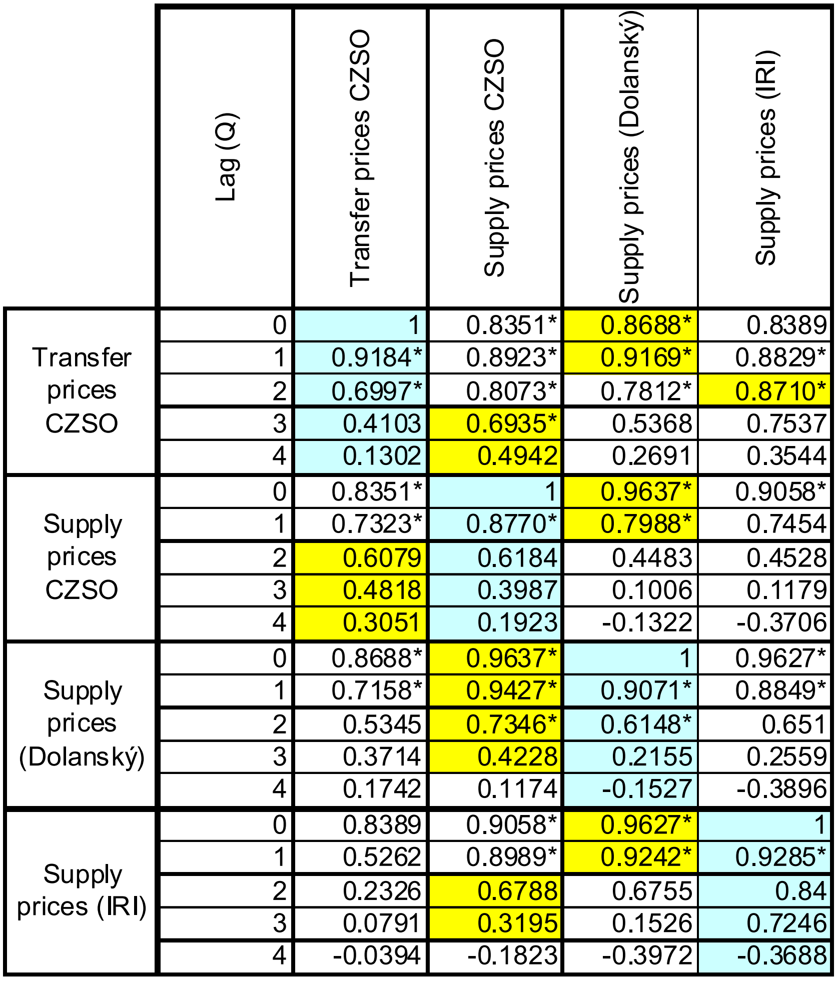
Appendix 2: Piecewise Correlations between Different Indexes According to Lags

The first and second tables depict the correlation of the given source of data for the given region (Prague and the rest of the Czech Republic) to see whether one source “leads” the others. For example, the first block depicts the dependence of Czech Statistical Office transfer prices on lagged values from the other sources. The significance level of 99% is depicted by *. Cells highlighted in yellow depict the highest correlation coefficient for the given lag. Cells highlighted in light yellow depict the second highest coefficient. Blue highlighted cells depict the correlations of the given variable with its lagged values. The third table tries to compare prices in Prague and the rest of the Czech Republic according the given source to confirm the hypothesis of Prague being the price leader for the rest of the Czech Republic.

Correlations for Prague

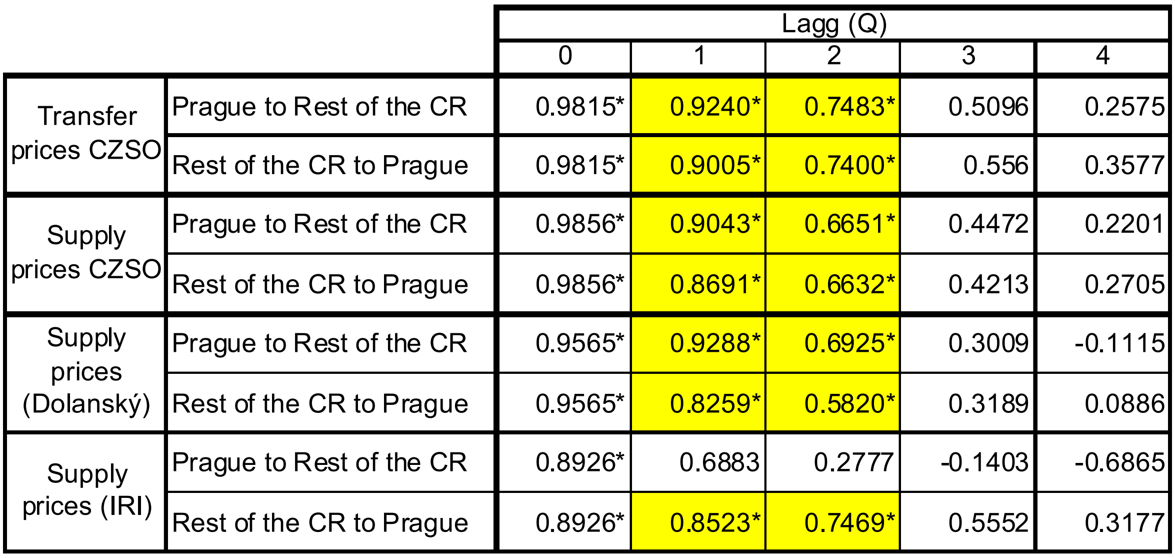
	Lag (Q)	Transfer prices CZSO	Supply prices CZSO	Supply prices (Dolanský)	Supply prices (IRI)	Supply prices (King Sturge)
Transfer prices CZSO	0	1	0.8756*	0.8527*	0.9315*	0.8894*
	1	0.9140*	0.8945*	0.8603*	0.8517*	0.6086
	2	0.7098*	0.8104*	0.7626*	0.6580*	0.1685
	3	0.4558	0.7344*	0.5860*	0.4337	-0.2229
	4	0.2253	0.6084*	0.4032	0.1672	-0.5401
Supply prices CZSO	0	0.8756*	1	0.9931*	0.8940*	0.3577
	1	0.8051*	0.8958*	0.8740*	0.6593*	-0.2562
	2	0.7326*	0.7085*	0.5869	0.3774	-0.2926
	3	0.6024	0.4642	0.2562	0.0865	-0.3958
	4	0.4261	0.2888	-0.0708	-0.126	-0.443
Supply prices (Dolanský)	0	0.8527*	0.9931*	1	0.9047*	0.5846
	1	0.7885*	0.9288*	0.9030*	0.7190*	-0.0786
	2	0.6979*	0.7697*	0.6722*	0.4736	-0.1235
	3	0.5223	0.5691	0.4082	0.2529	-0.2676
	4	0.2892	0.4013	0.153	0.0432	-0.3597
Supply prices (IRI)	0	0.9315*	0.8940*	0.9047*	1	0.9050*
	1	0.9024*	0.9760*	0.9603*	0.9026*	0.5133
	2	0.8301*	0.9131*	0.8761*	0.7367*	0.0587
	3	0.7375*	0.7830*	0.6717*	0.5182	-0.2695
	4	0.6281*	0.6269*	0.4468	0.3012	-0.3772
Supply prices (King Sturge)	0	0.8894*	0.3577	0.5846	0.9050*	1
	1	0.6688	0.8352*	0.8771*	0.8906*	0.6944
	2	-0.0249	0.9008*	0.8665*	0.7985*	0.2556
	3	-0.6598	0.6778	0.8461*	0.5751	-0.3103
	4	-0.9476	0.429	0.614	0.2526	-0.7709

Correlations for the rest of the Czech Republic



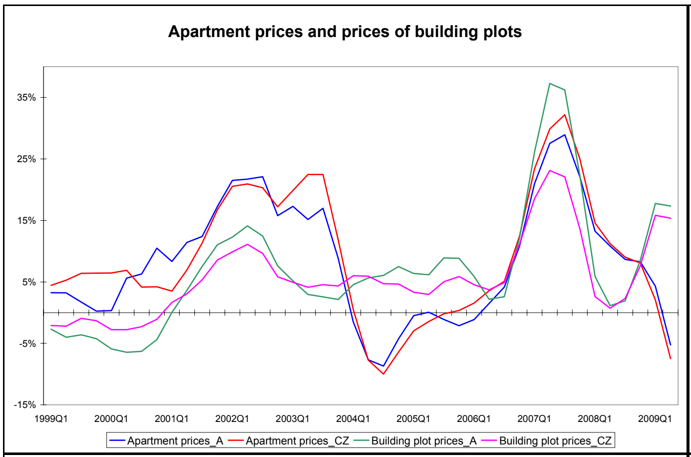
	Lag (Q)	Transfer prices CZSO	Supply prices CZSO	Supply prices (Dolanský)	Supply prices (IRI)
Transfer prices CZSO	0	1	0.8351*	0.8688*	0.8389
	1	0.9184*	0.8923*	0.9169*	0.8829*
	2	0.6997*	0.8073*	0.7812*	0.8710*
	3	0.4103	0.6935*	0.5368	0.7537
	4	0.1302	0.4942	0.2691	0.3544
Supply prices CZSO	0	0.8351*	1	0.9637*	0.9058*
	1	0.7323*	0.8770*	0.7988*	0.7454
	2	0.6079	0.6184	0.4483	0.4528
	3	0.4818	0.3987	0.1006	0.1179
	4	0.3051	0.1923	-0.1322	-0.3706
Supply prices (Dolanský)	0	0.8688*	0.9637*	1	0.9627*
	1	0.7158*	0.9427*	0.9071*	0.8849*
	2	0.5345	0.7346*	0.6148*	0.651
	3	0.3714	0.4228	0.2155	0.2559
	4	0.1742	0.1174	-0.1527	-0.3896
Supply prices (IRI)	0	0.8389	0.9058*	0.9627*	1
	1	0.5262	0.8989*	0.9242*	0.9285*
	2	0.2326	0.6788	0.6755	0.84
	3	0.0791	0.3195	0.1526	0.7246
	4	-0.0394	-0.1823	-0.3972	-0.3688

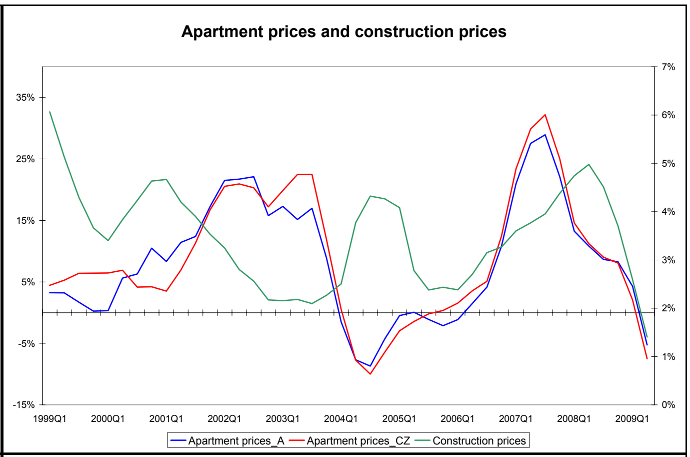
Correlations of Prague and rest of the Czech Republic by source

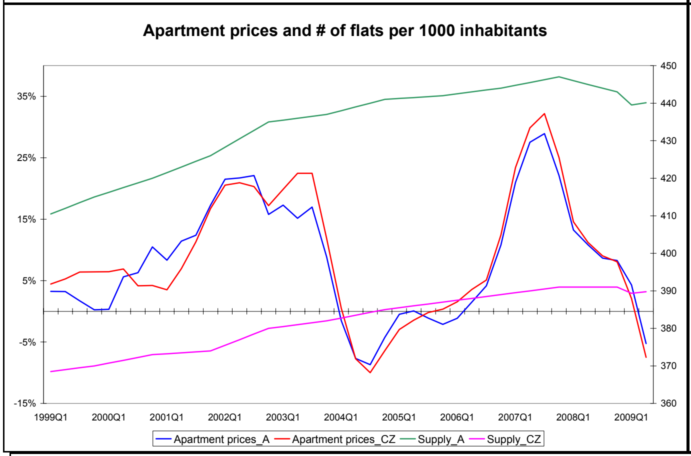


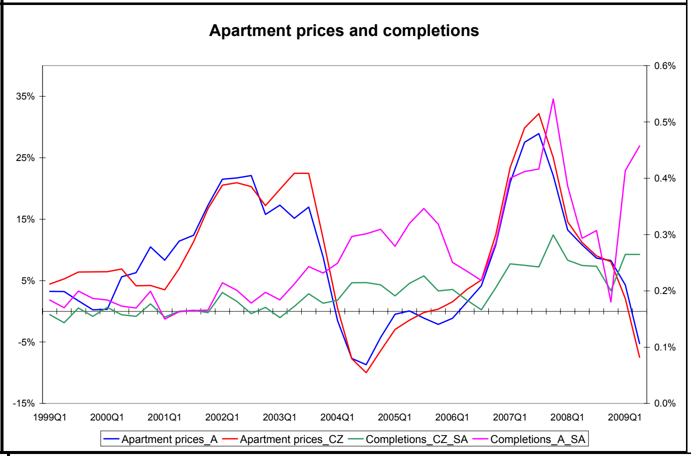
		Lagg (Q)				
		0	1	2	3	4
Transfer prices CZSO	Prague to Rest of the CR	0.9815*	0.9240*	0.7483*	0.5096	0.2575
	Rest of the CR to Prague	0.9815*	0.9005*	0.7400*	0.556	0.3577
Supply prices CZSO	Prague to Rest of the CR	0.9856*	0.9043*	0.6651*	0.4472	0.2201
	Rest of the CR to Prague	0.9856*	0.8691*	0.6632*	0.4213	0.2705
Supply prices (Dolanský)	Prague to Rest of the CR	0.9565*	0.9288*	0.6925*	0.3009	-0.1115
	Rest of the CR to Prague	0.9565*	0.8259*	0.5820*	0.3189	0.0886
Supply prices (IRI)	Prague to Rest of the CR	0.8926*	0.6883	0.2777	-0.1403	-0.6865
	Rest of the CR to Prague	0.8926*	0.8523*	0.7469*	0.5552	0.3177

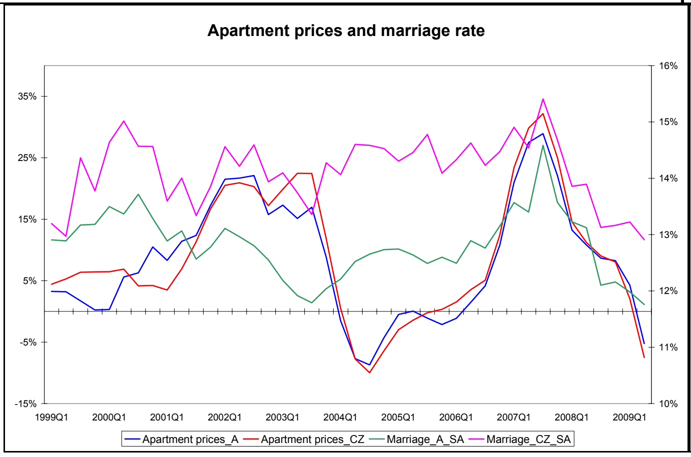
Appendix 3: Explanatory Variables and Apartment Prices (apartment prices always on left-hand axis; A denotes Prague, CZ total Czech Republic, SA seasonally adjusted data)

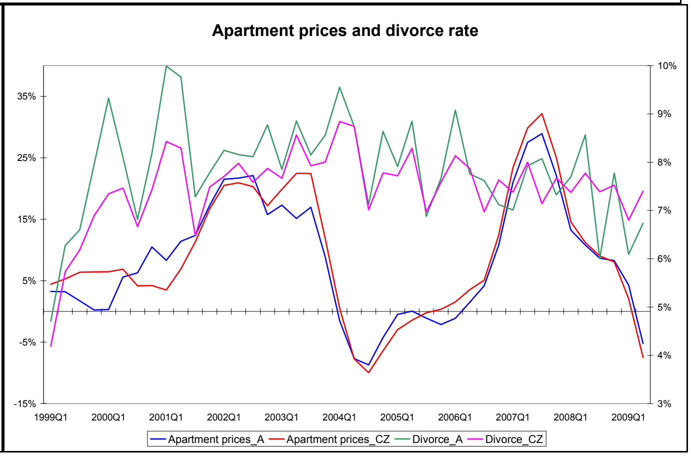

Apartment prices and prices of building plots

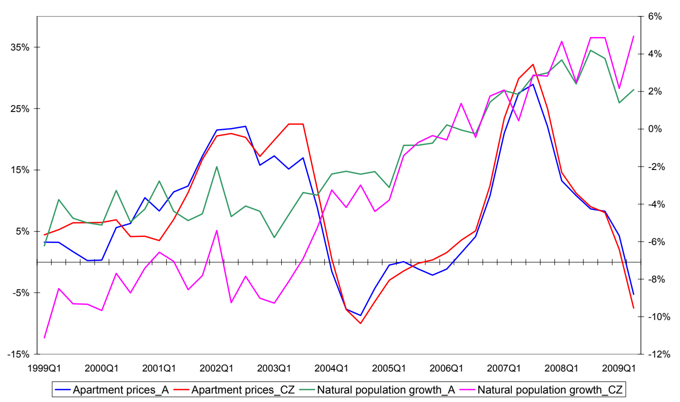

Apartment prices and construction prices


Apartment prices and # of flats per 1000 inhabitants

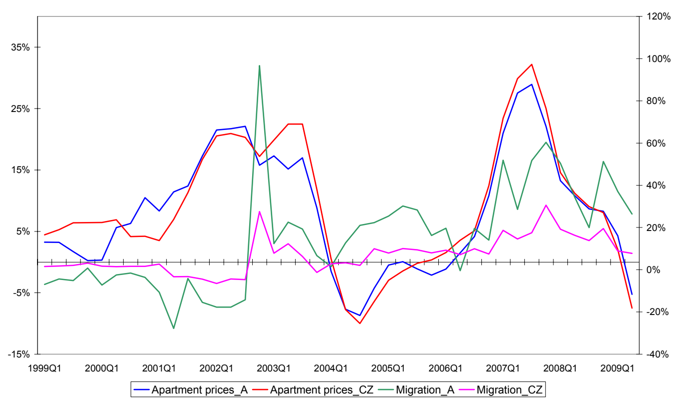

Apartment prices and completions


Apartment prices and marriage rate

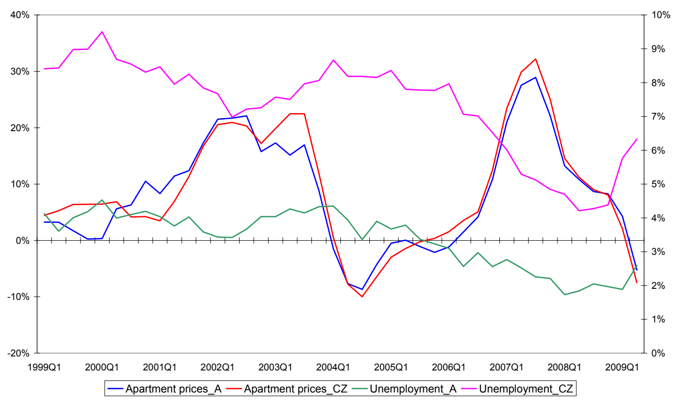

Apartment prices and divorce rate



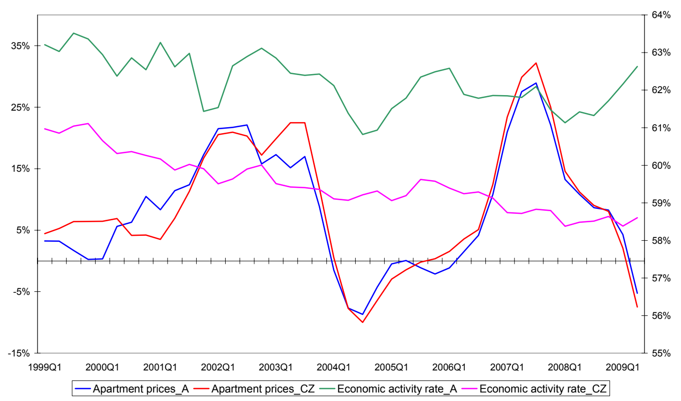
Apartment prices and natural population growth



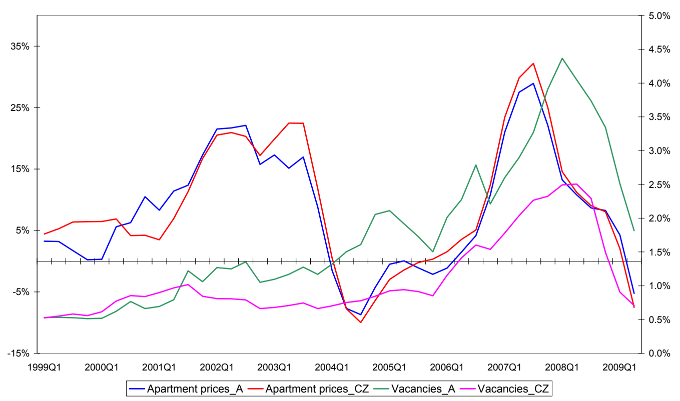
Apartment prices and migration



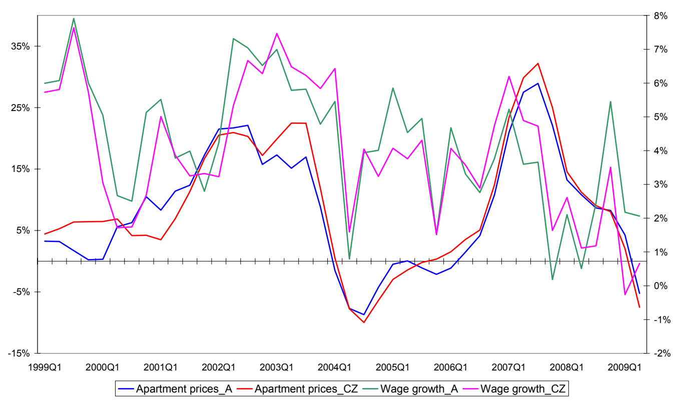
Apartment prices and unemployment



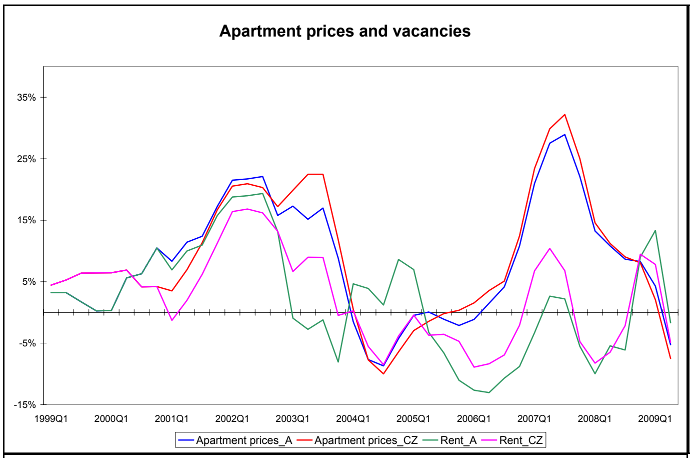
Apartment prices and economic activity rate

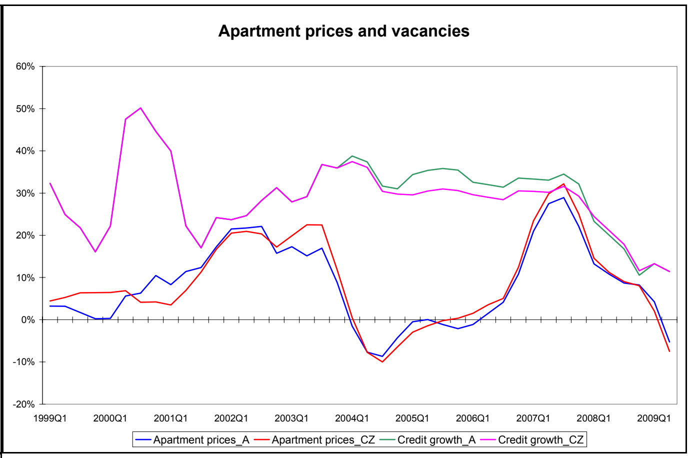


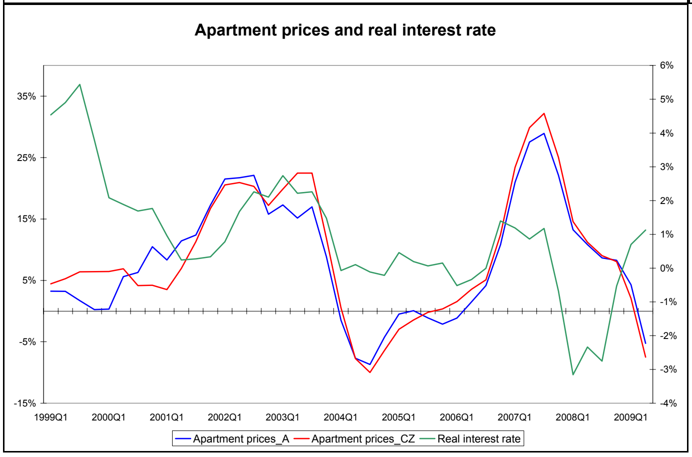
Apartment prices and vacancies



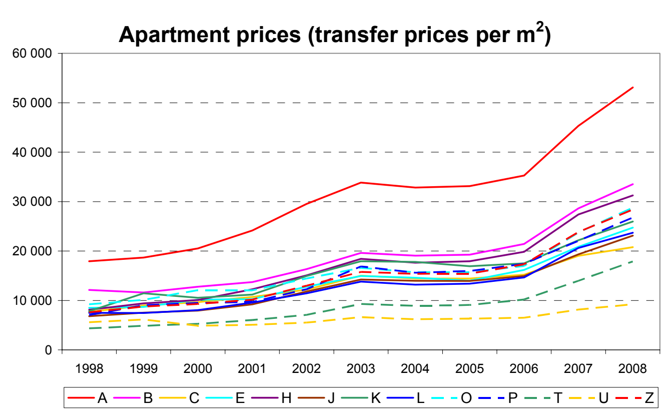
Apartment prices and vacancies


Apartment prices and vacancies
35%
25%
15%
5%
-5%
-15%
1999Q1
2000Q1
2001Q1
2002Q1
2003Q1
2004Q1
2005Q1
2006Q1
2007Q1
2008Q1
2009Q1
Apartment prices_A
Apartment prices_CZ
Rent_A
Rent_CZ

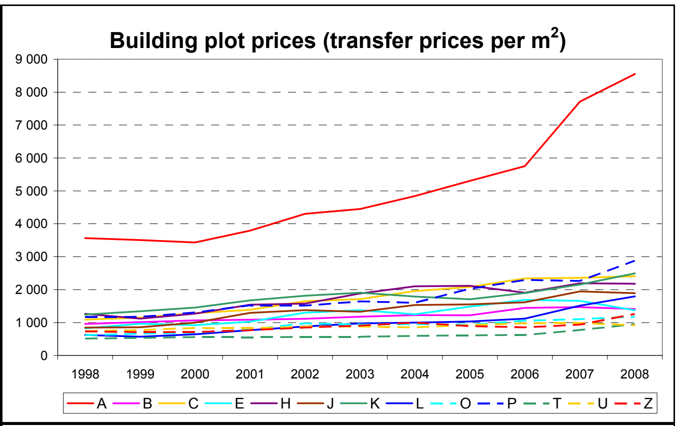

Apartment prices and vacancies
60%
50%
40%
30%
20%
10%
0%
-10%
-20%
1999Q1
2000Q1
2001Q1
2002Q1
2003Q1
2004Q1
2005Q1
2006Q1
2007Q1
2008Q1
2009Q1
Apartment prices_A
Apartment prices_CZ
Credit growth_A
Credit growth_CZ


Apartment prices and real interest rate
35%
25%
15%
5%
-5%
-15%
6%
5%
4%
3%
2%
1%
0%
-1%
-2%
-3%
-4%
1999Q1
2000Q1
2001Q1
2002Q1
2003Q1
2004Q1
2005Q1
2006Q1
2007Q1
2008Q1
2009Q1
Apartment prices_A
Apartment prices_CZ
Real interest rate

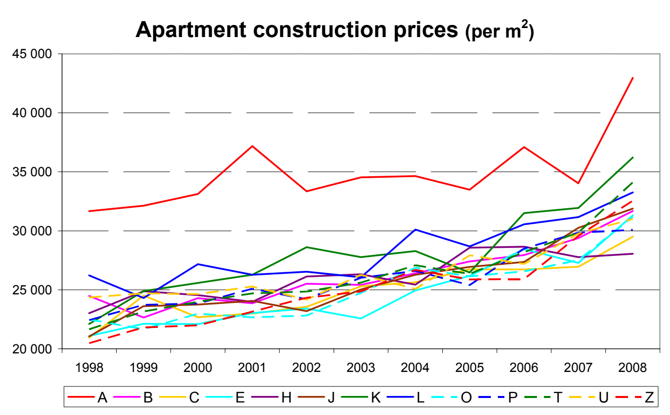
Appendix 4: Explanatory Variables across Regions (A – Prague, B – Brno, C – České Budějovice, E – Pardubice, H – Hradec Králové, J – Jihlava, K – Karlovy Vary, L – Liberec, P – Plzeň, O – Olomouc, T – Ostrava, Z – Zlín)



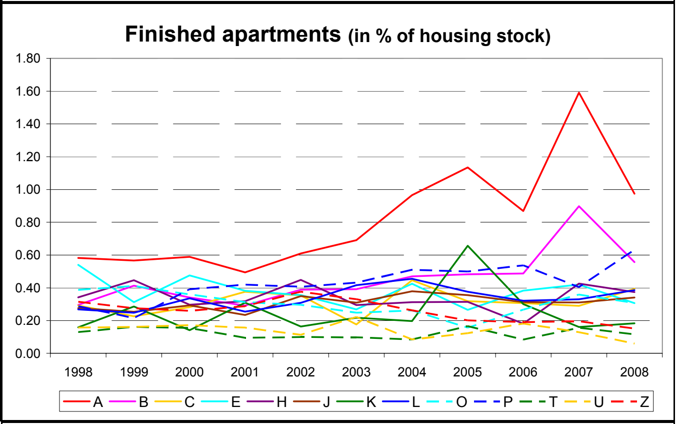
Apartment prices (transfer prices per m^2)



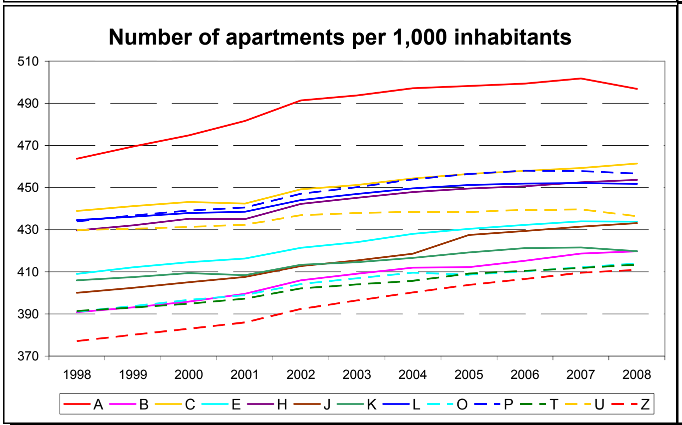
Building plot prices (transfer prices per m^2)



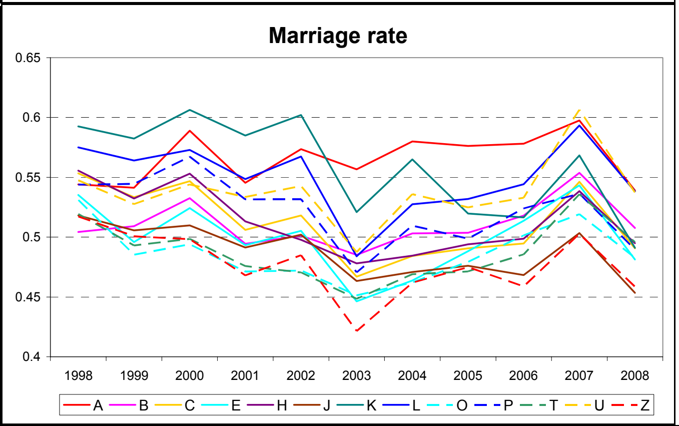
Apartment construction prices (per m^2)



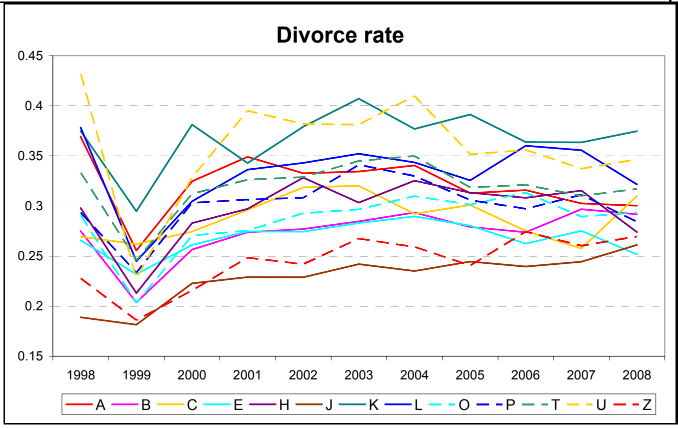
Finished apartments (in % of housing stock)



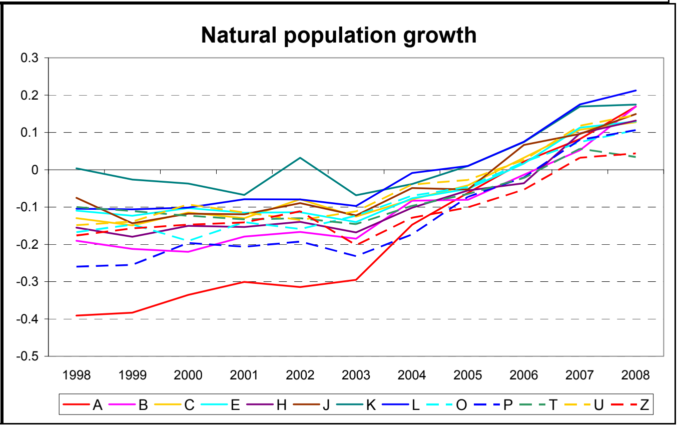
Number of apartments per 1,000 inhabitants



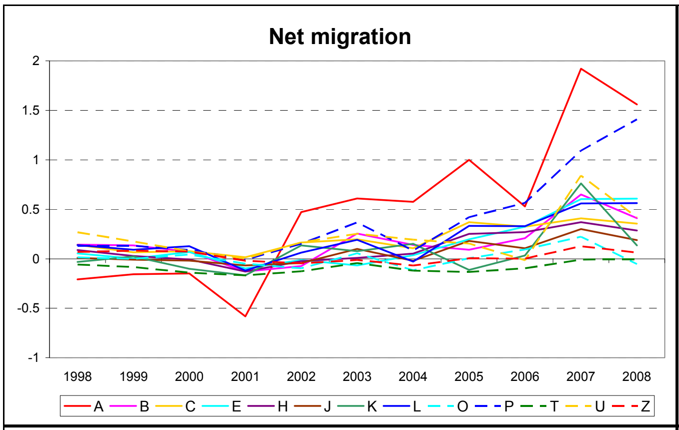
Marriage rate



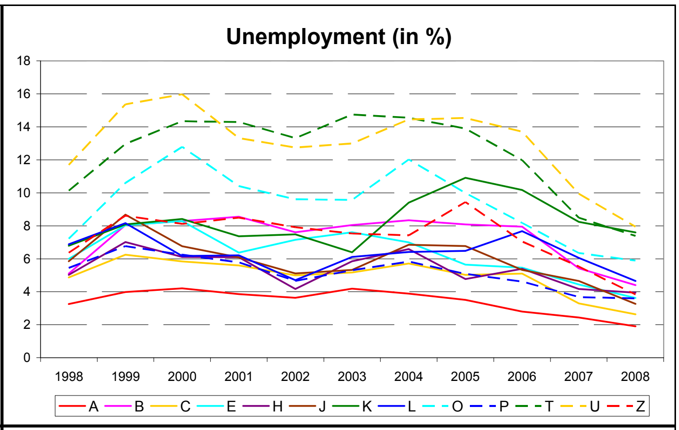
Divorce rate



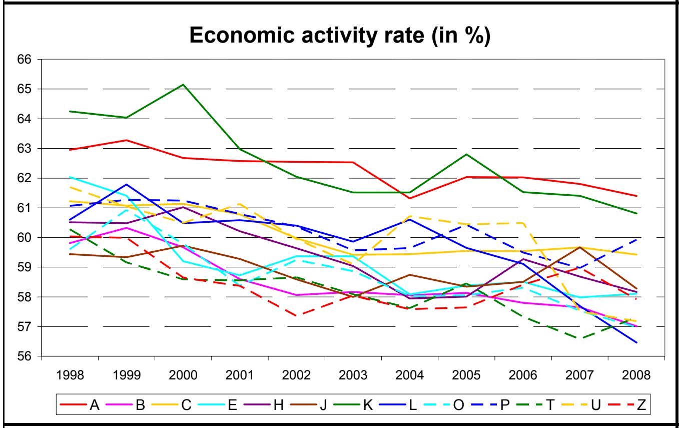
Natural population growth



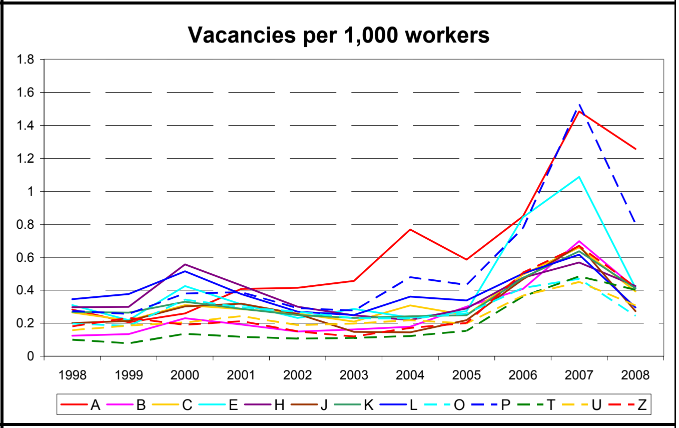
Net migration



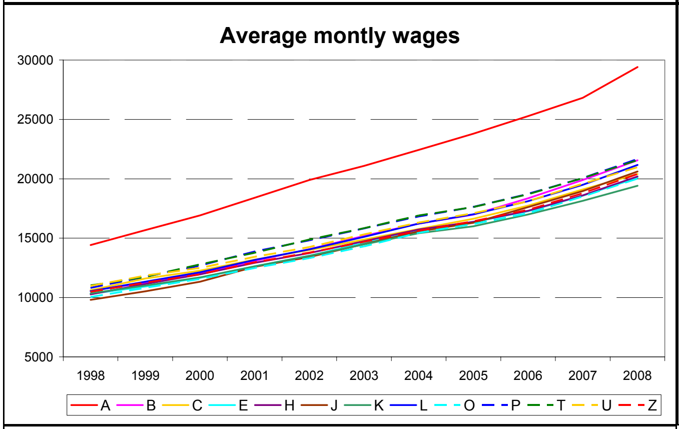
Unemployment (in %)



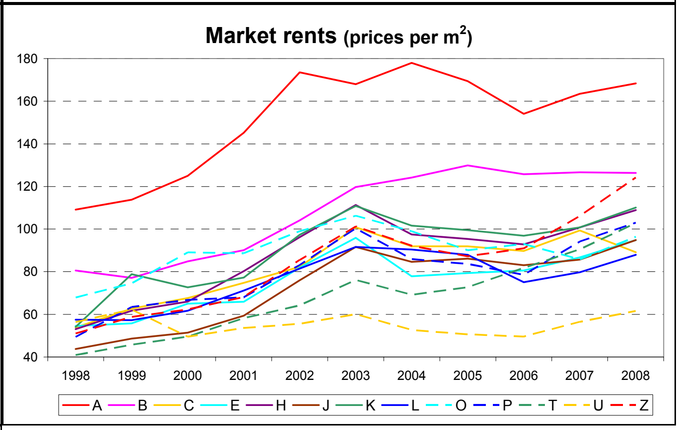
Economic activity rate (in %)



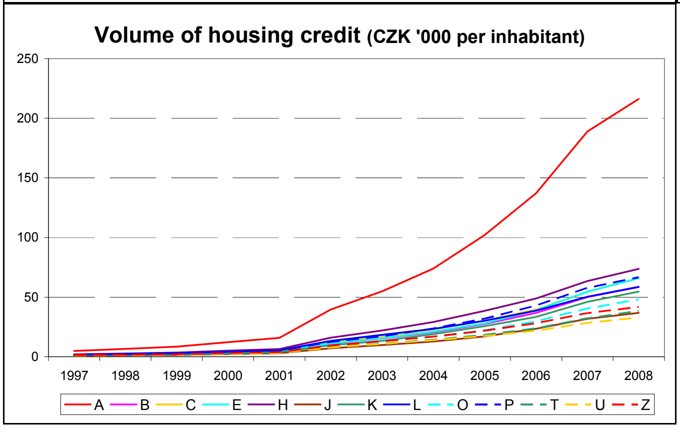
Vacancies per 1,000 workers



Average montly wages



Market rents (prices per m^2)



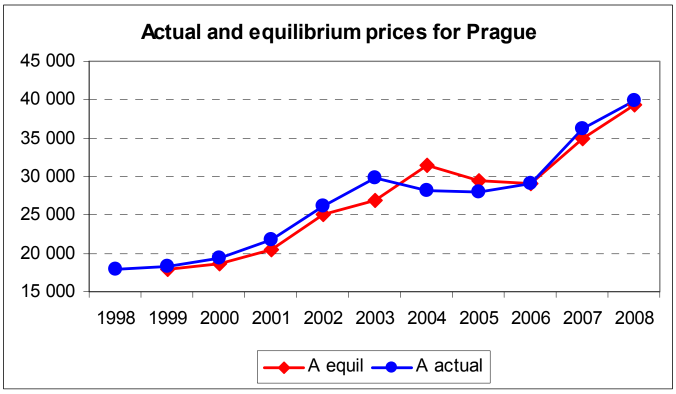
Volume of housing credit (CZK '000 per inhabitant)

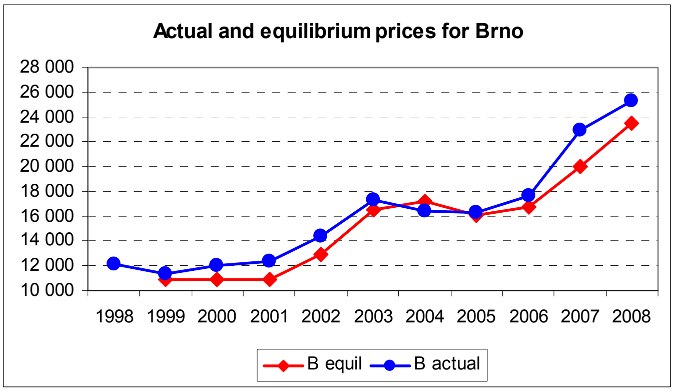
Appendix 5: Panel Unit Root Tests

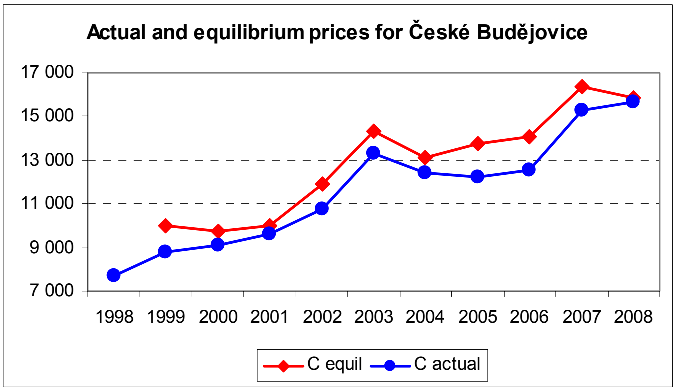
	levels		differences	
Variable	homo	heter	homo	heter
Apartment prices	1.906 (0.0283)	1.997 (0.0229)	-0.098 (0.5389)	-0.283 (0.6113)
Building plot prices	8.336 (0.0000)	3.480 (0.0003)	-1.318 (0.9062)	0.540 (0.2945)
Apartment construction prices	1.441 (0.0748)	2.023 (0.0215)	-1.831 (0.9664)	-1.610 (0.9463)
Completed apartments	-0.286 (0.6126)	0.781 (0.2175)	-2.243 (0.9875)	-2.214 (0.9866)
No. of apartments per 1,000 inhab.	2.361 (0.0091)	1.480 (0.0695)	-0.026 (0.5103)	0.020 (0.4919)
Marriages	1.680 (0.0464)	1.470 (0.0707)	-2.397 (0.9917)	-2.320 (0.9898)
Divorces	-0.687 (0.7539)	0.334 (0.3693)	-0.344 (0.6347)	-0.492 (0.6885)
Natural population growth	1.412 (0.0790)	0.843 (0.1998)	-1.138 (0.8724)	-0.961 (0.8316)
Net migration	1.014 (0.1552)	2.258 (0.0120)	-2.811 (0.9975)	-1.978 (0.9760)
Unemployment rate	3.077 (0.0010)	2.233 (0.0128)	-0.204 (0.5807)	-0.407 (0.6580)
Economic activity rate of population	1.858 (0.0316)	1.364 (0.0863)	-0.833 (0.7975)	-0.397 (0.6544)
Vacancies/labour force	2.177 (0.0147)	2.166 (0.0151)	0.558 (0.2886)	0.711 (0.2384)
Average monthly wage	1.914 (0.0278)	1.892 (0.0292)	0.260 (0.3973)	0.214 (0.4151)
Rent per month	8.839 (0.0000)	7.013 (0.0000)	-0.401 (0.6560)	-0.229 (0.5906)
Loans	12.820 (0.0000)	12.257 (0.0000)	-1.336 (0.9093)	-1.133 (0.8715)
1Y Pribor	-0.930 (0.8238)	-0.930 (0.8238)	-2.123 (0.9831)	-2.123 (0.9831)

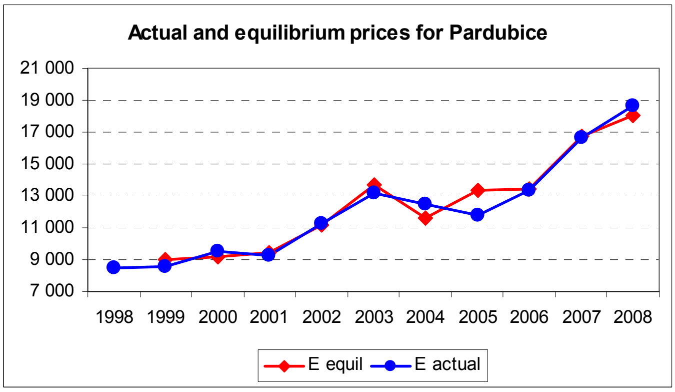
Note: H0: all 13 timeseries in the panel are stationary processes
Homo: homoskedastic disturbances across units; Hetero: heteroskedastic disturbances across units;
Cells in yellow highlight the series which are seen as stationary.

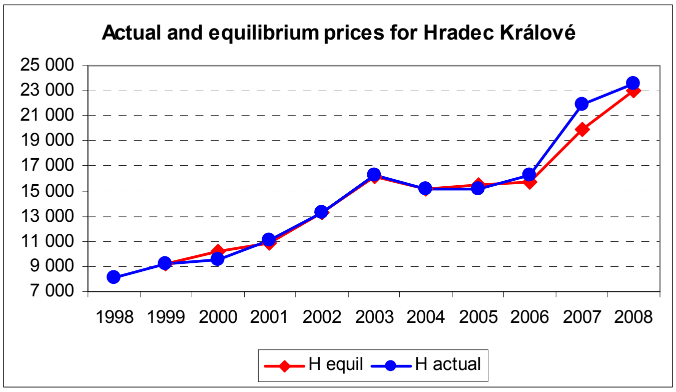
Appendix 6: Actual and Equilibrium Prices in Czech Regions according to Regression in Section 7.2 (in CZK per m2; real 1998 prices)

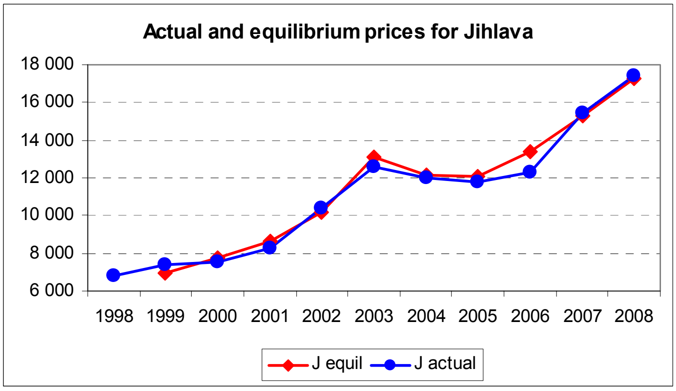

Actual and equilibrium prices for Prague

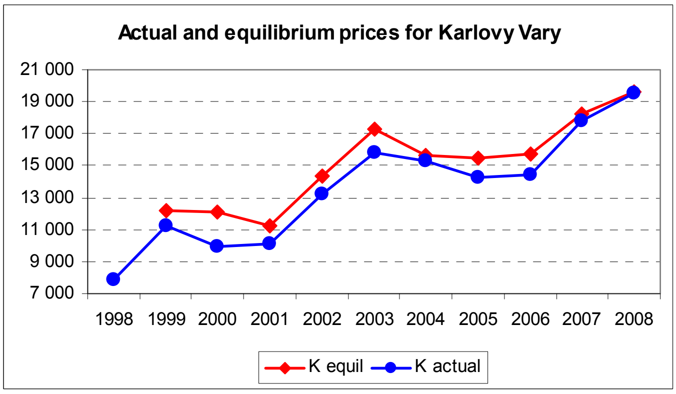

Actual and equilibrium prices for Brno

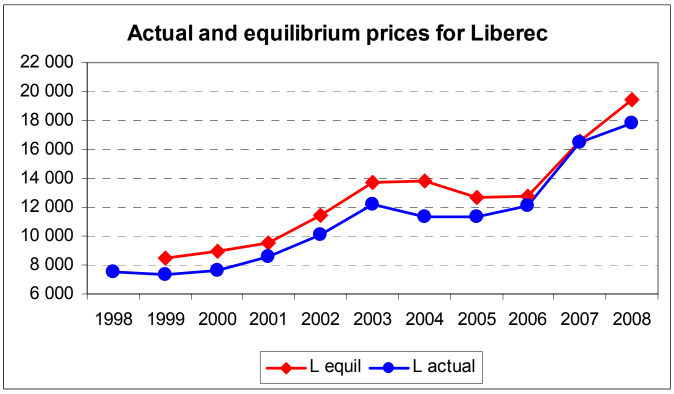

Actual and equilibrium prices for České Budějovice

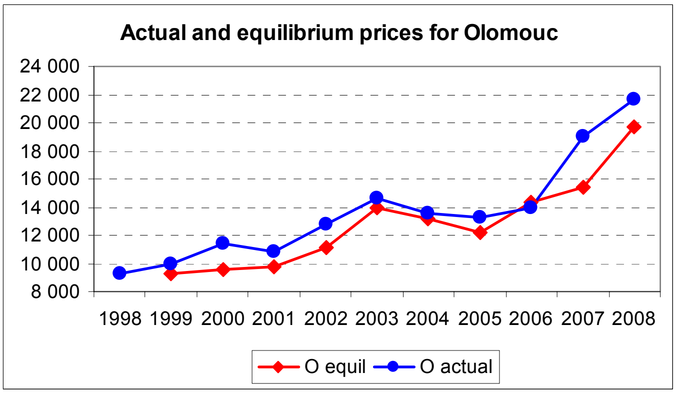

Actual and equilibrium prices for Pardubice

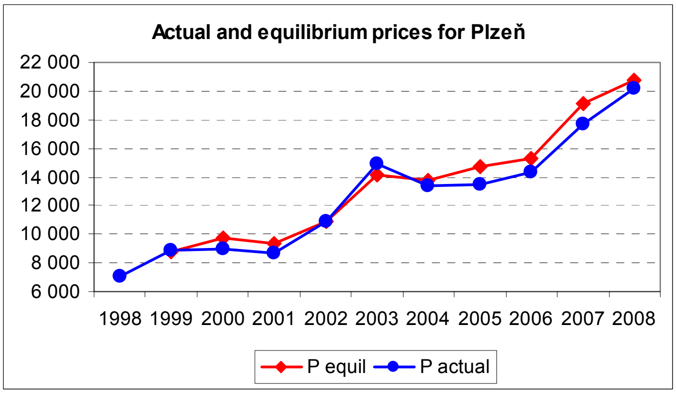

Actual and equilibrium prices for Hradec Králové

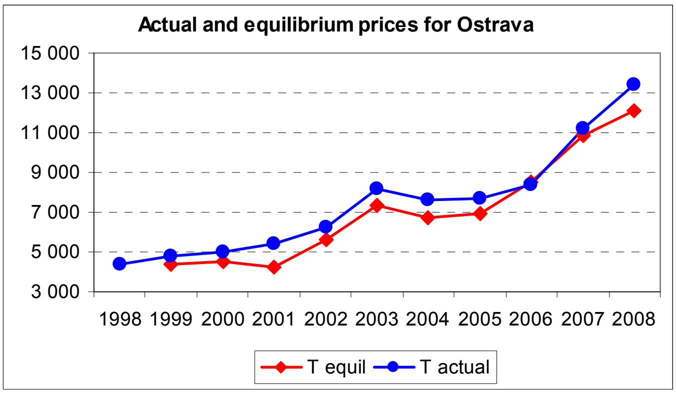

Actual and equilibrium prices for Jihlava

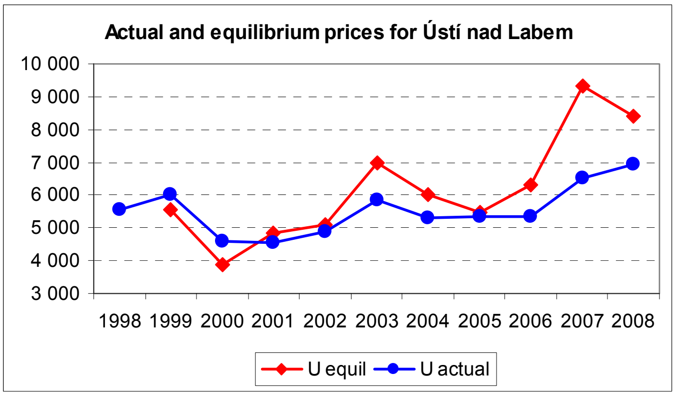

Actual and equilibrium prices for Karlovy Vary

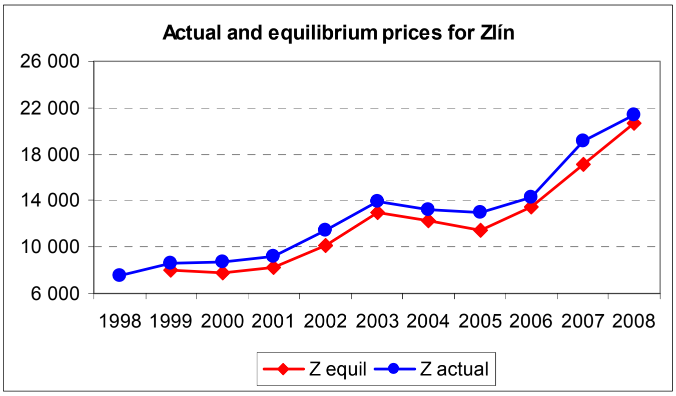

Actual and equilibrium prices for Liberec


Actual and equilibrium prices for Olomouc


Actual and equilibrium prices for Plzeň


Actual and equilibrium prices for Ostrava


Actual and equilibrium prices for Ústí nad Labem


Actual and equilibrium prices for Zlín

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