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DIPLOMA THESIS

Residential Real Estate Market During the Financial Crisis – Empirical Evidence from the CEE Region

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Declaration of Authorship

The author hereby declares that he compiled the thesis *„Residential Real Estate Market During the Financial Crisis – Empirical Evidence from the CEE Region“* independently, using only the listed sources and literature.

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Prague, May 17, 2012 ……..……..

Signature

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Abstrakt

Tato diplomová práce se zabývá jednak faktory ovlivňujícími vývoj cen rezidenčních nemovitostí, tak i možností existence cenových bublin na tomto trhu v rámci střední a východní Evropy před začátkem a v průběhu ekonomické krize let 2007-2009. V práci jsou použity tři různé kvantitativní přístupy za použití dat shromážděných od mezinárodních institucí, jednotlivých centrálních bank a od národních statistických úřadů. Metoda používající koeficient "cena ku příjmu" indikuje přítomnost bublin, které byly v průběhu krize eliminovánu, u tří z pěti zkoumaných zemí. Druhý přístup za pomoci základních regresních modelů pro panelová data zkoumá faktory ovlivňující ceny a přináší alternativní pohled na přítomnost cenových bublin. Výsledkem jsou růst HDP, míra nezaměstnanosti a průměrná mzda jako hlavní faktory v pozadí cen bytů. Tyto modely také naznačují významný trend perzistence cen na trhu rezidenčních nemovitostí v regionu CEE jako celku. Přesnější výsledky ohledně určujících faktorů poskytuje vektorová autoregrese a její součásti (variance decomposition a impulse response functions). Jednotlivé země jsou modelovány zvlášť a analýza odhaluje výrazné rozdíly mezi nimi. Polsko je jedinou zemí, kde nejsou patrné známky perzistence cen nemovitostí, zatímco dynamika cen bytů v Rakousku je v porovnání s novými členy EU zkoumanými v této práci méně volatilní.

Klasifikace	G12, E39, R21, R31, R32
Klíčová slova	Rezidenční nemovitosti, cenová bublina, faktory růstu cen nemovitostí, koeficient "cena ku příjmu", vektorová autoregrese

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Abstract

This thesis investigates the housing price determinants and possibilities of housing price bubbles in the residential real estate markets of Central and Eastern Europe before and during the economic crisis of 2007-2009. Using data from international institutions, national central banks and national statistical offices three quantitative methods are applied. Price-to-income ratios suggest housing price bubbles that were eliminated during the crisis in three out of five countries covered. Second approach of simple panel data models sheds additional light on housing price bubbles and indicates GDP growth, unemployment and average real wage as the main determinants of housing prices in the region. First indication of severe housing price persistence in CEE is demonstrated by the results of the models as well. More reliable results for housing price determinants are obtained from variance decomposition and impulse response functions of vector autoregression models. Each country is modeled separately and substantial differences exist between the countries. Poland is the only country that does not exhibit housing price persistence and dynamics in Austria are less volatile as compared to the new EU members in the sample.

JEL Classification	G12, E39, R21, R31, R32
Keywords	residential real estate, housing price bubble, housing price determinants, price-to-income ratio, VAR

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Master Thesis Proposal

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Notes: The proposal should be 2-3 pages long. Save it as "yoursurname_proposal.doc" and send it to mejstrik@fsv.cuni.cz, tomas.havranek@ies-prague.org, and zuzana.irsova@ies-prague.org. Subject of the e-mail must be: "JEM124: Thesis Proposal Yoursurname".

Proposed Topic:

Real Estate market during the financial crisis – Empirical evidence from the CEE region

Topic Characteristics:

Until recently, the Real Estate markets in Europe have been overlooked by economists. Only very limited number of papers and studies were published focusing on the price determinants and possible market bubbles in the Central and Eastern Europe (CEE) despite the importance of real estate market for the overall stability of financial sector (through "health" of commercial banks). More attention is being paid due to the collapse of housing market in the USA and its role in the recent financial and economic crisis. However, due to previously underdeveloped institutions and legal framework, situation on the CEE real estate market hasn't been that dramatic and despite the region being often viewed as homogeneous, vast differences exist also among the individual countries of the region.

In this diploma thesis I will explore the impact of recent financial crisis on the housing price determinants based on the previous research of multiple authors as well as employing own models using recent data from national central banks and statistical offices; and will try to identify potential real estate bubbles in the region/individual countries in the up-to-date quarterly data from same sources. Estimation will cover 4 developing CEE countries (the Czech Republic, Slovakia, Poland and Hungary) and Austria as a more developed benchmark country that is close to the rest of CEE sample both geographically as well as in size.

Hypotheses:

1. Identified house price determinants do not differ across CEE countries but do differ from the ones identified for Austria
2. Determinants of house prices have significantly different weight in individual CEE countries
3. Recent financial crisis changed the relevant determinants of housing prices in the CEE
4. There is evidence of real estate bubble in the CEE even during the financial crisis (after the American bubble bursted)

Methodology:

First theoretical part will cover the various theories of house price determinants – both the supply and demand side determinants in a form of a literature survey. Similar approach will be employed to summarize the so far limited empirical evidence on the topic in CEE before the financial crisis (latest data used are from 2008), focusing on simple indicators (price to income ration) and simple time series and panel regressions. Brief description of developments of individual countries during the financial crisis will demonstrate the heterogeneity of the region both on macroeconomic level as well as of its real estate markets. Last part will introduce the data used in the model, the model itself and the results of regressions. As is common in the related literature, I will employ both time series and panel data regressions to estimate the impact of financial crisis on the focus real estate markets and housing price determinants.

Outline:

I. Introduction
II. House Price Determinants and Housing Market Bubbles
  a. Theories of House Price Determinants
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    i. Price Determinants
    ii. Market Bubbles
III. Developments of CEE countries during the Recent Financial Crisis
  a. Macroeconomy
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IV. Data Description
V. Model Setup and Results
VI. Conclusions
VII. Appendices

Core Bibliography:

Čadil J. (2009): “Housing Price Bubble Analysis – Case of the Czech Republic“
Czech National Bank (2011): “Financial Stability Report 2010/2011”, Prague
Czech National Bank (2010): “Financial Stability Report 2009/2010”, Prague
Égert B. and Mihaljek D.: “Determinants of House Prices in Central and Eastern Europe.” Working Paper No. 1/2008, Czech National Bank
Hlaváček M. and Komárek L. (2009): “Housing Price Bubbles and their Determinants in the Czech Republic and its Regions”, Working Paper Series, Czech National Bank, December 2009
Národná banka Slovenska (2010): “Financial Stability Report 2009”, Bratislava
Národná banka Slovenska (2011): “Financial Stability Report 2010”, Bratislava
National Bank of Poland (2010): “Financial Stability Report 2010”, Warsaw
OECD (2005): “Housing finance markets in transition economies: trends and challenges.”, Paris
Palacin J. and Shelburne R. (2006): “Is There an East European Housing Bubble?”, Global Economy Journal, Vol.6 Issue 3, Article 1
Statistik Austria (2011): “Wohnen 2010”, Wien 2011
Vizek M.: “Short-run and Long-run Determinants of House Prices in Eastern and Western European Countries”, Privredna kretanja i ekonomska politika 125/2010
Zemčík P. (2010): “Is There a Real Estate Bubble in the Czech Republic?”, CERGE-EI Working Paper 390

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Acronyms

BIS	Bank for International Settlements
CEE	Central and Eastern Europe
DOLS	Dynamic Ordinary Least Squares
EBRD	European Bank for Reconstruction and Development
ECB	European Central Bank
EIRO	European Industrial Relations Observatory
EU	European Union
GDP	Gross Domestic Product
HCSO	Hungarian Central Statistical Office
IMF	International Monetary Fund
IRF	Impulse Response Function
NBS	National Bank of Slovakia (Národná banka Slovenska)
OECD	Organization for Economic Cooperation and Development
(P)OLS	(Pooled) Ordinary Least Squares
P/I	Price to Income
P/R	Price to Rent
RPPI	Residential Property Price Indices
RRE	Residential Real Estate
SEE	South-Eastern Europe
(S)VAR	(Structural) Vector Autoregression

1. Introduction

> *"The only economic factors that could seriously hinder future rises in house prices over the next years are a doubling of interest rates, stamp duty or unemployment. No economist in the world is expecting any of these for the UK, even those at the IMF! We continue to confidently forecast house price inflation of 8% for this year"*
>
> John Wriglesworth, Hometrack's Housing Economist
> (*April, 2004*)

Fairly recent events of the financial crisis still do impact everyday lives of the majority of population and have been therefore the center of many studies and research papers. Main focus was, quite understandably, on the developments in the United States as the burst of the American housing bubble started the turmoil and eventually through economical and financial problems spread throughout the world. However, US housing market was not the only one, that saw real estate prices plummet. United Kingdom along with Ireland and Spain represent the Western European countries where such development was observed (Čadil, 2009, p.38). The situation in the UK was even described to be on the edge of the first consumer-led recession since 1991 (Lott, 2007) despite the clear optimism of British experts, as illustrated by Mr. Wriglesworth quote.

Why is it that real estate markets and housing prices specifically should be paid attention? Several points could be made – straight forward macroeconomic explanation is the wealth channel. Since housing is one of the essential goods and major item both on the assets account as well as expenditure account of households, any shift in housing prices may reduce the net wealth of households, hence reducing their spending and limiting their borrowing potential. Moreover, shifts in housing prices also directly impact the construction industry. What is even more important is the influence and interconnection to the financial system. With sudden drop in real estate and housing prices (namely a burst of a housing price bubble) the probability of default on mortgages increases as well as the risk of loans to developers not being repaid – especially in the environment with steadily increasing indebtedness of individual households and sovereign countries alike. Threat that a housing price bubble presents to the financial stability of a country is the reason why it is

of greater importance to the Central Bank than would a stock market bubble be (Hlaváček and Komárek, 2009, p.2).

Despite the region of Central and Eastern Europe (CEE)[1] being often perceived as homogeneous, the development of individual countries was significantly different over the course of the global crisis. This leads to a question of possible similarity of housing price determinants and the effects of the deep recession on them on one hand, and to the estimation of evidence on housing price bubbles in individual countries and region-wide on the other hand. Since more research has been devoted to the real estate markets in the CEE region over past 6 years, this thesis has sound foundations to build on. Cross-country studies are, however, working mostly with datasets ending in year 2006 and even one of the most recent papers by Zemčík (2010) estimates the Czech data ending in 2008 only, as do Posedel and Vizek (2011). For the purpose of examination of the effects of the financial and economic crisis the latest available dataset for all the five countries is used, leading to new insight into the development of the residential real estate markets in the CEE region. The objective of this thesis is to determine whether the housing price determinants are the same across the CEE region and in case they are if they differ vastly in their importance. Second of the pillars is finding evidence on whether the Central and Eastern European countries experienced a housing price bubble during the global financial and economic crisis. Austria as a representative of the old EU is expected to differ from the rest of the sample on basis of the historical development despite its similarity both in size and geographical location.

The rest of the thesis is organized as follows: Chapters 2 and 3 introduce the two cornerstones of the thesis, that is the housing price determinants and the housing price bubbles respectively, with overviews of both the theoretical aspects and the latest literature review; Chapter 4 offers short overview of individual countries development to demonstrate difference across the sample; Chapter 5 describes the issues of data collection and the actual dataset used in econometric estimation; Chapter 6 introduces the methodology, sets up the models to be estimated and presents the results of regression and tests while Chapter 7 concludes the results.

Due to the uncertainty of future developments, talking about the crisis in past tense might prove premature. In this light, all conclusions about the effects of the crisis still have

[1] For the purpose of this thesis the CEE region will consist of 4 new European Union members (Czech Republic, Hungary, Poland and Slovakia) and one representative of the old EU (Austria).

to be considered with an open mind and the topic should be revisited once the global economy is on the boom path for good again.

2. Housing price determinants

Generally, real estate can be defined as "Land and anything permanently attached to it, under and above it, including natural resources and any technical improvements such as buildings and other constructions". Real estate has characteristics of both an investment asset and regular consumption good. Some of its specifics include long-term nature, relatively high cost of supply, possibility to use as collateral for loan, existence of well-developed secondary market, fixation to one location and most importantly extremely high heterogeneity. Therefore real estate market can be thought of more as a group of loosely interconnected but segmented markets (Iacoviello, 2000, p.8). Housing, or in other words residential real estate, is the best example of these properties out of all the real estate sub-segments. While the valuation of real estate applies specific methods and approaches (e.g. Land residual value, EBITDA multiplier, Comparable yields) its objectivity usually suffers from the high individuality of assets and lack of sufficient data even on one single market.

Even though real estate is often used as a long-term investment that is supposed to be good protection against inflation, the residential sub-segment is mostly playing a role of essential good that is fundamental for every household. Therein lies the importance of studying the house price determinants and their models. The severity of current crisis is to a large extent due to many Americans losing one of the essential constants in their lives. And even though a popular saying simplifies the determinants of housing prices and real estate prices in three words as "Location, location, location", these are worth of taking a closer look. Finding objective and quantifiable variables was a goal of multiple previous studies and as was mentioned before, will be one of the cornerstones of this thesis as well. In the following subchapters I will first introduce the theories of housing price determinants and then summarize the results and approaches of recent studies that estimate the determinants of housing prices with focus on countries of geographical proximity to the CEE as defined for the purposes of this thesis.

2.1. Theories of housing price determinants

Based on the numerous papers from the 1960's, theories of housing and its price determinants are not new in the economic literature. Olsen (1969) is one of the first who tries to elaborate the competitive theory of the housing market into the terms of general

microeconomic theory. Since the primary purpose of his article was to derive practical implications for housing policy and to provide additional tests of the above mentioned competitive theory, its implications for modern studies are of limited relevance. What is interesting in Olsen's approach is his challenge of one of the assumptions of perfectly competitive market, namely the homogeneity of housing stock[2]. Since the quality of housing is very difficult to measure and includes very subjective attributes it can virtually never be considered homogeneous. In face of this fact, however, Olsen concludes that "*The assumption of a homogeneous good called housing service can only be rejected if theories of the housing market without this assumption have greater explanatory power.*" Greater explanatory power may lie in the so called Hedonic models which incorporate individual characteristics of real estate that influence the price. Such models can be used to precisely distinguish the price components of land and structure as well as to compare price developments of real estate in perfectly comparable locations and conditions. Unfortunately, these models are very data intensive and collection of necessary data would be very expensive and complicated. Also the high number of characteristics may lead to omitted-variable bias when trying to simplify the model or to low comparability across various studies as different variables or transformations of variables might be used.

More often cited and widely used model is the one introduced by Poterba (1984). It builds on the assumption of efficient markets and models separately the equilibriums on market for existing owner-occupied houses and the flow of net new construction. Demand for existing housing stock, which is fixed in the short run, is modeled through the market clearing rent and alternatively the real price of housing is calculated as the net future income flows discounted at the homeowner's real after-tax interest rate. Market for new housing determines the residential investment and is dependent on the real price of housing structures (existing housing stock). Incorporating depreciation, deductible property taxes, personal income taxes, mortgage interest payments and other factors he arrives at the long-run steady state for both housing stock and its price. This influential paper can be seen as one of the reasons why it is common in the modern literature that the existing and new housing are considered separately[3].

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[2] Olsen uses the term housing service throughout the paper but for the purpose of this thesis these terms are interchangeable.

[3] Paper by Poterba (1984) actually focuses on the implications of changes to expected inflation on user costs of housing and role of taxes therein. For the purposes of this thesis the model set up is the relevant part.

Housing price determinants modeling always considers two basic groups of factors – supply-side and demand-side. Since the supply of residential real estate is driven by the profitability of such construction and is regarded as sticky in the short run (Hlaváček and Komárek, 2009, p.13). Supply side determinants can again be divided into 2 groups, depending if either the stock of existing housing or the new housing construction is considered. The former can be characterized by investments in improving the existing stock, housing stock changes and therein stemming the saturation of housing needs. The latter supply factors include mostly the cost-of-construction influencing phenomena – availability and cost of land and the cost of construction. Alternatively the construction output index can be used. As Hlaváček and Komárek (2009) conclude, the more important are the demand side determinants. Intuitively, the disposable income (mainly based on wages) is of main importance. Other labor market factors, such as unemployment rate, usually influence disposable income either directly or indirectly. Further demand side determinants include changes in the demographic structure (population growth, divorce rate, net migration, age structure), financial market factors (interest rate, mortgage conditions and volume of housing loans granted) and prices of substitute assets. Consistent with the above mentioned facts of dominance of demand side determinants, Posedel and Vizek (2011) stress the high number of studies focusing on the wealth effect.

Considering the methodology used in studies on house price determinants, the dominant approach employs linear framework. Most of the papers use vector autoregression (VAR) models, cointegration and error correction models (Granger causality tests) and panel data regressions. Should the housing price data series, however, show some non-linear properties like do the stock market returns, GDP or unemployment rates, different tools might be needed. The non-linear models usually employ threshold cointegration and asymmetric adjustment models but as will be seen in next section they are rather rare especially in the transitional countries.

2.2. Empirical studies and up-to-date literature review

Topic of real estate price dynamics has been long established in the economic field. Modern papers build on the research on role of asset prices in transmission mechanisms as old as Veblen's work from 1904. More concrete specification of housing prices became popular after the 1980's and even more so nowadays. Iacoviello (2000) presents extensive

overview of older studies that engaged in application of several theoretical frameworks. These include Tobin's q theory, Modigliani's life-cycle model and the "credit channel" view. Most of the older literature is of a descriptive nature but in agreement with the significance of determinants such as GDP growth and interest rate developments as it was concluded by the latter quantitative studies. Substantial body of literature models the price determinants in developed countries while the transitional or less developed countries (including CEE region) are rarely included in the research. Generally, three types of econometrical analysis are used to assess the factors influencing housing price determinants. Majority of papers is centered around cointegration and error correction models. Among others using this approach are Malpezzi (1999), Ayuso et. al (2003), Rae and van den Noord (2006) or Vizek (2010). Second group of researchers resorts to use of longitudinal data and application of panel dynamic OLS, which is the mean group of individual DOLS estimates or pooled mean group models. Representatives of this second approach are Annett (2005), Stepanyan et. al. (2010) and Égert and Mihaljek (2007). Last of the mainstream econometrical approach is the (structural) vector autoregression ((S)VAR) and will constitute the main part of this thesis as well. VAR technique became very popular after influential article of Simms (1980). Concerning the housing price it was employed by e.g. Tsatsaronis and Zhu (2004), Iacoviello (2000), Posedel and Vizek (2009) or Sutton (2002). Égert and Mihaljek (2007) provide extensive overview of current papers studying the housing price determinants, adapting the summary from OECD (2005a). Most interesting in regard to this thesis is the work of Égert and Mihaljek (2007) who estimate price determinants for all the CEE countries of interest. They use several specifications of panel dynamic ordinary least squares models for nineteen developed OECD countries split into three groups and eight CEE transition economies[4] split into two groups. Several different factors are used in the analysis including proxies for institutional development taken from EBRD. Authors come to expected results. GDP per capita is highly significant and elasticities substantially higher in transition countries than in developed countries.

[4] Obviously, CEE is defined in much broader terms here.

Regional coverage and authors	Elasticity of real house prices			Methodology, comments
	Real disposable income	**Real interest rate**	**Other factors**	
Euro area Annett (2005)	0.1 to 1.4 short-run impact	-0.01 to -0.03 short-run impact	Real credit 0.1 to 0.2 Real money 0.4 to 0.6	Panel regressions for sub-groups of countries based on common institutional characteristics; short- to medium-run equations. Institutional factors help explain the relationship between credit and house prices
Six industrial countries Sutton (2002)	GNP 1 to 4 after 3 years	-0.5 to -1.5, weaker for longer rates	Equity prices 1 to 5 after 3 years	VAR model, 1970s-2002Q1
17 countries Grouped by mortgage finance structures Tsatsaronis and Zhu (2004)	Accounts for <5% of total variation in house prices after 5 years	Accounts for <11% of total variation on house prices after 5 years	Inflation accounts for 50%; bank credit, term spread each for ~10% of total variation in house prices after 5 years	VAR model, 1970-2003 Mortgage market structures matter for the sensitivity of inflation to interest rates and the strength of the bank credit channel
18 countries Terrones and Otrok (2004)	0.5 to 1.1	-0.5 to -1.0 short-term rate	Housing affordability (t-1) -0.1 House price (t-1) 0.5 Real credit 0.1 Pop. growth 1.8 Bank crisis -2.4	Dynamic factort model, 1980-2004Q1 Real house prices show high persistence, long-run reversion to fundamentals and dependence on economic fundamentals. Real house prices are strongly pro-cyclical; average correlation with output (consumption) declined since the mid-1990s. House prices in industrial countries tend to move together, have become more synchronized in the 1990s.
Ireland Rae and van den Noord (2006)	1.8	-1.9	Housing stock supply -2.0 (new) to -0.007 (existing)	ECM, 1977-2004 for new and existing houses. The sharp increase in the price of existing relative to new houses since the mid-1990s partly reflects supply constraints. Short-run income elasticities high.
Spain Ayuso et al. (2003), Bco. de Espana (2004)	2.8	-4.5 (in nominal terms)	Equity market return -0.3	ECM, 1989-2003 Estimated overvaluation increasing over time.
27 CEE and OECD countries Egert and Mihaljek (2008)	Up to 2.0 (CEE) and up to 1.0 (OECD)	Up to -0.05 (CEE) and up to -0.02 (OECD)	Housing loans 0.41 to 0.96 Equity prices -0.16 to 0.16 Labor market factors	Panel regressions for sub-groups of countries, data sample varies for countries and ends in 2005. Model is varied with disposable income and interest rate being complemented with one additional explanatory variable at a time.
3 CEE and 3 developed countries Posedel and Vizek (2009)	Yes	Yes	House price (t-1) Housing loans, Employment, Construction costs and output	VAR and multivariate regressions, 1995-2007Q4 Impulse response functions confirmed responses o house prices to house price shocks and interest rate at least for some of the countries.
4 post-transitional and 3 developed countries Vizek (2010)	0.26 to 2.27 long-run elasticities	-1.71 to 1.41	Construction output -0.81 to 0.24 Housing loans 0.47 to 0.79	ECM, 1995-2009Q2 Confirmed high housing prices persistence across the countries with exception of Ireland. Only GDP significant for all the countries.

Table 1: Overview of studies on housing prices and their results
Source: Égert and Mihaljek (2007, Appendix), Author's extension

However, when smaller samples were estimated the maximum number for elasticity of income proxy did not differ for groups including Austria ("OECD small" sample) and the rest of CEE countries discussed in the remainder of this thesis at 0.8. Real interest rate was established as the other major determinant with the expected negative sign. Other factors differed for OECD and CEE countries. For CEE some links between population and house prices were established while unemployment was only significant for Estonia, Bulgaria and Lithuania.

Vizek (2010) assesses both the long-term and short-term determinants of 4 transitional countries (the Czech Republic, Croatia, Bulgaria and Estonia) and 3 developed EU countries (Ireland, Spain and UK). Using cointegration and error correction models he comes to the conclusion that interest rates on housing loans are important determinant in both long and short run, while income expressed as GDP can be often excluded from the estimation in the long run. Since three of the hardest hit residential real estate markets from the EU were selected it does not come completely as surprise that there were not as many differences between the two natural groups as there were among individual countries. Nevertheless, one of the main conclusions of Vizek's research is the high persistence of house prices as their lagged values were significant for all countries with the exception of Ireland and the persistence in the United Kingdom even showed strengthening tendency.

Other – less common – frameworks include the work of van den Noord (2006) who uses PROBIT analysis to assess probability of housing prices bust in 17 OECD countries. As explanatory variables in the final estimation nominal long-term interest rate, the real house price gap and the two-quarter moving average of the rate of change in real house prices were used for pooled analysis. Some extra explanatory variables such as inflation and unemployment were added for single-country models. Either way, United States, France, Denmark, Ireland, New Zealand, Spain and Sweden were marked as "at risk of nearing a peak if interest rates significantly increased from levels observed in the fourth quarter of 2005".

Hedonic housing price models were used by Tomczyk and Widlak (2010) to explore secondary housing market in Warsaw. In order to improve the measurements of house price dynamics in Poland they employ three methods of constructing the hedonic price index. These include time dummy variable, characteristic price and imputation methods. After performing estimations of numerous models the characteristic price model shows the highest variation. The results from Warsaw data are quite robust with fairly high

coefficient of determination, suggesting that hedonic price indices and models just might be the future of housing price determination.

To the best knowledge of current writer, Posedel and Vizek (2011) are first to employ non-linear framework on the issue of housing prices in Europe. They explore possible threshold effects in housing prices in four developed countries and four transitional countries from Central and Eastern Europe. Using the M-TAR model with an unknown threshold authors come to the conclusion that changes in housing prices are characterized by threshold effects in all transitional countries and in the US. Similarly to the previous studies, Posedel and Vizek confirm persistence of house price changes but attribute the price boom to its combination of persistence with either slow adjustment process or total absence of adjustment. Since it is virtually impossible to separate studies on housing price determinants and housing price bubbles, additional literature on the topic including estimations of price bubbles is presented in Section 3.2.

3. Housing price bubbles

3.1. Definitions and theories of price bubbles

Even though the term "housing bubble" is rather young[5], bubbles have interested economists for a long time. There is no single definition that the academic circles would agree on, but probably the most commonly used one originates from Charles Kindleberger. According to him a price bubble is *"…a sharp rise in price of an asset or a range of assets in a continuous process, with the initial rise generating expectations of further rises and attracting new buyers – generally speculators interested in profits from trading in the asset rather than its use or earning capacity. The rise is usually followed by a reversal of expectations and a sharp decline in price often resulting in financial crisis*" (Hwang Smith and Smith, 2006, p.2)

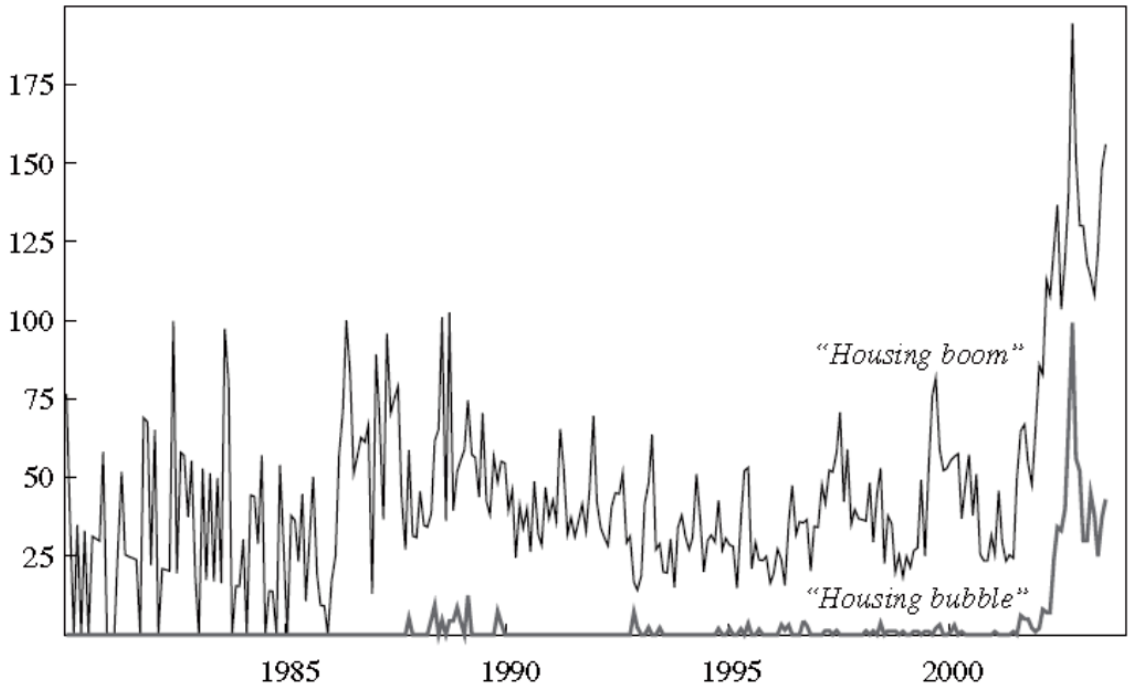


Figure 1: Appearances of "Housing Bubble" and "Housing Boom" in U.S. Newspapers and Wire Services, Jan 1980–Jul 2003
Source: Case and Schiller (2003, p. 302)

Stiglitz (1990) stresses the speculative attribute of the price bubble, saying that bubble is created if the current price is high based solely on the beliefs of high price in the

[5] See Figure 1 for illustration of use of the "Housing bubble" term in US newspapers.

future. That is if the fundamental factors cannot explain the high price. Case and Schiller (2003, p.2) agree saying that the term bubble *"refers to a situation in which excessive public expectations for future price increases cause prices to be temporarily elevated"*. This mechanism can be thought of as a self-fulfilling prophecy and a vicious circle that, in case of a housing bubble, leads to investment decisions in favor of real estate that under normal conditions would be considered too expensive. Under housing bubble investors see a prompt compensation in a form of increasing price of their newly acquired asset. That is, however, only until the bubble bursts.

Different definition of a bubble, this time directly connected to real estate, is employed by Hwang Smith and Smith (2006). Since they view real estate and housing to be an investment in principle rather than considering the investment attribute of real estate to be an aspect that defines housing bubble, they focus on the anticipated cash flow from the asset. In their view a bubble occurs if the market price of an asset increases substantially above the present value of the asset's expected cash flow. As such the bubble is consistent with the properties of previous definitions by Stiglitz and Kindleberger, i.e. steep price increase, speculative nature of investments in the asset, the possibility of a bubble bursting (sudden drop in market prices). In one sentence a bubble is present if the asset's expected cash flow does not explain the current market price.

"Bubble" nowadays carries a negative connotation due to the speculative attribute[6]. Stiglitz (1990) introduces an alternative use of the term that is used less often and has no fundamentals in speculations. There are multiple studies that created models under which the price of an asset is now at high levels due to expectations of high future price and these beliefs transmit into the change of fundamentals that in the future justify the high price. Therefore the "bubble" can last forever and *"bubbles are simply an inter-temporal manifestation of a general lesson: markets may have multiple equilibria"* (Stiglitz, 1990, p.14).

Following the same line of argumentation, Garber (1990) points out the three most notorious examples[7] of asset price "bubbles" from history and contradicts the common belief that these periods should be considered as representatives of price bubbles. He advocates the bubble explanation to be one of the last resort and encourages wider

[6] Why "speculation on open market" is viewed in negative sense and the role of mass media therein could be an interesting topic for cross-disciplinary research.

[7] Tulipmania in the 17th century, Mississippi bubble regarding the Compagnie d'Occident (later renamed to Compagnie des Indes) in France and the South Sea bubble named after the British South Sea Company.

perception of the market fundamentals. Namely should the expectations of high future returns be considered as one of the explanatory factors, none of the historical events would qualify as a price bubble: *"If the undertaking appeared sound at the start, however, and only looks foolish in hindsight, economists should classify this event as being driven by market fundamentals"* (Garber, 1990, p.41). The case of Tulipmania in the Netherlands, according to Garber, is not significantly different from price developments of rare goods in other markets and even though the price volatility was high, vast majority of it can be rationally explained by market factors. Importantly, the fact that *"…there is no evidence of serious economic distress arising from the tulipmania"* (Garber, 1990, p.39) also suggests that the first profound asset price bubble was not a bubble after all. Different explanation is used for the other two examples as the South Sea bubble was inspired by the events in France. Nevertheless, both events were merely a failed economic experiment that was at the time being driven by the best knowledge of its participants. Mississippi and South Sea "bubbles" might have been Ponzi scheme or chain-letter scams (hard to prove when the intentions of its originators are not known) or could have failed due to sudden loss of investor confidence. Still the majority of interpretations blames irrationality of investors and labels these two failures as speculative bubbles.

Generally, an asset price bubbles can be either rational or irrational. Under irrational bubbles the rational agents could exploit the arbitrage opportunities from market price misalignments and from the presence of noise traders. However, the bubble can only exist on the market long enough in case when the rational investors forgo the opportunity to exploit the mispricing or in case noise traders are a permanent presence. Such irrational bubbles are of the main focus of this thesis and their size can be measured as the difference of realized price and the price justifiable by market fundamentals (namely price that would be recorded on perfectly rational markets with no arbitrage opportunities). The other possibility is a rational bubble. Under this construct the current asset price comprises of two factors – fundamental price component (e.g. discounted future cash flows from the asset) and bubble component. Here the bubble is based on the present value of the asset in the distant future and according to its properties can either result in explosive, periodically collapsing, intrinsic or stochastic bubble (Hilbers et. al., 2008, p.38).

Alternative differentiation of speculative bubbles based on rational expectations is given by Hamilton (1986). He explores three different types of bubble-like phenomena, namely the deterministic, collapsing and continuously regenerating bubbles. Despite

certain similarities to the types of bubbles by other authors, bubble is defined in much more detail. Most importantly, an alternative explanation for asset price behavior based on market fundamentals' dynamics is introduced for each type of bubble. Therefore *"any empirical search for the presence of speculative bubbles clearly must begin with a careful specification of the dynamics of the fundamental driving variables if we are to be persuaded to favor one interpretation over another"* (Hamilton, 1986, p.550)

3.2. Empirical studies and up-to-date literature review of housing price bubbles

As compared to the housing price determinants research, the empirical literature on residential property price overvaluation is rather rare. Even though some papers mention price bubbles either in their title or in the body of the literature, actual econometrical assessment of the phenomena is presented only in a few materials. Case and Schiller (2003, p.4) present a rather descriptive and theoretical approach to bubbles in four major American cities. They argue that: *"The notion of a bubble is really defined in terms of people's thinking: their expectations about future price increases, their theories about the risk of falling prices, and their worries about being priced out of the housing market in the future if they do not buy. Economists rarely ask people what they are thinking when they make economic decisions, and some economists have argued that one should never do so. We disagree. If questions are carefully worded and people are surveyed at a time close to their making an actual economic decision, then by making comparisons across time and economic circumstances, we can learn about how the decisions are made"* and used a questionnaire sent out to 500 home buyers in each city to capture human behavior in time of the reported bubble and compare it to situation in 1988. They infer that evidence on bubble is not as strong as was in 1988 but real estate prices should stagnate or slightly decrease in the future.

Majority of the literature on housing price bubbles uses some modification of comparing fundamental value of housing with market rents or use the simple price-to-income (P/I) and price-to-rent (P/R) ratios. These include Hwang Smith and Smith (2006), Shelburne and Palacin (2006) and presents a base for all the remaining housing price bubble literature as well. Himmelberg et. al. (2005) criticizes the use of P/I and P/R ratios and rather introduces a framework of home values based on local annual costs of owner-

occupied housing and local incomes and rents. They conclude that the four metropolitan US areas in their research do not show characteristics of price bubbles in 2004. Different conclusions came from Hwang Smith and Smith (2006), who, using infinite horizon of projected net rental savings discounted by required rate of return, find prices in ten American cities to be under the value justified by fundamentals in 2005. These are all examples of studies on American housing market which, similarly to European housing markets, is quite heterogeneous among the cities.

Several housing price bubble research papers were also concentrating on Asian countries. Youngzhou (2010) uses three different techniques including those of previous authors (the present value, P/I and P/R ratios) while introducing statistical tool of control chart used in manufacturing sector. Evidence on price bubbles suggests that bubble was forming in Beijing since 2005 and peaked in 2007 while Shanghai might have experienced bubble in 2003-2004 based on the control chart. Chung and Kim (2004) also use three different approaches to estimate possibility of housing price bubbles in three regions of South Korea. They find the share of bubble component in housing price to differ depending on the approach used with fundamental market value indicating the largest bubble. P/I ration indicates smaller magnitude and the smallest bubble is estimated by the lung-run equilibrium price approach.

In Europe Shelburne and Palacin (2006) provides rather a descriptive view of situation in Central and Eastern Europe with housing prices compared to yearly rental value being the proposed measure of housing bubble. He suggests that the signs of an ending price bubble include declining rate of sales of property and increasing inventories, and that was not the case in 2006. Otherwise the discussion is rather theoretical. Taipalus (2006) uses the traditional unit root test for log price-rent ratio to test for the existence of real estate bubbles. On the sample of Finland, US, UK, Spain and Germany, several periods of possible bubbles are identified by newly introduced Rolling ADF test in every country, although e.g. for Germany the evidence is rather week.

Literature on the housing price bubbles in the CEE is very limited and covers only the Czech Republic. Čadil (2009) investigates developments of three separate segments of housing market in the Czech Republic – Apartments, Houses and Parcels. First the simple P/I ratio is used to indicate possible periods of overvaluation and then VAR models were estimated for each segment. Variance decomposition of the housing price dynamics were then analyzed with lagged value of price change representing the speculative demand and

hence the bubble. For apartments the bubble component reached more than 48% with only other significant factors being income and population development. Very similar is the situation on the market for houses. Additional significant explanatory variable is the short term interest rate, but speculative demand still accounts for 44% of the price change. One period of a possible price bubble was identified prior to the accession of the Czech Republic to the EU in 2004 and some concern is expressed about the rising prices at the end of the data sample at the end of 2006.

Hlaváček and Komárek (2009) reach similar results as Čadil concerning the price determinants, as well as is the case of housing price bubble identification. They use P/I ratio and rental returns, time series analysis and panel data models both on the aggregate level and regional level. Despite some limitations they identify periods of 2002-2003 (pre-EU accession period) and 2007-2008 as the ones exhibiting residential property prices above the level that can be explained by fundamentals. Vast regional differences were identified as well, with periods of overvaluation present in each region.

Zemčík (2009) employs panel data stationarity and Granger causality techniques for the Czech Republic and its regions. Panel data unit root tests on prices, rents and price to rent ratios are performed to indicate possible housing price bubbles. Zemčík finds the apartments in the Czech Republic to be overpriced but the bubble is not substantial. Also the implications of present-value model are confirmed by the fact, that the results of causality tests lead to the conclusion that the changes in rents predict changes in prices and vice versa.

4. Development of CEE countries during the recent financial crisis

All of the countries worldwide were affected by the economic downturn, either directly or indirectly. The region of Central and Eastern Europe is no exception. On the contrary, some of the countries in the area were among the hardest hit countries. From the narrow definition of CEE for the purposes of this thesis, only Hungary has suffered and is still suffering heavily. According to the OECD study (2010), CEE and SEE[8] countries were narrowing the economic gap between them and their Western European counterparts before the crisis, at least in term of GDP per capita. It can be and was argued that the growth prior to the crisis was driven mainly by high current account deficits and rising external debts. This should not be seen as a significant downside, CEE and SEE countries had much lower public debt to GDP ratio compared to Western European countries, let alone Japan. What it meant over the course of the crisis is the fact that it deepened the adverse effects.

The late but dramatic onset of the crisis in CEE can be attributed to the crisis's origin in Western capital markets, as well as the region's heavy dependence on external markets and foreign capital. The distant epicenter of the crisis initially allowed foreign investors to keep capital committed to CEE markets. The region enjoyed positive returns through the first three quarters of 2008. CEE, however, did not go unscathed during the first phase of the crisis: from July 2007 to September 2008 credit creation and foreign capital flows to the region, predictably, began to slow down – but initially without a serious impact on economic growth. According to the European Bank for Reconstruction and Development (EBRD), *"the main reason why these signs did not manifest themselves in declining output in most countries before the second half of 2008 was the continued expansion of exports"* (Mesterhazy, 2010). Although lending rates in the region slowed markedly during the first three quarters of 2008, exports as well as imports only began to contract in the fourth quarter. Unfortunately, when the full force of the financial crisis finally struck Central and Eastern Europe, it struck both the region's financial and real economies in a devastating fashion as well as foreign capital and demand in tandem.

[8] SEE – Southeastern Europe

4.1. Macroeconomic development

Austria

Austrian economy is defined by its large tertiary sector dominated by insurance and banking. Industry is led by small and medium enterprises while the agriculture is small in size but quite efficient. International trade is essential for Austria, both in goods as well as services. To their main partners belong Germany, Italy, US and Switzerland, which as well experienced the effects of the crisis differently, thus impacting the exports of Austria in a hard-to-predict way. Since the world-wide recession started as a financial crisis, crucial parts of the economy were hit. Austrian banks proved to be in worse condition than expected and heavy governmental intervention was needed. However, currently the banks seem to have undergone a healthy procedure and latest stress tests do not show any immediate needs or threats to the Austrian banking industry.

The real economic output of Austria (real GDP, seasonally and working day adjusted) was still increasing in 2008 by 2.05% to the total level of EUR 315.6 bn, only to record a sharp drop of 3.8% in 2009. This negative figure can be explained by an unfavorable development of exports which contribute to the GDP by almost 60%. Exports began to decline as soon as in the second quarter of 2008 but hit the bottom in the Q4 2008 and Q1 2009. Total drop of 15% over the 2009 compared to 2008 was not helped by neither the exchange rate development, nor by the increasing labor unit costs after the last round of collective bargaining in Austria (OeNB, Quarterly review of economic policy). The recovery was rather quick owing to the good condition prior to the crisis and to the measures adopted by elected officials. Austria recorded a GDP growth of 2.3% in 2010 and exports rose by 14.3% year-on-year.

Despite the unfavorable situation of the economy as a whole, the labor market remained quite stable compared to other European countries. Traditionally low rate of unemployment prevailed in Austria also during the crisis rising by more than 1% from 2008 figure of 3.8% to 5.1% in 2009. This is mostly thanks to the anti-crisis measures described in the following section and also given by the nature of Austrian labor market where *"the Austrian industrial relations system is mainly based on close voluntary cooperation between employers, employees and the state – which is commonly referred to as social partnership"* (EIRO, Country profile Austria). Unemployment reached the peak at 5.1% in Q3 2009, but the trend was reversed and after minor fluctuations the

unemployment almost reached the pre-crisis value at 4.1%. The most significant problems seem to be low employment rates of low skilled workers and older workers, which is nothing surprising given the nature of Austrian economy.

Several ways of coping with the crisis were brought together in Austria. Austria adopted two fiscal stimuli packages to counter the economic downturn, tax reform was sped up and implemented in 2009 instead of planned 2010, as well as measures to ensure the viability of its banking sector were introduced. On top of that, the individual Länder provided additional infrastructural investment programs. The reaction was quite fast and first steps were taken already in November 2008. Even though it is hard to compare the extent of individual national anti-crisis measures, according to WIFO study (which takes methodology of OECD) Austria's measures were well below OECD's un-weighted average with the total spending of 1.1% of 2008 nominal GDP over the period 2008-2010. However, this methodology disregards off-budget measures and the investment programs of individual bundes-states which are of high importance in Austria. Accounting for these, the share on 2008 nominal GDP increases to 4.2%, meaning that the anti-crisis actions were rather massive.

Table 2: Tax reform and measures included in stimulus "package" I and II [Million €]

	Year		
	2009	**2010**	Package
Federal level (government programme)	**4702.5**	**5135.0**	
Infrastructure investment	***690.0***	***745.0***	
ÖBB	175.0	175.0	Stimulus package I
Asfinag	50.0	50.0	Stimulus package I
BIG	355.0	520.0	Stimulus package II
Broadband services	10.0	0.0	Stimulus package I
Energy-saving renovation	100.0	0.0	Stimulus package II
Lowering of corporate financing cost	***840.0***	***1240.0***	
Accelerated depreciation	0.0	250.0	Stimulus package II
Profit tax allowance	0.0	150.0	Tax reform
Third-party credits EIB 1)	200.0	200.0	Stimulus package I
Interest-subsidised ERP credits	200.0	200.0	Stimulus package I
Higher guarantee ceiling aws	400.0	400.0	Stimulus package I
Silent participations aws	40.0	40.0	Stimulus package I
Increase in private disposable income	***2987.5***	***2965.0***	
Income tax cuts	2300.0	2300.0	Tax reform
Family "package"	510.0	510.0	Tax reform
Tax deductability of sponsoring	100.0	100.0	Tax reform
Subsidised homebuilding	20.0	20.0	Stimulus package I
Regional employment "package"	35.0	35.0	Stimulus package II

Car scrapping premium	22.5	0.0	
Government consumption	***120.0***	***120.0***	
Compulsory pre-school year free of charge	70.0	70.0	Stimulus package II
Research and development	50.0	50.0	Stimulus package II
Subsidies	***65.0***	***65.0***	
Regional employment "package"	40.0	40.0	Stimulus package II
Globalisation "campaign"	25.0	25.0	Stimulus package I
Länder	**1073.2**	**1007.7**	
Infrastructure investment	876.8	876.8	
Increase in transfers	196.3	130.9	
Total	**5775.7**	**6142.7**	
Asfinag = Autobahnen- undSchnellstraßen Finanzierungs-Aktiengesellschaft			
BIG = Federal Real Estate Agency			
ÖBB = Austrian railways			

Table 2: Anti-crisis measures in Austria – Overview
Source: Breus et. al. (2009)

Czech Republic and Slovakia

Common history of the two countries would suggest heavy similarities. That is true to only some extent – since the split of Czechoslovakia in 1993 each country went its own way towards transformation into free market economies. Czech Republic was considered to be the frontrunner to its "little brother" but both countries met the requirements for EU accession in 2004 and since then, Slovakia was outperforming the Czech Republic and even adopted Euro in 2009. But the recent economic crisis changed the environment. Both countries can still be described as industrial even though service sector is the main contributor to GDP. Czech industry is dominated by automotive sector, which with its suppliers creates up to 20% of all industrial production (CIA factbook). Meanwhile, Slovakia has historically higher share of heavy industries, including steal and metal production, with more technology-demanding sectors on the rise. Both economies are quite open as for trade exchange, thus more sensitive to drops in exports, as those represent up to 80% of GDP. Continuing with the similarities, banking sectors are dominated by big foreign banking groups (e.g. Erste, KBC, Raiffeisen, Société General) and were in very good condition prior to the onset of the financial and economic crisis.

If measured by the growth rate of GDP compared to the same quarter of previous year, the crisis in the Czech Republic and Slovakia started one quarter later than in Austria and Hungary (namely in the first quarter of 2009). Again as was the case of Austria the decline in GDP (average of 4.5% for the Czech Republic and 5.0% for Slovakia in 2009)

lagged one quarter behind a rather massive drop in exports, that in quarter to quarter of the previous year comparison reached up to 17.5% and 24.2% for CZE and SVK respectively. Neither of the countries suffered domestic financial crisis as any excessive credit boom in the "good times" was avoided. Local branches of international banks did not require any recapitalization from public authorities as they are focused mainly on domestic retail and were not allowed to participate in the risky investments prior to the crisis. Interesting debate is the one concerning the influence of Euro area membership. Czech koruna provided, through the depreciation at the peak of the crisis, a little help to Czech exporters. On the other hand, Slovakia benefited from the lower lending rates in the Euro area as compared to the Czech Rep. (OECD 2011a, p.8).

While exports returned to growth quite fast and the GDP is currently around the pre-crisis level, labor market suffered more persistent blow. Unemployment was increasing rapidly since Q1 2009 and peaked in both countries in Q1 2010 (15.2% in Slovakia and 8.1% in the Czech Republic). The current levels are still far from the values at the end of year 2008 – current 6.6% as opposed to 4.4% in CZE and 13.1% against 8.6% in SVK. Especially the Slovak high numbers are little surprising as Slovak government reacted quite fast, establishing the Council for economic crisis in November 2008 and adopting first measures at the same time. Czech authorities reacted long six months later, adopting the National anti-crisis plan in May 2009. Both countries used a balanced mix of stabilizing and growth stimulating measures focusing on the supply side of economy. Such measures included lower corporate taxes (CZE), temporary changes to the unemployment and social benefits (CZE, SVK), credit guarantees for SMEs (CZE, SVK), car scrapage premium (SVK) and many others focusing also on energy efficiency and R&D. Also volumes of the fiscal stimuli were among more conservative in Europe, accounting for 2.1% of GDP in CZE and for only about 0.4% in SVK. In general the future development of Czech and Slovak economies will mainly depend on developments of their Euro area trading partners, predominantly Germany. In the meantime pension scheme and healthcare reforms should be in focus as well as labor force productivity enhancement.

CZECH REPUBLIC **Measure**	**Budget Impact** [CZK bn]
Realized and approved measures	
Use of reserve funds	1.5
Increase of guarantees to SMEs	-0.5
Subsidies for farmers	-2.3
Reduction of state operational costs	6.5
Strengthening of the Rural area development program	-0.3
Investments in science and R&D exceeding the approved budget	-0.3
Higher investments into transport. Infrastructure	-7.2
Increase of public employees' wages	-2.3
Co-financing	-1.0
Decrease of insurance rate for health insurance and state employment policy	-18.4
Decrease of corporate income tax	-6.0
Increase of equity in Czech Export Bank	0
Increase of EGAP insurance coverage	0
Change of legislation on insurance of export with state subsidies	0
Fiscal incentives supporting R&D	-1.9
Lowering of deposits for income tax	0
TOTAL	**-32.2**
Proposed measures	
Discounts for employers on social security and state employm. policy contributions	-18.0
Cancelation of mandatory back-ups	0
Accelerated depreciation in 1. and 2. group	-9.4
Wider application of VAT deductions for personal vehicles	-2.4
Faster VAT returns	0
Guarantees and support of loans to SMEs	-2.1
Subsidy program for improvement of energy efficiency of buildings	-6.0
Strengthening of the subsidy program PANEL	-0.6
Increased expenditure for securing the transportation services	-2.0
Postponement of deposits	-1.0
TOTAL	**-41.5**

Table 3: Czech anti-crisis measures overview
Source: National anti-crisis plan of the Czech government (p. 33), Author's translation

SLOVAKIA Measure	Budget 2009-2010 [EUR m]*	Period
Increase of untaxed base of employees and increase of employee bonuses	-367	2009-2010
Decrease of the insurance rate in the mandatory reserve solidarity fund from 4.75% to 2.0%	-40	2009
Time for returning of excess deductibles from VAT shortened from 60 to 30 days	-511	2009
Adjustments to the asset depreciation	-34	2009
Changes to the corporate tax structure reducing administrative costs	0	2009
Support in creating and maintaining social companies	-229	2009-2012
Compensation to employers restricting operations and employees' working time	-28	2009-2012
Subsidy to new employees who found job on their own behalf	-25	2009-2012
Increase of the compensations for commuting to the job	-11	2009-2012
Subsidy to the employer for each new employee that was previously unemployed (upper limit at EUR 142 in Bratislava and EUR 284 in other regions)	-12	2009-2012
Incentives for corporate R&D	-100	from 2009 on
Financing of concrete projects of Research and Development	-6	from 2009 on
Incentives for SMEs - subsidies from state budget	-8	from 2009 on
Programs increasing energy efficiency and improvement of energ. infrastructure	-133	from 2009 on
Financial grants for restoration of cultural heritage sites	-10	from 2009 on
Increase of funds for development and financing of programs of SMEs	-124	2009
"Scrapage premium" - subsidy for car purchase on condition of discarding old one	-55	2009
Financial support of rail incumbents (ZS Cargo and ZSR)	-236	2009
Program supporting citizens who are no longer able to finance their mortgage as a result of the crisis	-18	2009-2012
Interest free loans for heat insulation of residential real estate as high as 100% of justifiable costs of the project	-71	2009
Option to use the flexi-account for companies	0	2009-2012
TOTAL	**0**	

* Includes funds from the EU budget

Table 4: Slovak anti-crisis measures overview
Source: National reform program of the SR 2008-2010: Implementation report (p. 9-10), Author's translation

Hungary

Hungary's position among other CEE countries is vastly different. It is heavily agriculture-oriented country with main industries including machinery, chemical, energy and automotive industry. Previously dominant heavy industries such as mining and metallurgy have been declining since the transition of the economy. Hungary is also heavily oriented on exports as they represented more than 82% of GDP in 2008 (OECD, 2010, p.7). Despite the successful fiscal consolidation prior to the outbreak of the crisis that lowered the public deficit from 9.4% to only 3.7% of GDP over the course of 2006-2008, Hungary was the

only country in CEE that needed a loan from international institutions[9] to stabilize the economy (and mainly financial markets forcing Hungarian forint into downward spiral).

Decrease in exports in face of the global downturn was only one of the factors contributing to the severe recession in Hungary. According to the OECD Economic Survey (2010), it was one of the most severe recessions among OECD countries. Compared to its CEE peers[10], not only were the GDP growth rates (seasonally adjusted growth rates compared to the same quarter of the previous year) in the red numbers for two quarters longer, the fall in 2009 was also steeper at -6.8% compared to 2008. This proportionally excessive impact of the worldwide recession is attributed to the increasing level of external debt in the pre-crisis period. The fact that gross official reserves were surpassed in volume by the short-term foreign debt at remaining maturity put Hungary in dangerous position that proved to be crucial after the loss of investors' confidence in forint-denominated assets. Several demand and supply side factors combined for the increasing indebtedness in foreign currency (see Figure 2 for illustration) – lenders were attracted by wide spreads between Hungarian and WE interest rates and the expectation of convergence while banks preferred loans in foreign currency (mostly Swiss Franc) due to low domestic savings in HUF and less optimistic perception of convergence from their side. As markets experienced large amounts of forint denominated bonds being dumped in October 2008, the nominal exchange rate plummeted by 25% leading to an increase in interest rates by the Hungarian central bank. Despite the positive impact of the IMF loan, the exchange rate remained extremely volatile and had adverse effect on households and corporations. Households suffered from the real increase of their foreign-currency-denominated loans and companies, especially the SMEs, were hit by a severe credit crunch.

[9] International Monetary Fund, European Union and World Bank combined for loan guarantees in total amount of EUR 20 bn in November 2008.

[10] Again I would like to stress the narrow definition of CEE for the purpose of this thesis, for example Estonia suffered GDP decrease of 14.3% over 2009, easily surpassing Hungary for the largest drop.

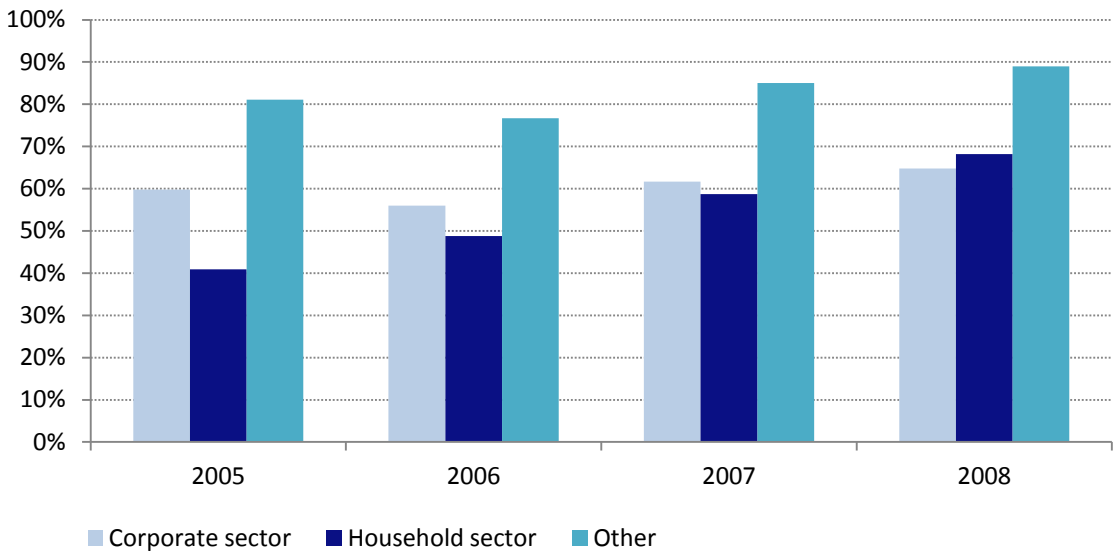


Figure 2: Share of foreign currency loans in total domestic credit
Source: OECD (2010)

Labor market is different from the rest of CEE as well. Real wages are rather flexible thanks to the consensual approach towards nominal wage setting at national level that helps to shape mutual agreements among employers, employees and public officials. Unemployment has been steadily rising since 2003 with some stagnation in 2007and reached the peak at 11.8% in Q1 2010, similarly to other countries. Two major differences can be spotted – firstly the unemployment rate climbed back to 11.6% in Q1 2011 due to unfavorable development both in global and domestic markets and secondly, Hungarian market is characterized by low participation rate and low employment rate of men. These characteristics were valid even before the crisis and the onset of recession merely deepened the trends.

Hungarian government had its hands tied with total external debt reaching about 120% of GDP at the end of 2008, compared to less than 50% in Poland and 40% in the Czech Republic. First steps were taken already in 2008 by the enactment of the Fiscal Responsibility Act and by establishing the Fiscal Council. According to the OECD (2010, p.52) "*The (fiscal responsibility) framework includes numerical fiscal rules, along with procedural and transparency requirements. With a medium-term perspective, the rules include annual spending targets for each of the next three years, and an "error correction" mechanism that in effect constrains the government to correct, within the next three years, any deviation of debt from the targeted level*". However, the fiscal rules only

apply for the central government. Hungary adopted first batch of measures to improve fiscal balances while restraining domestic demand and economic growth in mid-2009, combining one-off measures and structural changes with long-term effects. This first anti-crisis package is summarized in Table 5 below.

Measure	**Effect** [HUF bn]		
	2009	**2010**	**2011**
Elimination of 13th month pension benefit	--	165	165
Change to pension indexation	0	76	91
Freezing minimum pension benefits	0	12	25
Postponement of the 2009 pension benefit correction to 2010	10	--	--
Cancellation of second instalment of the 13th pension benefit	82	--	--
Malus expansion for pensions (July 1, 2010)	--	2	6
Cancellation of the reduced pension benefit correction in 2010	--	5	5
Reduction of the pension benefit correction due in 2010	0	35	36
Elimination of 13th monthly wage in the public sector	90	181	181
Inflation-adjusted net wages in the public sector (increase only for low wages in gross)	--	70	70
Restricted disability pensions	10	20	20
Reduced or restricted housing subsidies (including social policy interest rate)	24	52	72
Blocking proceeds form Kyoto quote sales	20	--	--
Agricultural subsigy cuts (TUP UP and other)	35	35	35
Raduced natural gas and distance-heating compensations	20	40	40
Reduced prescription subsidies	30	30	30
Freezing of sources in ministries	60	60	60
Increasing the funds to the Research Fund	10	--	--
Freezing family allowances	0	12	25
Cancellation of the September 2009 family allowance increase	4	17	17
Entitlementto the family allowance reduced to 20 years of age from 23 years	--	9	9
General rate of sick-pay reduced from 70% to 60% (September 1, 2009)	3	16	17
Local government subsidy cut	0	120	120
TOTAL	**398**	**957**	**1024**

Table 5: First Hungarian anti-crisis package – Summary
Source: Hungarian Ministry of National Economy (2011, p.6)

With the world economy falling deeper than expected, the 2010 budget deficit originally set at 3.8% of GDP seemed impossible to achieve after the first half of the year[11]. To counter the development that by the estimates of Hungarian Ministry of National Economy would lead to a deficit between 6 and 7%, controversial measures were adopted in the course of second half of 2010. The bank tax was introduced in June 2010 and was supposed to raise 187 billion forints through the tax on banks, insurers and other financial-services companies each of the 3 years for which it was planned. This tax was levied at 0.5% of banks' assets over 50 billion forints at the end of 2009, which is 3 times higher than any similar measure introduced by other countries during the crisis. This all despite the opposition not only by the banks present on the Hungarian market but also by international organizations such as IMF. The crisis tax was levied on the major players in the energy, retail and telecom sectors using the principles of the above mentioned bank tax. The measures from what could be called a second anti-crisis package are summarized in Table 6.

Provisional, not structural, deficit reduction					
Measure	**2010**	**2011**	**2012**	**2013**	**2014**
Bank tax	180	180	180	90a	90a
Crisis tax	161	161	161	--	--
Private pension fund payment	60	360b	--	--	--
Private pension fund asset	--	529	--	--	--
Budget freezing	220	250	--	--	--
TOTAL	**621**	**1120**	**681**	**430**	**430**

a = EU compliant Hungarian bank tax
b = 97% returned to the state pension system, 3% remained

Table 6: Second Hungarian anti-crisis package – Summary
Source: Hungarian Ministry of National Economy (2011, p.8)

Poland

Poland is considered to be the superstar not only among the CEE countries but in the European and OECD-wide context as well. Since the year 2007 Poland's performance in the real GDP growth category has been at the top of the list. And in the actual economic recession this position was confirmed by a 1.7% real GDP growth rate, the highest number

[11] To achieve the figure was important for two reasons – it was set under the new legislation of Fiscal Responsibility Act and the level below 4% of GDP was also agreed on with IMF upon receiving the international loan.

among OECD members. There are many factors contributing to this extraordinary performance, nevertheless, the current situation and outlook is far from perfect. Even though Poland did not record as high GDP growth in the pre-crisis period as for example Slovakia, the situation was unsustainable. Poland entered the recession with inflationary pressures caused by excess demand and global downturn ironically helped the country whose estimated output gap was nearing 5.5% of GDP in 2007 (OECD, 2010a, p. 23). As compared to its CEE peers Poland benefited from the larger domestic market and relatively low openness of economy. Moreover, the massive depreciation of zloty improved the price competitiveness of domestic products and helped to satisfy local demand from local suppliers, easing the situation on labor market and enhancing domestic demand through second-round effects.

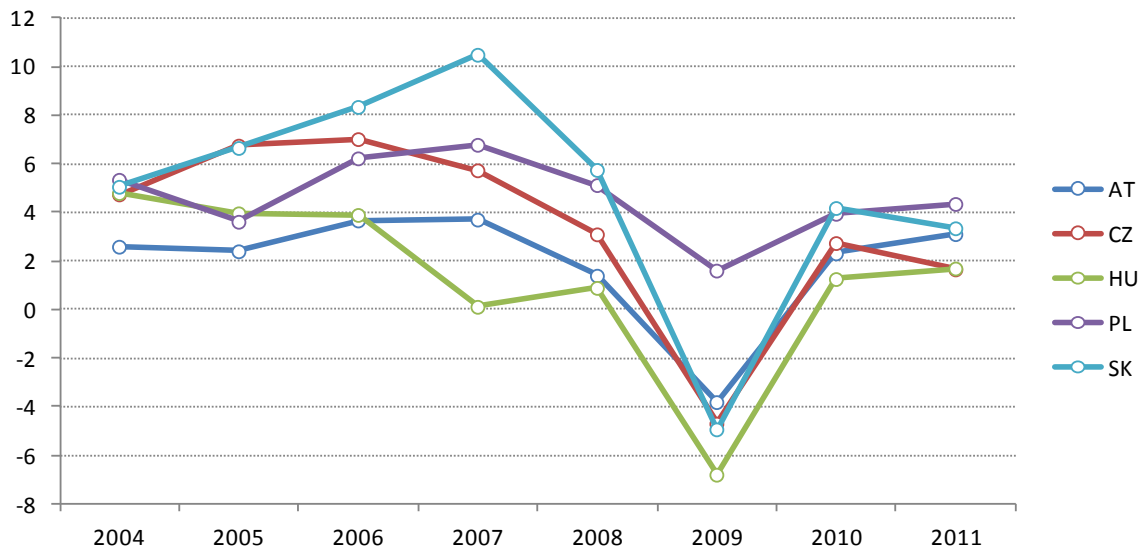


Figure 3: Annual real GDP growth rates, [%]
Source: OECD

Although Poland did not record negative real GDP growth in 2009, the drop in the indicator was substantial. Therefore for 2009 Polish government introduced the "Stability and Development Plan" to boost the economy. Main quantifiable measures are summarized in Table 7 but in general they covered three basic interconnected areas: financial system stabilization, stabilization of public finances and support of economic growth. Similarly to other countries, the pro-growth measures included faster depreciation of assets, tax incentives for R&D, support for start-up companies or support for SMEs in form of guaranteed lending. Additional steps were undertaken to improve the situation on labor market. Rigidity of working-time limits was eased to smooth the impact of variations in

production, companies facing falling revenues were incentivized to retain employees and rather cut their working time with respective decrease of the wage and in case of unemployed citizens facing mortgage payments they were offered an interest-free loans. Besides the above mentioned measures, funding of the active governmental labor market policies was substantially increased, including bigger role of private employment agencies in matching the jobless with vacancies in the market. Despite the efforts of the government on the labor market, the unemployment rate increased to around 10% during 2009 and remained at the high level even after the stabilization of global economy. According to OECD (2012) this was caused by the increasing participation rate under the "Programme 50+" and as a consequence of tightening of early-retirement schemes.

Measure	**2009 planned expenses** [PLN bn]
Increasing the LG/LC limit for the economy and the financial market	40
Creating additional, safe credit action for small and medium enterprises (SMEs)	20
Advancing the investments co-financed by the European Union by increasing expenses qualigying for the European Committee certificate	16.8
Earlier prepayment from the European Committee to expend the EU assets	3
Supporting investments in renewable energy sources (the National Fund for Environmental Protection and Water Management)	1.5
Sub-Total	**81.3**
Introducing two-tier PIT settlements	8
VAT reform	2
TOTAL	**91.3**

Table 7: Polish anti-crisis measures overview
Source: Stability and development plan (p. 3), adjusted by author

Although major concerns were present regarding the Polish banking sector, Polish banks navigated through the crisis fairly with ease owing to the support of their large foreign mother-companies and to the limited exposure to the high-risk innovative instruments. Hence the main concern nowadays is about the fiscal sustainability and increasing public debt. Even though the anti-crisis package was not among the largest ones in Europe, the Excessive Deficit Procedure with Poland was ended only after the turmoil in the US had already started. Given the history of high public deficits and necessary measures including tax cuts during the crisis, the accumulated public debt rose substantially in the past years. With the government deficit reaching 7.8% of GDP in 2010, it can be said that the exceptional performance came at high cost and the situation would

have been worse if Poland was not the receiving side of the highest share of the EU's Structural and Cohesion Funds over the 2007-2013 period (19% of all the funds to be allocated). The debt-to-GDP ratio worsened, but the criticality depends on the definition of the ratio used. Under the Maastricht definition the indebtedness reached 57% of GDP which should have triggered corrective actions embedded in Polish legislation[12]. But since ratio under the national definition remained under the threshold of 55%, the central government remained with its hands untied. Further fiscal consolidation is necessary but that can be said about the region altogether. Despite the large domestic market, future development of Polish economy will depend on the EU as the contagion can be transmitted through trade, foreign-investment and exchange rate channels (OECD, 2012, p. 6).

4.2. Development of the real estate market

All of the countries except for Poland which experienced the mildest recession amongst not only CEE but the whole EU as such included some measures towards housing, real estate or at least energy efficiency of housing that might influence the residential real estate market. The real estate market itself is subject to periodical volatility in prices, at least in the developed countries. Therefore the experience of Japan and other countries experiencing significant decrease in housing prices should have served as an example of what could be expected once the events in the US unfolded. Any thoughts of the recession having no or limited impact on the CEE region were utopist given the openness and interconnectedness of CEE and Western Europe. As Deloitte (2009, p.6) points out: *"A real estate market boom usually leads to underestimation of risks and to a linear model of thinking where stable and permanent growth of prices and performance indicators such as revenues are expected. The mutually strengthening relationship between the growing real estate prices and ever more available loans is usually quickly reversed. Owners of overvalued properties (customers, developers or financial institutions) experience collapse of their balance sheets when the prices significantly drop"*. This description fits well the situation on international real estate markets prior to the crisis. What is even worse for the economy is the decreasing confidence of consumers and investors once the asset prices start to decline.

[12] Although the constitutional debt limit is set at 60% of GDP, threshold level for corrective actions is already at the 55% of GDP.

Factors influencing the demand side (wealth channel, credit crunch, job insecurity etc.) are profound and have been discussed to some extent in previous sections of the thesis. For the supply side of real estate market the construction production is the essential indicator. Construction business suffers from the credit crunch as well but as it was mentioned before, the supply is inelastic and there is a significant lag between investment and funding decision and the actual supply of the good/service to the market[13]. Therefore the influence of the crisis should be evident with certain delay as opposed to the other macroeconomic factors. Figure 4 shows the development of the real construction industry output with values mostly increasing until Q1 2008. Over the course of 2008, despite the initial drop, the situation stabilized owing to the projects already under construction and the main continuous decline started in 2009. Poland has to be considered in slightly different way as major infrastructural construction activities are carried out in connection with the upcoming football European Championship in Summer 2012. Nevertheless, even in Poland the year 2009 saw certain slowdown in construction activities. Hungary is an exception with its economy facing severe construction downturn well ahead of the worldwide turmoil.

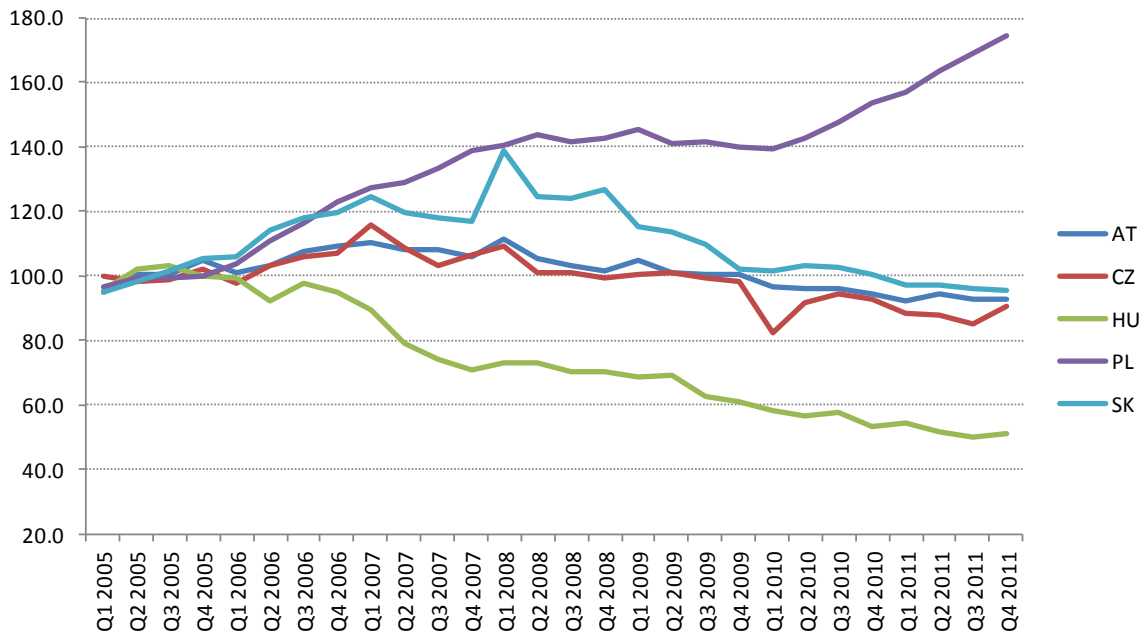


Figure 4: Real Construction Production Index, 2005=100, Seasonally adjusted,
Source: Eurostat

[13] Situation when the project becomes unprofitable during the construction and is still finished due to the preservation and maintenance costs leading to higher losses is quite common.

As the construction production index contains both engineering (or infrastructural) construction and building construction the values do not seem so alarming. However, Delloite (2009, p.9) points out that during the 4.2% decline in the end of 2008 in the EU, building construction segment "contributed" by dropping 4.6% as opposed to the decline of engineering construction of 2.5%. On top of that residential buildings sub-segment is usually the hardest hit and the slowest to recover.

Years 2009 and 2010 were the true test to the construction industry. At the beginning of 2010 it accounted for around 6.5% of GDP in the Czech Republic and up to 9.5% of employment in the private sector. All of the CEE's residential real estate markets saw decrease in prices of properties, while Poland's figures illustrate the general cooling of the market – sales of residential property recorded a month-on-month decline of approximately 50% in number of transactions during Q1 2009 and the prices of new housing stock dropped as much as 12% Q-o-Q (Deloitte, 2010, p. 11-12). The availability of housing as measured by the number of apartments per 1,000 inhabitants was not hampered in 2009. This can be attributed to the continuation and finishing of construction started prior to the crisis. Nevertheless, as can be seen from the chart published by Deloitte (2010), countries in CEE with exception of Austria (as was expected) and the Czech Republic are far below the EU average.

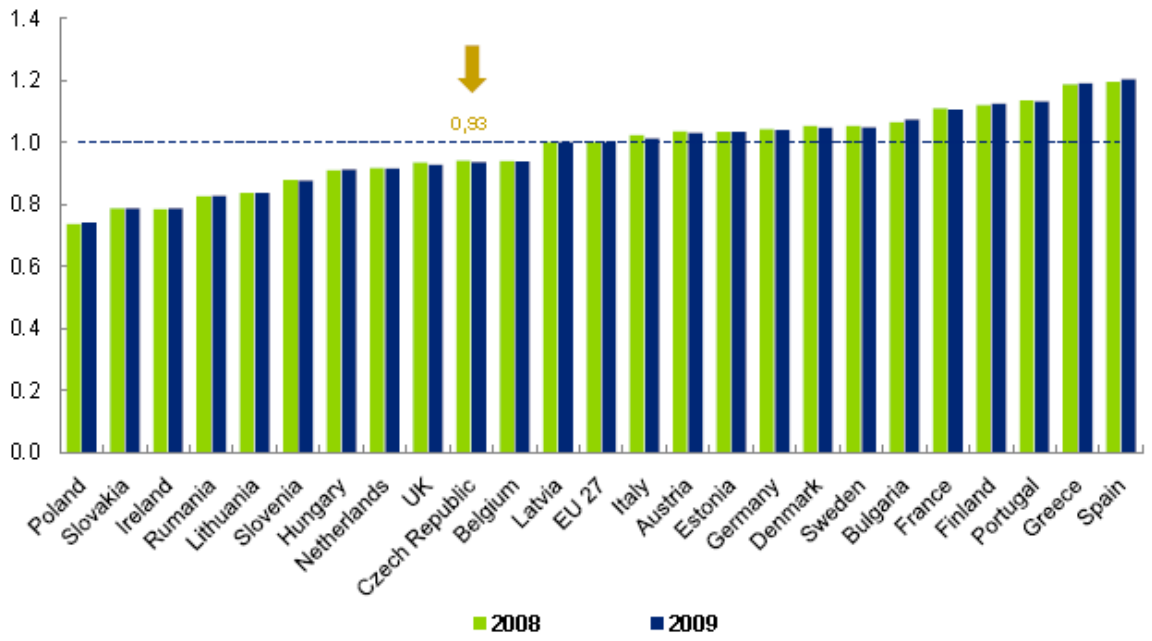


Figure 5: Number of apartments per 1,000 inhabitants; EU 27 = 1.0
Source: Deloitte (2010, p. 11)

Despite certain revival in second half of 2010 and mainly 2011, the future of real estate markets in CEE is still very doubtful. Europe's largest construction business research group Euroconstruct adjusted the projections for 2011 and 2012 downwards, now predicting the 2012 to be the new low of the construction industry. This prediction is for the whole Europe, but the CEE region should not be different. Heterogeneity of the region and its development can be illustrated also by the number of completed apartments per 1,000 citizens. Values in 2011 as compared to 2008 plummeted in Hungary, only slightly decreased in the Czech Republic and recorded substantial increase in Poland (Deloitte, 2012, p.5).

5. Data description

This section discusses the issues and specifics connected to the real estate data and describes the data used in the following econometric analysis, including their sources. As it is mentioned in the vast majority of similar research papers and studies, heterogeneity and lack of timely data have been the main obstacle in analyzing the residential real estate markets in (not only) Europe. Despite current efforts of various international organizations the situation concerning historical data has not improved. However, increasing availability and comparability of data promise more reliable analyses in the future.

"Real estate has been a neglected area because it has always been treated as an independent sector. Now, the real estate sector is viewed as a significant contributor to the financial position of financial institutions in terms of mortgage loans as well as asset holdings. Thus, real estate prices are critical for the financial sector and in terms of measuring the wealth of the country. This is an area where information is lacking. In our country, there is no agency that collects real estate market prices." (Heath 2003, pg. 6). The preceding citation was recorded as a comment to the Compilation Guide on Financial Soundness Indicators by the IMF in March 2003 and represents a lean summary of general view of both the compilers and users of real estate data. Gaps in available statistics were evident long before the onset of US real estate market crash. Joint conference organized by the IMF and BIS in October 2003 can be considered as one of the first efforts to promote the unified collection and use of real estate data (hofinet.org). While the topics were mostly general, the conference spurred further discussion and special chapter on residential property price indices was added to the Compilation Guide of Financial Soundness Indicators. The importance of real estate price indicators was further stressed at the mutual OECD and IMF workshop in Paris in October 2006. New use of real estate price indices was proposed (including precise measuring and comparability of real estate price bubbles), but the main subject of the workshop were the responsibilities for reliable data collection and the methodology of price index construction[14]. Financial crisis revealed substantial deficiencies in the data collection and in order to explore the information gaps IMF and FSB prepared a document for G-20 Finance Ministers and Central Bank Governors. With

[14] Diewert (2007) provides extensive summary of the workshop agenda, indicates the target indices to be produced, introduces suggested methods for creating homogenous real estate price indices as well as proposes further steps and recommendations.

the heterogeneity of countries and the constant development of institutions, problems with appropriate data availability are always present. It is, however, the turbulent times that stress the lack of timely information that can have detrimental impact on policy makers and their capability of creating and applying effective measures. The above mentioned document aims at providing appropriate proposals for strengthening data collection and does so in a form of 20 recommendations. The second-to-last of the recommendations deals directly with the issue of real estate price indices: *"The Inter-Secretariat Working Group on Price Statistics to complete the planned handbook on real estate price indices. The BIS and member central banks to investigate dissemination on the BIS website of publicly available data on real estate prices. The IAG*[15] *to consider including real estate prices (residential and commercial) in the Principal Global Indicators (PGI) website"* (IMF and FSB, 2009, p.8). A key lesson for the future was the importance of ensuring, that collection of statistical information remains adaptable in response to rapid changes in the financial markets. Further adapting this recommendation was the conference held in Basel in November 2009. Its purpose was to elaborate on the uses of residential property price indices (RPPI), basis for compiling such data and how statistical organizations – both private data providers and official statistics – should address various methodological and compilation issues. Eurostat took lead in preparing the Handbook on Residential Property Price Indices, given the strong links to its ongoing work on owner-occupied housing and the role that house price indices will have in Eurostat's set of "Principal European Economic Indicators"(Eurostat). The Handbook on RPPI is a so called live document opened for comments and suggestions. However, the current version (the last update is from November 2011 and includes the suggestions from a workshop on RPPI in the Netherlands in February 2011, as of April 30, 2012) is already quite extensive and provides first international guidance for compilers of RPPIs. The final section offers recommendations on all the main issues concerning compilation of the index, including e.g. scope of the index, weighting, statistical methods to be used or decomposition between the building and land components. For the institutions producing RPPI for the first time a straightforward guide selecting the simplest approach is presented in order to stimulate creation of the indices in more and more countries. Given the continuous activity in the area of real estate prices and the tangible results in the form of Eurostat's Handbook,

[15] IAG – Interagency Group on Economic and Financial Statistics

hopefully the information gap will be narrowed and completely eliminated in the near future.

Statistical data used for similar studies and research papers are usually of two types. Real estate transfer prices are the closest approximation of the actual market price but their main disadvantage is their timeliness as the official quarterly data are published with lag of up to one year. On the other hand real estate supply prices are available with virtually no lag. Such datasets are mostly based on information provided by commercial real estate agencies and real estate advisories (e.g. King Sturge, Knight Frank, REAS, Lexxus and many others) and are then maintained by independent institutions. In the Czech Republic it is the Institute for Regional Information, for Poland the Real Estate Database (BaRN) is maintained by the National Bank of Poland since 2006. Unfortunately, their methodological construction is inferior to the transfer prices. Usually the supply price data are biased by the real estate agent's provision or by the prolonged presence of overpriced estates in the dataset. Since the spread between supply and transfer prices in 2011 reached 11% in the Czech Republic (Deloitte, 2012, p.12), author opts to work solely with the data provided by public institutions such as national banks and national statistical offices with transfer prices (if available) being the most reliable and preferred option.

Nevertheless, the quality and availability of data used for this study vary from country to country. This does not come as a surprise since even the ECB has had trouble compiling data for the more developed Euro area countries (Palacin and Shelburne, 2006, p.2). Inconsistencies hampering the comparability and reliability of the data lie in multiple dimensions. Indices can include prices of any combination of apartments and family houses, new and existing dwellings and regional coverage including or excluding the capital city. Ideal composition selected for this thesis consists of existing apartment prices of the whole country, including the capital city. Existing stock represents most of the market and the composition effect on price is lower than in case of the newly built apartments. Prices in the capital cities are usually multiple times higher than in the rest of the country[16], however, the difference in price development is only minor. Given the availability of data in CEE countries, inclusion of capital cities in the data sample is justifiable. The Czech statistical office provides transfer prices based on transfer tax returns data from the Ministry of Finance. Index is based only on the existing flats and

[16] In Austria the capital city of Vienna is second to the Alpine skiing resorts in the most expensive areas ranking.

covers the whole country – includes data from all regional capitals and generally all cities above 50,000 inhabitants with some representatives of municipalities with population in range of 10,000-50,000. The price index is available for period 1998-2011 and price levels of CZK per meter squared can be calculated from shorter time series. This can be considered as the benchmark of data quality in the CEE. Data for Austria are not collected by the statistical office, but the national bank in cooperation with Austria Real Estate Exchange and Vienna University of Technology publishes the real estate price index. The index is available for 2000-2011, however, information on price per square meter is completely missing. For the purpose of this thesis the value for Q4 2011 was estimated based on internet research and has to be taken with extra caution. Situation in Slovakia is similar to the one in Austria. National Bank of Slovakia (NBS) has the responsibility for publication of the price index and does so with the help of local association of real estate agencies. Indices and price levels are published with regional breakdown and also by the types of dwelling. Methodology in both countries stresses the intent to use the transfer prices. Nevertheless, NBS points out that the use of supply prices is less important setback compared to the possibly restricted regional coverage. Situation is considerably worse in the two remaining CEE countries. Polish national bank's financial stability report provides only supply price-based data on price per square meter covering 7 major cities with quarterly coverage starting in 2005. At least the annual data for previous 3 years are also available. The Hungarian central statistical office (HCSO) began using the data on stamp duty receipts, which are provided by the Hungarian Tax and Financial Control Administration (NAV) only in 2007. It now provides data individually for new and existing dwellings, breakdown for apartments and family houses is not available. HCSO is the only institution in CEE that provides a split of the price change in composition and pure price effects. For the following calculations was used different data set from HCSO. It uses the supply prices from real estate agencies for the capital city of Budapest and as the only long time series has to be taken as representative data for the whole country. Bank for International Settlements (BIS) collects and publishes these time series on their website in a single file and it was used as the primary source. Some adjustments had to be made to unify the base of indices and BIS only publishes index for Slovakia covering all types of dwellings. Therefore data from NBS website were used for the analysis.

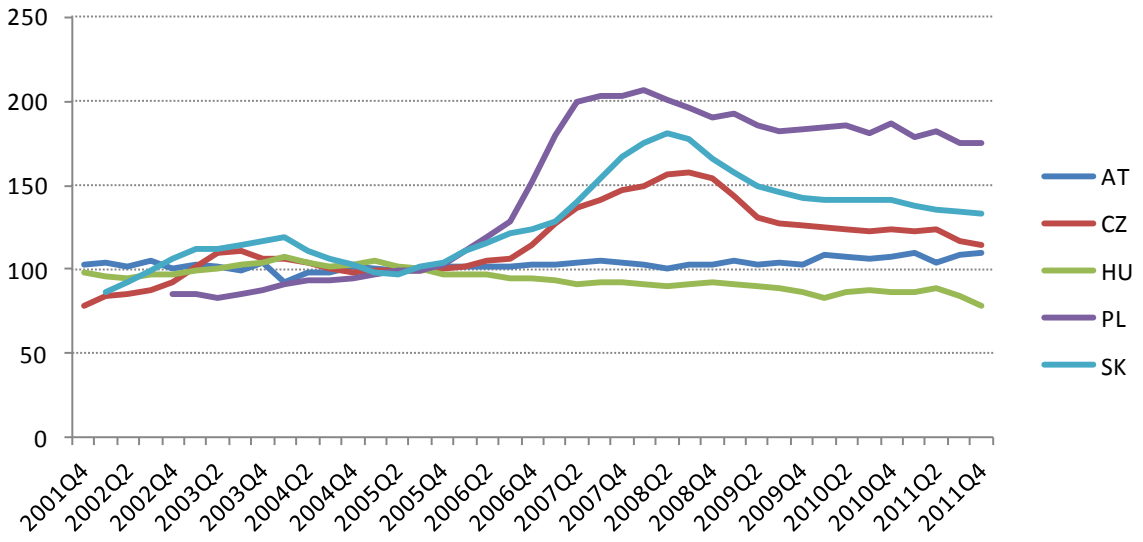


Figure 6: Real Housing price index, 2005=100
Sources: National Banks, National Statistical Offices, BIS

Other mainly macroeconomic variables (GDP, unemployment, core inflation, Construction Production Index, Short term and Long term interest rates) were obtained from Eurostat and OECD databases that offer wide range of highly homogeneous quarterly data. Population statistics from national statistical offices sometimes suffered from unavailability of quarterly data. For housing loans interest rates databases of national central banks were used. Although all the banks publish such data, some were only available starting in 2004. For older period interest rates on housing loans were replaced by general consumer credit rates. One important generalization had to be made concerning the housing interest rates. Despite important share of housing loans being denominated in foreign currency (especially in Hungary (CHF) and Poland (EUR)), the data used for analysis are those for housing loans carried out in domestic currency. Lastly, for segments of data that were available only at annual frequency simple linear interpolation was used to obtain necessary quarterly data. Given the aforementioned imperfections of the dataset used, implications of following estimations have to be considered carefully. Detailed description of the data including their sources can be found in Appendix I.

6. Methodology, model description and empirical results

Three different econometric techniques will be used to assess the price determinants of residential real estate in CEE as well as the potential price bubbles on the markets. These include simple indicators, country-specific time series analysis using vector autoregression and basic panel data regression approach. Comparison with previous studies on the topic may then suggest alterations to the previously perceived price determinants to be altered by the financial and economic crisis of 2007-2009 and more clear evidence on the possibility of price bubble in the times during and after the crisis[17] is to be assessed.

6.1. Simple indicators

The simplest indicators of possible housing price bubble are two commonly used ratios: the rental return (or its inverse, the price to rent) and price to income ratio (P/I). Given the lack of data on rents for CEE over the followed period, author resorts to using only the latter for primary indication of price bubbles on the CEE residential real estate markets. Price to income ratio is calculated as the real price of standardized average apartment (in line with Hlaváček and Komárek (2009) and Zemčík (2010) an apartment size of 68m^2 is used throughout the period, quality of average housing stock is assumed to be constant) over the cumulated real wage for the last 4 quarters[18]. One of the factors influencing the price level of housing per meter squared is the size of an apartment. Palacin and Shelburne (2006) conclude that slight tendency exists for the price per meter squared to be higher in the very small and very large apartments. For the purpose of this study we assume that the data on price levels in each country are compiled from apartment of fairly similar structure concerning their size, therefore not biasing the following calculations.

[17] Assuming the crisis ended in 2009/2010 which is currently not very likely.

[18] For countries where latest data on nominal wages are not available the real wage is assumed to stay the same as for the last observed quarter.

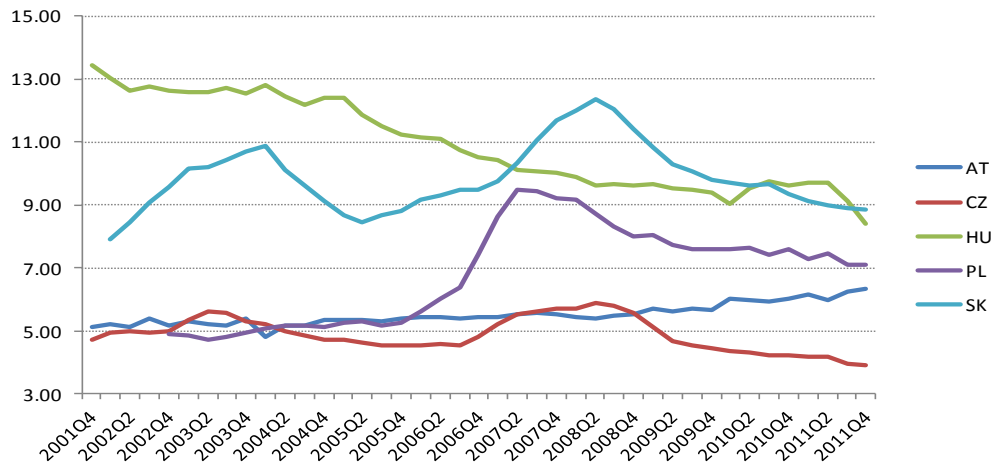


Figure 7: Price to Income ratios, Author's calculations
Sources: National Banks, National Statistical Offices, BIS

P/I ratio shows the affordability of housing for an average-income household, however the equilibrium values differ significantly for individual countries and are affected by several factors (e.g. financial sector development, regulatory conditions, demographic developments, taxes etc.). Malpezzi (1999, pg.10) suggests that the optimal P/I ratio should range between two and three. That is valid, however only for houses but not necessarily for apartments. In general, low P/I ratio is desirable since the high P/I is a sign of an inelastic housing market that could even suffer from a substantial capital misallocation. Ratio constructed in the above described way does not perfectly capture the market situation – typical buyers on the market earn above-average wage. However comparison of the P/I ratio with its long term average value shows periods of over- and undervaluation. Data from OECD (2005a) show that most of the countries around the globe faced significant housing price overvaluation in 2005. Following the work of Čadil (2009) a different method of detecting housing price bubbles from P/I ratios is employed. Given the restricted time dimension, actual P/I values are compared to their trend, modeled by Hodrick-Prescott filter with $\lambda = 1600$ typical for quarterly data, instead of the long term average. From Figure 7 and 8 it is apparent that the countries are quite heterogeneous. Austria displays the most stable development as it was expected given the well developed institutions and longer benefits of liberal markets. There are two common periods of interest apparent for the P/I ratios – the pre-EU accession period of approximately 2002-2004 and the crisis period of 2007-2009. In the former P/I increase can be attributed to the expected price increase that never occurred when joining the EU (CZ, SK, HU, PL) while

the short and sudden drop in Austria might be a reaction to the intensified competition in RRE market.

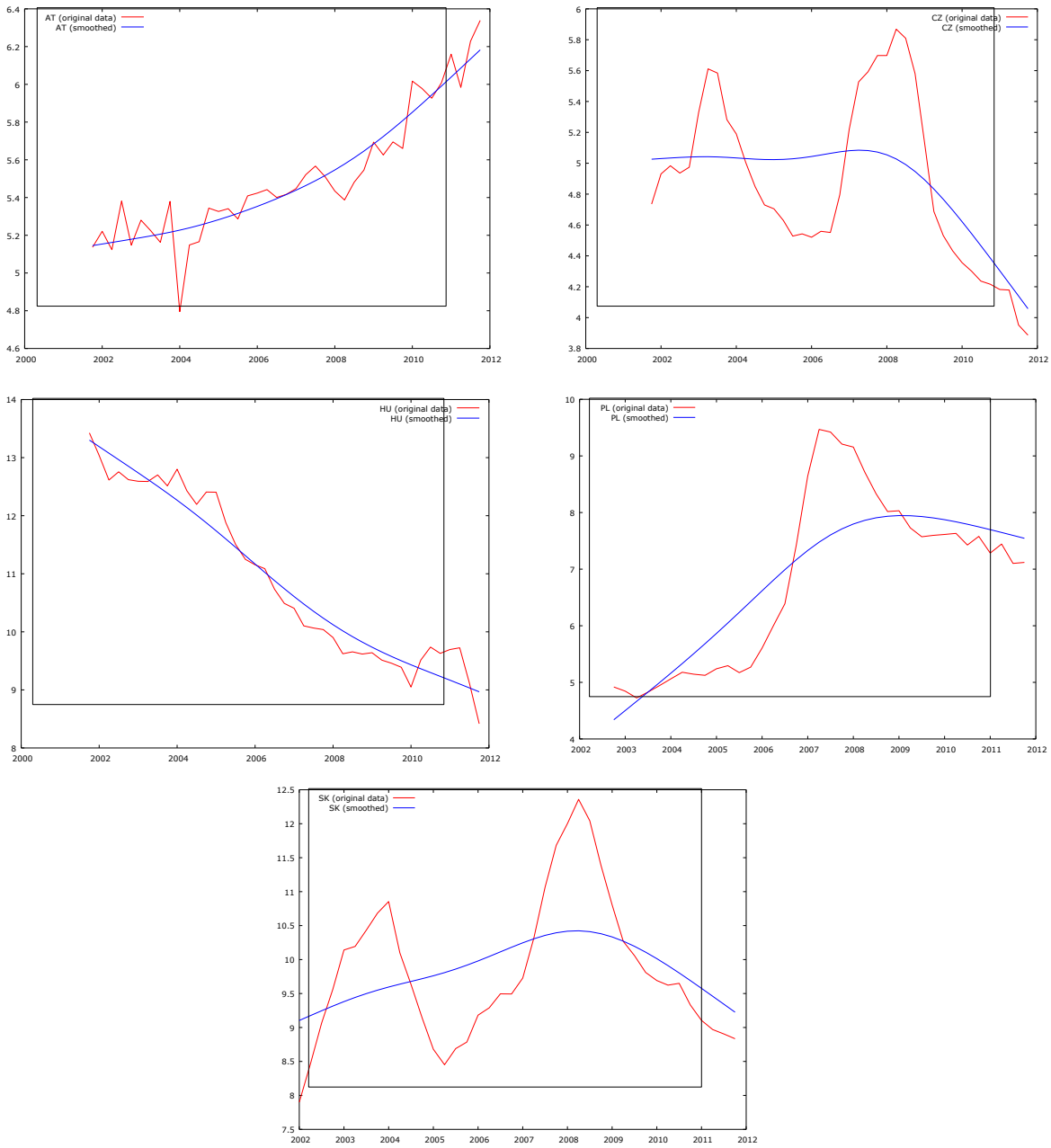


Figure 8: P/I ratios compared to trend, Author's calculations, from left to right and top to bottom – Austria, Czech Republic, Hungary, Poland, Slovakia
Sources: Same as Figure 3

In Hungary the approach of EU membership pushed prices up as well – however, the growth in real wages was even higher causing the P/I ratio to decline. The latter period saw substantial deterioration of affordability (hence potential price bubble) in Poland, the Czech Republic and Slovakia with the peak coming in Q2 2007, Q2 2008 and Q2 2008 respectively. Austria only a saw minor correction before the upward trend was restored and

P/I ratio in Hungary continued to decline until Q1 2010. Given the severity of the crisis in Hungary this is not a surprising development. With the continuing economic turmoil exacerbating, another sharp drop occurred in the second half of 2011 and future developments will be of great interest. The Czech Republic and Slovakia typically show almost identical development; Slovak data exhibit little more volatility.

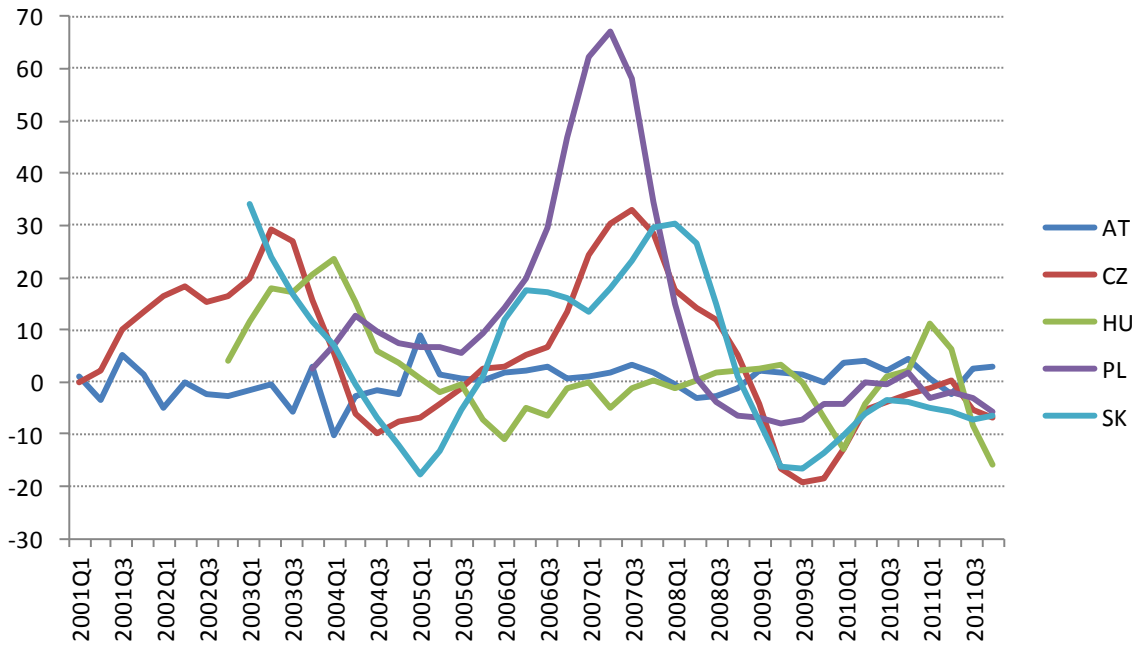


Figure 9: Housing Real Price Growth [% on the previous year]
Source: National Banks, National Statistical Offices, BIS

Based on the growth rates of housing real prices we can incur that the decline in P/I ratio in Hungary was until 2005 caused by the growing real wages while the current downward adjustment is due to the decreasing property prices. Similar conclusions can be made for the remaining four countries as well, including the extreme growth rates in Poland between Q2 2006 and Q4 2007.

Chung and Kim (2004) introduced the method of quantification of the bubbles identified by the simple P/I ratio. They argue that the "normal" price should not dramatically exceed the annual income of a household. This principal can be applied to various models. Specifically for P/I indicator, it means that the ratio should not exceed the long term average plus one standard deviation:

$$B_t = (P/I)_t - (P/I)_t^e \qquad (1)$$

where $(P/I)_t^e = \overline{P/I} + \sigma(P/I)$

The excess P/I is expressed as a percentage to show to what extent the bubble is present. Table 8 summarizes the findings for the observed countries. It has to be pointed out that the time period covered is rather short and that the current crisis influences the threshold values especially in case of Poland. Quantitative analysis of the P/I ratios confirms some of the facts stated previously – Polish and Slovak volatile markets display the highest share of bubble component at maximum value of almost 12% while the Czech Republic recorded its peak at under 8%. Data for Hungary and Austria show inverse developments in the two countries: Hungarian market faced a bubble in the very beginning of the observed period while Austria exhibits high share of a bubble component in the real price at the very end of the data sample.

Country	P/I average	P/I st. dev.	Threshold value
AT	5.506	0.340	5.846
CZ	4.880	0.540	5.420
HU	10.914	1.434	12.348
PL	6.818	1.542	8.359
SK	9.847	1.063	10.910

Country	Period (max. share)	Period (max. share)
AT	--	Q1 2010 - Q4 2011 (7.8%; Q4 2011)
CZ	Q2 2003 - Q3 2003 (3.4%; Q2 2003)	Q2 2007 - Q4 2008 (7.6%; Q2 2008)
HU	Q4 2001 - Q1 2004 (8.0%; Q4 2001)	--
PL	--	Q1 2007 - Q2 2008 (11.7%; Q2 2007)
SK	--	Q3 2007 - Q4 2008 (11.7%; Q2 2008)

Table 8: Estimate of bubble based on P/I ratio,
Source: Author's calculations

There were also several periods of identified undervaluation of residential real estate in all of the countries under consideration. Namely, it were the beginning of the observed period for Austria, Poland and Slovakia, and the end of the sample for the Czech Republic and Hungary. Given the decreasing trend in P/I ratio in Hungary throughout the whole period it might provide only a limited value as to predicting the future developments. In the case of the Czech Republic, the long seven quarters of undervaluation

at the end of the followed period may suggest that the trend should be soon reversed and the real prices of apartments may grow again. Nevertheless too many influential factors remain unaccounted for. Therefore the identified periods of residential real estate overvaluation are just a preliminary indicator to be taken with caution. More detailed analysis of fundamental factors and their explanatory power of changes in housing prices are necessary.

6.2. Panel data model – Is the CEE region somewhat homogeneous after all?

If we assume the heterogeneous data on housing prices to be comparable to a sufficient extent, then a straightforward analysis using panel data models can be carried out. It requires multiple assumptions and its outcomes are severely limited especially regarding the endogeneity of explanatory variables. Nevertheless, it provides an alternative view of both property price determinants and a potential over- and undervaluation.

So called panel or longitudinal data are observed for a group of units (countries, individuals, companies etc.) over at least two dimensions. Although multidimensional data sets exist, typical panel data are observed over two, time and cross-sectional, dimensions. Observations then carry two subscripts, one for the time series component and second for the representative unit (in case of this thesis for a given country). General panel data model takes the following form:

$$y_{it} = \alpha + X_{it}^{'}\beta + u_{it} \qquad (2)$$

where i denotes cross-sections and t denotes time-periods with $i = 1, 2, ..., N$, $t = 1, 2, ..., T$. α is a constant, β is $K \times 1$ and X_{it} is the *it*-th observation on K explanatory variables. Disturbances can be written as $u_{it} = \mu_i + \upsilon_{it}$ where μ_i is a cross-section specific component and υ_{it} are remainder effects. Characteristics of the term μ_i then influence which specific model should be applied. If the cross-section specific component is random, that is $\mu_i \sim IID\left(0, \sigma_\mu^2\right)$ meaning it is not correlated with both the regressors and remainder effects, random effects model is the correct specification. Random effects are usually applied in cases where the N units are drawn randomly from a large population (e.g. population surveys). In case the correlation exists and the N units are selected specifically the fixed effects model is applied. Additional problem can be encountered when applying

fixed effects model – as $K+N$ parameters have to be estimated, large N will lead to substantial loss of degrees of freedom and estimation will be difficult[19]. As is apparent from the short discussion above fixed effects model is appropriate to evaluate the determinants of housing prices in CEE. This was also confirmed by Hausman test. Equation (2) can be rewritten for fixed effects into so called least square dummy variable that will be applied on the data set:

$$y_{it} = \beta x_{it}^{'} + \varepsilon_{it} \qquad i = 1,...,5 \qquad t = 1,...,T \text{ with } T \text{ up to } 48 \qquad (3)$$

All of the K explanatory variables are assumed to be exogenous and error term can be decomposed into $\varepsilon_{it} = \alpha_i + \omega_{it}$ with following properties: α_i is constant, $E\varepsilon_{it} = \alpha_i$, $E\omega_{it}\omega_{js} = \sigma_\varepsilon^2$ if $i = j$ and $t = s$ and $E\omega_{it}\omega_{js} = 0$ otherwise.

Eight explanatory variables were chosen on the basis of economic logic and previous research to explain the level of housing prices. We try to explain the level of real prices of apartments in the five CEE countries that are taken as an index of an average price level of 2005. The explanatory variables include proxies for household income (GDP growth), credit availability (interest rate on loans for housing purchase), labor market (unemployment rate), demographics (population growth rate), alternative investment (long-term interest rate on government bonds) two factors of the supply side (Construction production index and Labor cost index) and a proxy for improvement in quality of housing (real wage in 2005 prices). Model to be estimated looks as follows:

$$\begin{aligned} PPI_{it} = {} & \beta_1 GDPg_{it} + \beta_2 Hloan_{it} + \beta_3 Unemp_{it} + \beta_4 POPg + \beta_5 LTIR_{it} + \\ & + \beta_6 CPI_{it} + \beta_7 LCI_{it} + \beta_8 Wage_{it} + \varepsilon_{it} \end{aligned} \qquad (4)$$

PPI = real apartment price index, 2005 prices, 2005 = 100

$GDPg$ = real growth rate of GDP

$Hloan$ = real housing loan interest rate

$Unemp$ = unemployment rate

$POPg$ = population growth rate

$LTIR$ = real long term interest rate

CPI = real construction production index, 2005 prices, 2005 = 100

LCI = real labor cost index, 2005 prices, 2005 = 100

$Wage$ = real average monthly wage in 2005 prices

[19] Detailed information on properties, pros and cons of panel data models see Baltagi (2004).

Free econometric software gretl was used for the analysis. First of all stationarity of the explanatory variables was checked by Im-Pesaran-Shin test which is based on Augmented Dickey-Fuller test. Results of the test suggested that all of the variables had to be used in first differences to make them stationary. Only exception was the GDP growth that was already taken in growth rate and proved stationary. To solve the problem of nonstationary residuals two alternatives are used: differenced property prices as the dependent variable in the first regression and lagged value of property prices as another explanatory variable in the second regression. The first approach wipes out fixed effects and therefore simple OLS can be used while the second approach can shed some light on persistence of apartment prices.

	Full model estimate		**Restricted model estimate**	
Variable	POLS	FE	POLS	FE
Apartment prices [a]	--	0.969355*** (0.0146349)	--	0.968899*** (0.0135142)
GDP growth	107.136*** (28.4282)	87.7919*** (30.0377)	105.017*** (27.0423)	85.3986*** (28.2612)
Housing loans interest rate [b]	-23.1765 (36.7746)	-18.31 (36.7885)	--	--
Unemployment [b]	-145.511*** (52.4924)	-132.566** (52.8878)	-131.389*** (49.0507)	-116.284** (49.2619)
Population growth [b]	3.12799 (5.11941)	2.38598 (5.13812)	--	--
Long-term interest rate [b]	-0.0124867 (2.32452)	0.24285 (2.33504)	--	--
Construction production index [b]	0.107233 (0.0813743)	0.10007 (0.0822165)	--	--
Labor cost index [b]	-0.379621 (0.585705)	-0.297431 (0.589816)	--	--
Average monthly wage [b]	-0.100174* (0.0582711)	-0.0877711 (0.0586306)	-0.115947** (0.0522601)	-0.10249* (0.0524966)
R squared	0.161773	0.97686	0.125722	0.977235

*** significant at 1%, ** at 5% and * at 10% level of significance
POLS - Pooled ordinary least squares regression; FE - Fixed effects panel data regression
Standard errors in parenthesis
a - variable lagged by 1Q; b - difference

Table 9: Panel data regression output, stationary series
Source: Author's calculation

Table 9 summarizes results of model from equation (4). Second and third column refer to estimation of the full model as described by (4) for both approaches. First one is denoted POLS and the second one using apartment prices lagged by one quarter as

explanatory variable is denoted FE. Fourth and fifth columns provide results for restricted models whose specifications were obtained by eliminating the least significant determinant one by one for each approach.

All of the explanatory variables have the expected sign except for the real monthly wage and for the long-term interest rate where the sign depends on the method used. From the results of regressions it can be seen that the two approaches are consistent as far as the significant explanatory variables are considered. The results can be considered robust, although they are a bit surprising. GDP growth as a proxy for disposable income is significant even on a 1% level and has a positive sign as expected. Unemployment was confirmed as another important determinant with the sign according to economic logic, but unemployment rate also mostly affects the wealth of households and their disposable income. Interest rate on housing loans was not returned as significant even on a 10% level. This is not the first study that comes to this conclusion – but it is in contradiction with multiple other papers. Average monthly wage is significant at least on a 10% level; however, it does have opposite sign than was expected suggesting that the P/I ratio is on much higher levels that would be the equilibrium. Quite unexpected is the low level of variance in apartment prices that is explained by the POLS model which may suggest that an important explanatory variable was omitted (that is, however, not very likely) or that the model specification is not a good fit.

The second applied approach of fixed effects including lagged value of dependent variable suggests high persistence in apartment prices with values of coefficient below one pointing in the direction of eventual convergence. Other explanatory variables retained their position from POLS regression, including the signs of coefficients. As was expected the values of betas decreased across the original determinants owing to the emergence of new significant variable. Influence of the supply side of the residential real estate market seems to be limited and prices of apartments in CEE predominantly react to demand factors.

Perhaps, too much information was lost due to the differentiation. Despite the threat of spurious regression it should be beneficial to carry out regression described by (4) without differencing, that is using the nonstationary series. Fixed effects model was selected and again the variables are assumed to be exogenous. Analogically, the results of full model specification and of the restricted model are summarized in Table 10. The only improvement recorded rests on more determinants being significant, including

representatives of the supply side. Signs of coefficients were as expected, with one important exception of GDP growth rate. The notion of rising disposable income causing lower real apartment prices is against logic and these results should only serve the purpose of confirming the insignificance of housing loans interest rates. Also the extremely high R-squared statistics combined with Durbin-Watson statistic values well under 1.0 show that the suspected threat of spurious regression is present.

	Fixed effects model	
Variable	Full	Restricted
GDP growth	-136.813** (53.4697)	-157.414*** (50.696)
Housing loans interest rate	-61.6176 (61.2055)	--
Unemployment	-618.324*** (48.2363)	-603.545*** (46.3842)
Population growth	18.4845* (10.1285)	20.5565** (9.38878)
Long-term interest rate	4.80005 (3.14654)	--
Construction production index	0.1144 (0.0757495)	0.127572* (0.0738545)
Labor cost index	-1.42908* (0.736951)	-1.09934** (0.532659)
Average monthly wage	0.489553*** (0.0823335)	0.524431*** (0.077233)
R squared	0.907353	0.907644
Durbin-Watson	0.557643	0.59121

*** significant at 1%, ** at 5% and * at 10% level of significance
Standard errors in parenthesis

Table 10: Panel data regression output, non-stationary series
Source: Author's calculation

Use of the previous results to identify periods of housing price bubbles is rather limited and only of indicatory character. Using the actual and fitted values of the restricted FE model summarized in Table 9 several periods of apartment price overvaluation were identified. For Austria there is an evidence of a slight bubble during the crisis in the second half of 2008 and Q1 2009. In case of the Czech Republic, Hungary and Slovakia this approach confirms two periods of overvaluation – the pre-EU accession in 2002-2003 and different windows before or during the crisis: Q1 2007 until Q3 2008 for the Czech Republic, the bubble in Slovakia was in the lead by one quarter compared to its western

neighbor, while in Hungary the bubble started later, lasting from Q3 2008 through Q3 2009. Signs of overvaluation in Poland lasted for 2 years starting in Q1 2006. Residual charts on which the bubble identification is based can be found in Appendix II.

6.3. Time series analysis – Various countries, various factors?

Due to the variations of apartment price data series described in Section 5, panel data models may not be the appropriate econometric approach. To avoid limited comparability of countries, author chose to model each country separately using vector autoregression models. Building on the work of Posedel and Vizek (2009) and Tsatsaronis and Zhu (2004), the purpose of this section is to estimate and discuss results of these models, namely to determine which variables best explain the variation in real prices of the residential real estate. Due to the relatively short sample of data (ranging from 11 years for Austria to only 9 years for Poland) the short run effects are in the focus of this estimation. Data for the estimation were taken in log-differences and deflated when necessary, using the core inflation as opposed to widely used consumer price index. To perform the regressions and simulations EViews 7.0 software was used.

Methodology of the VAR approach can be summarized as follows. For countries $n = 1,...,5$ let $Y_{n,t}$ denote a (5×1) vector containing the values that the five endogenous variables assume at date *t*. The dynamics of $Y_{n,t}$ are presumed to be governed by a *pth*-order Gaussian vector autoregression:

$$Y_{n,t} = C_n + \sum_{j=1}^{p} \Phi_{n,j} Y_{n,t} + \varepsilon_{n,t} \tag{5}$$

where $p > 0$ represents the lag length , the (5×1) vector C_n contains the constant terms of the VAR, the matrices $\Phi_{n,1},...,\Phi_{n,p}$ contain the autoregressive coefficients while $\varepsilon_{n,t} \sim \text{i.i.d. } N(0,\Sigma)$. For more detailed information about VAR see Lütkepohl (2005) or Hamilton (1994). Besides the change in the real price index (ΔPPI) four proxies of different sectors of the economy were selected as the variables in $Y_{n,t}$. In order to be able to use the calculations in Section 6.2 as a vague robustness check, we choose variables from the same sample for VAR estimation. ΔGDP is the real quarterly growth rate of gross domestic product as a proxy for household income and for the demand side in general, $\Delta Hloan$ is the real interest rate on housing loans representing the credit

availability and financial markets. Remaining variables are $\Delta Unemp$ as the national unemployment rate, here used as a proxy for labor market and ΔCPI as the real construction production index represents the supply side of residential real estate market. Vector $Y_{n,t}$ can be then written as $Y_{n,t} = (\Delta PPI, \Delta GDP, \Delta Hloan, \Delta Unemp, \Delta CPI)$. Before the actual VAR can be carried the optimal value of *p* for each country in the sample has to be determined. Due to the relatively short time series used in the estimation the maximum lag length of 5 quarters was used. Based on the Hannan-Quinn information criterion and the likelihood ratio tests optimal length of 4 for Austria and 5 for the remaining countries were selected.

Posedel and Vizek (2009, p.333) provide straightforward introduction into the workings of VAR model. *"Impulse response functions are derived from the parameter estimates and the variation in the relative importance of different factors is mapped onto the structural characteristics of the various national markets".* Due to the potential correlation in individual reduced form disturbances, additional assumptions have to be made about the functioning of the economy in a form of ordering of the endogenous variables in the system of VAR equations. In line with previous studies the following order was chosen:

$$(\Delta GDP, \Delta Unemp, \Delta Hloan, \Delta CPI, \Delta PPI)$$

Depending on the order, the variable with a higher ranking is attributed all of the effect of any common component. Changes to GDP have the largest impact on the remaining variables within the same quarter and therefore are clear choice for the top spot. Unemployment is closely related with a substantial impact on remaining parts of economy and is placed second. The rest of ordering is rather arbitrary with housing prices being last for two reasons: firstly, their impact in the same quarter is hard to imagine and secondly, attributes and explanatory power assigned to apartment prices will not be biased by their incorrectly high ordering[20].

Variance decomposition separates the variance of the forecast error for an endogenous variable into components that are assigned to each of the identified structural changes. Thus, the variance decomposition provides information about the relative importance of each shock to one of the variables in affecting all the variables, including

[20] Unfortunately bias from wrong model specification in the sense of lag structure and mainly the variables selection is ever-present.

itself, in the VAR. Results of the variance decomposition for previously described model focusing on housing prices are summarized in Table 11. There are vast differences in the determinants of apartment prices based on the variance decomposition. The housing price persistence proved to be the main factor only for Austria and Hungary, where it accounts for the dominant portion of variance in the subsequent quarter as well as it maintains the leading position after almost two years. The Czech Republic is characterized by high importance of GDP growth and apartment price persistence both in short- (1Q) and long-term (15Q) horizons. Over almost two years however, the unemployment rate becomes the second most important factor leaving housing prices closely third. Development in Poland is also mostly influenced by GDP growth but more factors are involved both in short- and long-run. Housing interest rate and unemployment explain high shares of variance while, quite surprisingly, there is virtually no housing price persistence in Poland in the observed period. The only country showing significant impact of the supply side factors is Slovakia where the construction production accounts for almost half of the variance in apartment prices. Rest of the variance is relatively evenly distributed with only the housing loans interest rate being a non-factor. Interest rates on housing loans, that were generally insignificant in panel data regressions[21], play an important role in Poland but also in the long-run (15Q) in Austria and Hungary. The reasons why prices in the states of the former Czechoslovakia seem not to react to changes in housing loans interest rates could be an interesting topic for further research.

Due to the correlations in reduced form errors of endogenous variables the Choleski ordering of variables used in the estimation is of high importance. To test the previously introduced results, variance decomposition for different ordering was estimated for each country. New orderings were based on the highest correlation of two variables – from the two variables with the highest correlation in the correlation matrix the one with lower order was moved ahead of its counterpart from the matrix. Besides that the ordering remained the same. This resulted in the following new orderings:

Austria, Czech Republic and Hungary $(\Delta Unemp, \Delta GDP, \Delta Hloan, \Delta CPI, \Delta PPI)$,

Poland $(\Delta Hloan, \Delta GDP, \Delta Unemp, \Delta CPI, \Delta PPI)$

Slovakia $(\Delta GDP, \Delta Unemp, \Delta Hloan, \Delta PPI, \Delta CPI)$.

[21] Not only in this thesis but also in e.g. Hlavacek and Komarek (2009) where it was substituted by 1Y PRIBOR rate.

Table 11: Variance decomposition output

Country	Period	Impact on housing prices of a shock to:				
		GDP	Unemployment	Housing IR	Construction	Housing price
Austria	1Q	2.17	11.00	0.47	3.14	83.23
	7Q	3.46	15.73	12.53	25.19	43.09
	15Q	6.64	15.26	23.67	20.57	33.86
Czech Republic	1Q	53.53	3.50	0.04	0.35	42.58
	7Q	57.66	14.66	7.17	1.46	19.05
	15Q	47.55	22.01	7.75	2.16	20.53
Hungary	1Q	4.25	0.39	13.14	8.58	73.65
	7Q	6.69	9.01	35.52	4.64	44.15
	15Q	14.91	16.77	30.52	5.00	32.79
Poland	1Q	35.03	24.95	33.08	2.87	4.07
	7Q	29.31	17.91	48.36	2.61	1.80
	15Q	35.05	15.76	41.11	6.55	1.52
Slovakia	1Q	12.49	21.00	4.09	49.16	13.27
	7Q	19.10	17.27	4.38	48.07	11.17
	15Q	23.64	13.78	5.21	46.99	10.39

The numbers refer to the share o one variable's total variation that can be attributed to one standard deviation shocks in another variable at the one-quarter, seven quarter and fifteen-quarter horizon

Source: Author's calculation

The outcomes confirmed the results for Austria but for the other countries there were some significant changes in the variance decomposition. For the Czech Republic the previous price of apartments proved robust and became the leading determinant with GDP remaining more important than unemployment. Results for Hungary were also mostly confirmed with price persistence and housing loans as leading factors. In contradiction to the Czech Republic unemployment proved to be more important than GDP growth. The largest differences lay in the results for Poland. Over the first year after the shock GDP growth and unemployment rate explain most of the variance in housing prices but in longer horizon interest rates on housing loans are the dominant explanatory variable. Nevertheless, previous values of housing price development have very low explanatory power. As was expected, the high influence of construction production in Slovakia was due to the high correlation with apartment prices. When the order of these two variables is reversed Slovakia shows high housing price persistence and GDP growth and unemployment as other two main drivers. This is consistent with the previous research and with results for their CEE peers.

Second major output of the VAR analysis is the set of impulse response functions (IRF). Through IRF it is possible to quantify and predict reactions of one variable to an unexpected shock (in some literature called innovation) in one of the variables in the system over selected time horizon. The farther in the future we get, the less accurate the prediction but for short-term horizons the IRF provides high value. Although it is possible to retrieve impulse response functions for each variable, this thesis is concerned about the development of housing prices. Therefore the response functions of apartment prices to innovations of one-standard-deviation magnitude in the remaining variables as well as to change in itself are discussed in the following pages. As in case of variance decomposition the Choleski ordering of variables is important. The original order was used for all the countries except for Slovakia where the position of apartment prices and construction production were switched to better reflect reality.

Figure 10 illustrates the impact of a shock to GDP on the apartment prices over the period of two years. All the new EU member countries reacted positively to the GDP shock in the first quarter, but the development afterwards differs vastly. There is strong positive influence in the Czech Republic over the first year that gradually dies out during the second year. Reaction in Slovakia is milder but more persistent as the impact on future housing prices oscillates between 1 and 2% for whole two years (with the exception of the

fifth quarter). Hungary and especially Austria do not seem to react on changes to GDP; Hungary even records negative impact during the second year.

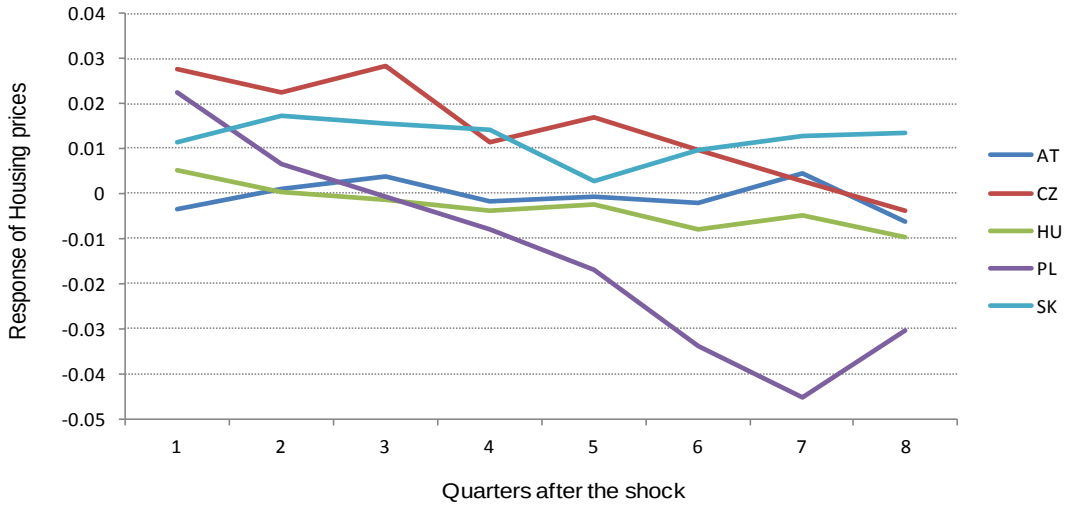


Figure 10: Impulse response functions of housing prices to GDP growth shock
Source: Author's calculation

Poland is a special because the initial strong positive reaction is reversed over the course of first year and extremely high negative correction is to be expected in the second year. House price changes remain quite volatile even after two years. This might suggest previous positive overreaction of housing prices to GDP growth and resulting overvaluation that needs to be corrected in the longer horizon.

Following a shock to the unemployment rate the expected immediate drop in housing prices is recorded in the first quarter following the shock only in the Czech Republic. Given longer transition mechanism three of the new EU members see pressure

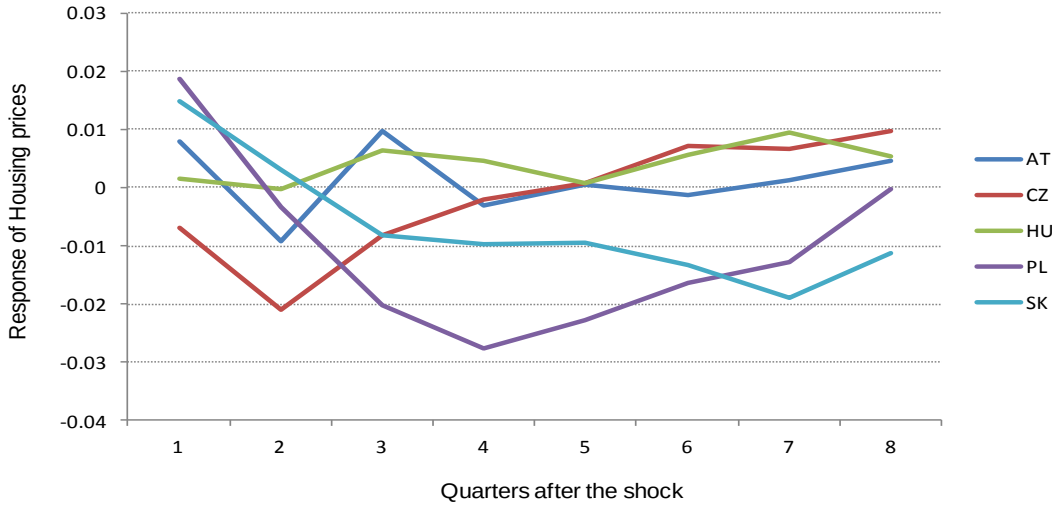


Figure 11: Impulse response functions of housing prices to unemployment rate shock
Source: Author's calculation

on housing prices decrease after three quarters. Again Hungary and Austria do not react strongly to innovations in unemployment. The volatile dynamics in Austria die out over the first year and data for Hungary suggest, against economic logic, that a higher unemployment rate would lead to higher apartment prices. Trend in the Czech Republic is reversed and correction to the initial price decrease is observed in the second year after the shock. All the responses seem to die out towards end of the second year except for the Czech Republic.

Lower availability of housing credit represented by shock to interest rate also does not have an immediate impact on housing prices. In fact only Austria reflects the expectations of a negative impact with lag of two quarters. Slovakia exhibits negative reactions in the second year. This can be attributed to the well developed financial system in Austria, while in Slovakia, perhaps, the adoption of Euro might have played a role.

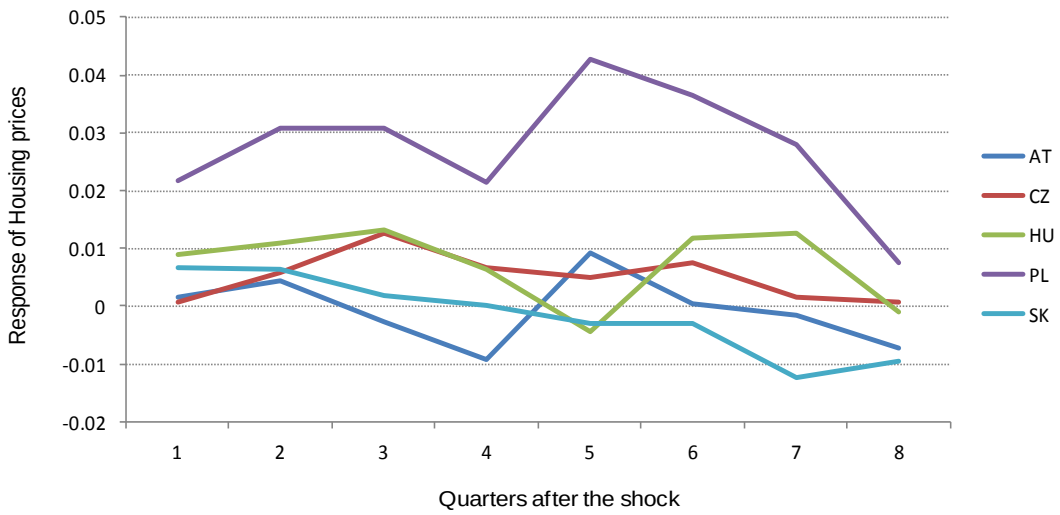


Figure 12: Impulse response functions of housing prices to interest rate shock
Source: Author's calculation

The remaining three CEE countries react opposed to expectations with mild increase of housing prices (Czech Republic and Hungary) with Poland being again an outlier with positive reaction as high as 4.26% in the fifth quarter. One explanation can be found in still developing institutions in the countries, but more probably the low original levels of housing credit led to an increase in housing credit level and housing prices regardless of the developments in the housing loans interest rates. Nevertheless, all the effects seem to die out after the consecutive two years.

As can be seen from Figure 13, housing prices react positively to the shock to the construction production index, which proxies the supply side indicators, in the first quarter

in all countries except Poland. Even though the patterns for individual countries are rather unique, reactions during the first year after shock are very mild. In case of construction production the transition mechanism take longer time materialize due to the nature of the industry. Increasing volatility in Austria and positive reaction of 1.66% in the eighth quarter after the shock in Poland suggest, that the influence of changes to CPI can go beyond the 2-year horizon.

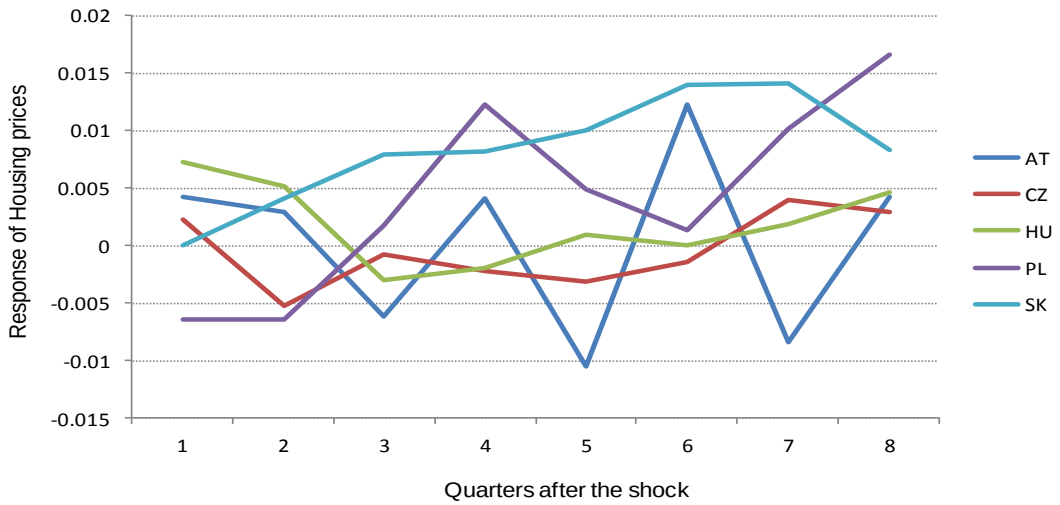


Figure 13: Impulse response functions of housing prices to construction output shock
Source: Author's calculation

In line with the variance decomposition results, immediate reaction of housing prices to innovation in themselves is the lowest in Poland and dies out even more over the two years. The strongest reactions are calculated for the former Czechoslovakia with Slovakian prices rising the next quarter by 2.56% and in the Czech Republic by 2.45%. Austria as the representative of the old EU shows slightly different dynamics than the rest of CEE but similarly to the other countries the effects die out after approximately one year. Hungary records values close to 1% for first six quarters but over the whole two years that are observed the effects die out as well. The only country that differs from its peers is thus Slovakia. It has to be noted that the situation for Slovakia changes significantly based on the ordering of the last two variables. The plotted variant that counts with a certain price persistence and is characterized by one year of positive influence on housing prices, followed by at least four quarters of negative corrections. Especially the end of the second year with values close to -3.0% shows high volatility of housing prices even long time after the initial shock. However, should the order of variables be reversed to the one used for other countries, the IRF of Slovakia is close to only 1.10% in the first quarter and its path

than mostly copies the one of Poland, only with higher values in first three quarters and convergence towards zero over the 2-year horizon. This is still in line with the variance decomposition as Slovakia under this ordering showed similarly non-persistent prices as did Poland. Overview of all impulse response functions can be found in Appendix III.

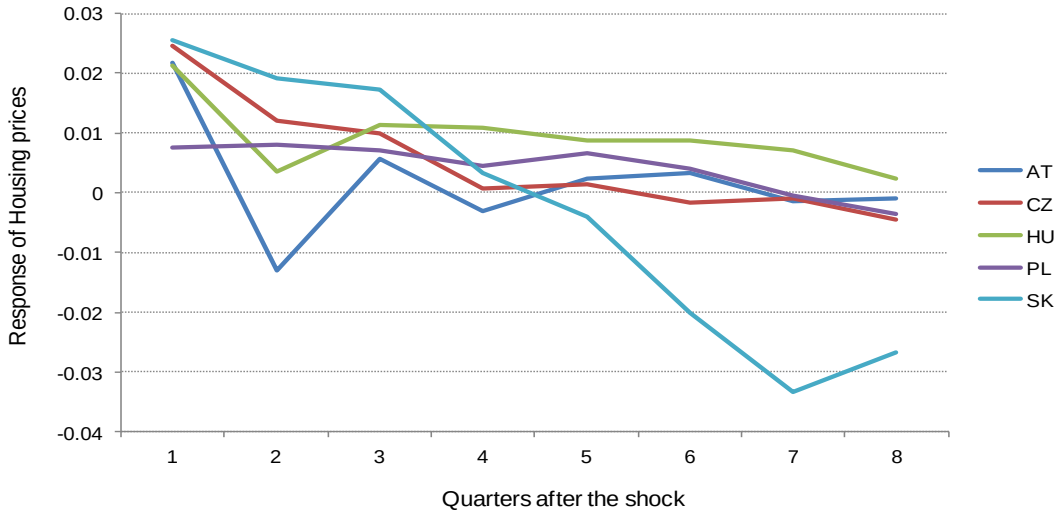


Figure 14: Impulse response functions of housing prices to housing price shock
Source: Author's calculation

Apartment prices show different reactions to changes in their estimated determinants in individual countries. Certain conservativeness of prices in Austria and high volatility of Polish housing prices can be pointed out as common denominators. Results for Poland are not surprising, given the extremely low housing price persistence in Poland that was estimated during the variance decomposition. On the other hand housing prices react to the changes in interest rate on housing loans only in Poland, impulse responses in other countries were very weak and died out over two years. Reliability of these estimates is unfortunately limited. If 5% confidence level is considered, then rarely any response function is significant after the first period after shock. Only the shocks to housing prices are significant for two quarters following the shock in Austria and Poland (where it only confirms very low housing price persistence). Response to shock to housing loans interest rate in Poland is also significant for two quarters. Reponses to housing price shock in other countries are significant for first quarter (Q1) and other variables whose innovation causes responses significant on 5% level for the first quarter following the shock are as follows: GDP in the Czech Republic, Poland and Slovakia; Unemployment rate in Austria, the Czech Republic (Q2 after shock instead of Q1), Poland and Slovakia; housing loans interest rate in Hungary and Austria (Q4 instead of Q1). Poland also shows significant

reaction to innovations in construction production index but only for the first quarter which has value close to zero (0.6%).

7. Conclusion

This thesis focuses on the situation on residential real estate markets of the narrowly-defined CEE region. Even though real estate markets appeared in discussions and in focus of a number of researchers and international entities throughout the past ten years, only the recent events of the financial and economic crisis had put them in the real spotlight. Since changes in housing prices can have profound impact on national economy, it is important to understand their behavior and determinants. Based on the substantial body of literature, this thesis provides first investigation into the geographical region of the so called Visegrad Four and Austria in order to also provide evidence on potential difference of the new and old EU countries in the region. Another phenomenon in focus is the housing price bubble which emerged as a red flag in the past few decades without being exactly defined.

Despite the recent efforts of IMF, Eurostat and BIS the data collection and availability remains the main bottleneck of the current and future research in this area. The high heterogeneity of sources of data, methodologies being used and the frequency of data publishing hinder our ability to conduct more exact quantitative research, at least in Europe. While data for the Czech Republic are reliable and available for long time periods, Poland and Hungary provide data series comparable with the rest of the region only with caution. The Handbook on Residential Property Price Indices combined with the example of new praxis of data collection in Hungary promise a brighter future for the real estate market research.

Subsequently three different empirical approaches were used to assess the possible housing price bubbles and to identify the housing price determinants. The simplest approach, based on affordability of housing, uses Price-to-Income ratio to determine periods of housing overvaluation. Since a bubble is generally defined as deviation of asset's price from its value explained by fundamentals, some "equilibrium" P/I ratio should be used for this assessment. Despite some equilibrium values being suggested in literature they differ substantially across countries. Therefore an average value combined with standard deviation bands is used to determine bubbles. In general, two periods of bubble-

like behavior of apartment prices among the new EU members were identified – the pre-EU accession period of ca. early 2002 till late 2003 (the Czech Republic and Hungary) and the beginning of the economic crisis running through 2007-2008 (the Czech Republic, Poland and Slovakia). Austria differs with the only indicated price bubble coming after the main events of the crisis and at the end of the time frame (2010-2011).

The second approach employs basic panel data regressions to provide both evidence on housing price bubbles for individual countries and indication on housing price determinants in the CEE region as a whole. Confirming the findings of previous researchers, the author comes to a conclusion that the residential real estate markets in the CEE region are demand-driven. Proxy for households' income growth proved significant while the interest rate on housing loans was not statistically significant from zero in any of the models carried out. The only two other significant variables were the unemployment rate and the average real wage. When the lagged value of apartment prices is included in the set of explanatory variables, results suggest high level of housing price persistence. Concerning the evidence on bubbles, it confirms the pre-EU accession bubble in the Czech Republic and Hungary but also includes Slovakia in this period. During the crisis all countries show signs of housing price overvaluation but the precise periods differ per country. Given the substantial shortcomings of this approach concerning endogeneity and stationarity of variables, the results have to be interpreted carefully.

In the last subchapter a vector autoregression model was applied separately for each country to model the housing price determinants. Using variance decomposition and impulse response functions it is clear that the importance of individual variables differs significantly. In Austria, Hungary and Slovakia most of the variance in apartment prices can be attributed to the persistence of prices. In the Czech Republic the dominant factor is the disposable income proxied by real GDP growth but the housing price persistence is present as well. The only country with virtually no persistence in apartment prices is Poland where multiple variables combine in explaining the housing price variance. Poland, together with Hungary, is the only country in the region where interest rate developments explain the volatility of apartment prices. The impulse response functions serve the purpose of tracking the impact of the variables on housing prices development in two years after the shock. Again the transmission dynamics differ per country and despite the dependence on ordering of variables some trends are apparent. Reactions in Austria mostly die out sooner than in other countries. The Czech Republic and Hungary usually record

mild reactions to shocks with the exception of the first four quarters in the Czech Republic after the shocks to the GDP and unemployment rate. In Slovakia and especially Poland the apartment prices react to shocks quite heavily and the persisting influence even after two years following the shock is not exceptional. Reliability on 5% level of confidence is however not very high.

Results of the analysis do not differ from previous research. Uniqueness of each country in the region was confirmed and Austria does not seem to substantially differ from the rest of the sample even though the response functions suggest less volatility in housing prices. Nevertheless, due to the problems with data availability, this issue should be revisited once more comparable time series are available for individual countries. In order to assess the influence of the crisis during 2007-2009 it is necessary to observe the future development and revise the issue when global economy is on a more stable path once again.

Bibliography

1. Annett, A. (2005): "House prices and monetary policy in the Euro area", *IMF country report, No. 05/266.*
2. Baltagi, B. H. (2008): "Econometrics", *Fourth Edition, Spinger, Berlin*
3. Breuss, F., S. Kaniovski and M. Schratzenstaller (2009): "Macro-economic Effects of the Fiscal Stimulus Measures in Austria", *Austrian Economic Quarterly, 4/2009*
4. Čadil, J. (2009): "Housing Price Bubble Analysis – Case of the Czech Republic", *Prague Economic Papers 1*
5. Case, K. E. and R. J. Schiller (2003): "Is There a Bubble in the Housing Market?", *Brookings Papers on Economic Activity, Vol.34 No.2*
6. Chung, H. S. and J. H. Kim (2004): "Housing Speculation and Housing Price Bubble in Korea", *KDI Working Paper 04-06*
7. Darvas, Z.:"The impact of the Crisis on Budget Policy in Central and Eastern Europe", *OECD Journal on Budgeting, Vol. 1/2010, OECD*
8. Deloitte (2009): "Financial Crisis in Residential Development", *Study, March 2009*
9. Deloitte (2010): "Residential Market Development in 2009", *Study, March 2010*
10. Deloitte (2012): "Property Index: Overview of European Residential Markets – How do Europeans live, and for how much?", *April 2012*
11. Diewert, E.(2007): "The Paris OECD-IMF Workshop on Real Estate Price Indexes: Conclusions and Future Directions", *Discussion Paper 07-01, The University of British Columbia, Vancouver*
12. Duca, J. V., J. Muelbauer and A. Murphy (2010): "Housing Markets and the Financial Crisis of 2007-2009: Lessons for the Future", *SERC Discussion Paper 49*
13. Égert, B. and D. Mihaljek (2008): "Determinants of House Prices in Central and Eastern Europe.", *Working Paper No. 1/2008, Czech National Bank*
14. Garber, P. M. (1990): "Famous First Bubbles", *Journal of Economic Perspectives, Vol.4 No.2, pp. 35-54*
15. Government of the Czech Republic: "Národní protikrizový plán vlády", *Prague, February 2009, as obtained from http://www.vlada.cz/cz/media-centrum/predstavujeme/narodni-protikrizovy-plan-53840/ on January 13, 2012*

16. Hamilton, J. D. (1986): “On testing for self-fulfilling speculative price bubbles”, *International Economic Review, Vol.27 No.3, pp. 545-552*

17. Hamilton, J.D. (1994): “Time Series Analysis”, *Princeton University Press, Princeton*

18. Heath, R. (2003): “Real Estate Prices as Financial Soundness Indicators”, *IMF/BIS Conference on Real Estate Indicators and Financial Stability, Washington DC, October 27-28*

19. Hilbers, P. et. al. (2008): “House Price Developments in Europe: A Comparison”, *IMF Working Paper, WP/08/211, International Monetary Fund*

20. Hlaváček, M. and L. Komárek (2009): “Housing Price Bubbles and their Determinants in the Czech Republic and its Regions”, *Working Paper Series, Czech National Bank*

21. Hott, C. and P. Monnin (2006): “Fundamental Real estate Prices: An Empirical Estimation with International Data”, *National Centre of Competence in Research Financial Valuation and Risk Management, Working Paper No. 356*

22. Iacoviello, M. (2000): “House Prices and the Macroeconomy in Europe: Results from a Structural VAR Analysis”, *ECB Working Paper Series, No.18*

23. IMF and FSB (2009): “The Financial Crisis and Information Gaps”, *Report to the G-20 Finance Ministers and Central Bank Governors*

24. Lütkepohl, H. (2005): “New Introduction to Multiple Time Series Analysis”, *Springer, Berlin*

25. Malpezzi, S. (1999): “A simple error correction model of house prices”, *Journal of housing economics, Vol. 8, No. 1, pp. 27-62*

26. Ministry of Finance of Poland: “Stability and Development Plan”, *November 2008, as obtained from http://www.mf.gov.pl/_files_/aktualnoci/2009/stability_and_ development_plan.pdf on January 15, 2012*

27. Ministry of Finance of Slovak Republic: “Národný Národný program reforiem Slovenskej republiky na roky 2008 - 2010 – Implementačná správa 2009”, *October 2009, as obtained from http://www.finance.gov.sk/Default.aspx?CatID=5197 on January 13, 2012*

28. Ministry for National Economy: “Hungary’s Structural Reform Programme 2011-2014”, *Budapest, March 2011, as obtained from http://www.kormany.hu/en/ministry-*

for-national-economy/news/hungary-s-structural-reform-programme-2011-2014 on January 15, 2012

29. OECD (2005): "Housing finance markets in transition economies: trends and challenges.", *Paris, 2005*
30. OECD (2005a): "Recent House Price Developments: The Role of Fundamentals", *OECD Econonomic Outlook, No.78, Paris, 2005*
31. OECD (2010): "OECD Economic Surveys Hungary", *OECD 2010*
32. OECD (2010a): "OECD Economic Surveys Poland", *OECD 2010*
33. OECD (2011): "OECD Economic Surveys Austria", *OECD 2011*
34. OECD (2011a): "OECD Economic Surveys Czech Republic", *OECD 2011*
35. OECD (2012): "OECD Economic Surveys Poland – Overview", *OECD 2012*
36. Oesterreichische Nationalbank (OeNB) (2010): "Monetary Policy and the Economy – Quarterly review of the economic policy", *Q2/2010*
37. Palacin, J. and R. Shelburne (2006): "Is There an East European Housing Bubble?", *Global Economy Journal, Vol.6 Issue 3, Article 1, pp. 1-37*
38. Posedel, P. and M. Vizek (2009): "House price determinants in transition and EU-15 countries", *Post-Communist Economies, Vo. 21 No. 3, pp. 327-343*
39. Posedel, P. and M. Vizek (2011): "Are House Prices Characterized by Threshold Effects? Evidence from Developed and Post-Transition Countries", *Czech Journal of Economics and Finance, Vol.6, Issue 61, pp. 584-600*
40. Poterba, J.M. (1984): "Tax Subsidies to Owner-occupied Housing: An Asset Market Approach", *The Quarterly Journal of Economics, Vol. 99, No. 4, pp. 729-752*
41. Rae, D. and P. van den Noord (2006): "Ireland's Housing Boom: What has Driven it and Have Prices Overshot?", *OECD Economics Department Working Papers, No. 492*
42. Hwang Smith, M. and G. Smith (2006): "Bubble, Bubble, Where's the Housing Bubble", *Brookings Paper on Economic Activity, Brookings Institutional Press*
43. Sims, C. A. (1980): "Macroeconomics and Reality", *Econometrica, Vol. 48, No.1, pp. 1-48*
44. Stepanyan, V., T. Poghosyan and A. Bibolov (2010): "House Price Determinants in Selected Countries of the Former Soviet Union", *IMF Working Paper, WP/10/104*

45. Sutton, G. (2002): "Explaining changes in house prices", *BIS Quarterly Review, September*
46. Taipalus, K. (2006): "A global house price bubble? Evaluation based on a new rent-price approach", *Bank of Finland Research Discussion Papers 29/2006*
47. Tomczyk, E. and M. Widlak (2010): "Measuring housing prices dynamics: The first investigation into the Warsaw market", *22nd International Housing Research Conference, ENHR, July 2010, Istanbul*
48. Tsatsaronis, K. and H. Zhu (2004): "What drives housing price dynamics: cross-country evidence", *BIS Quarterly Review*
49. van den Noord, P. (2006):"Are House Prices Nearing a Peak: A PROBIT analysis for 17 OECD Countries", *OECD Economic Department Working Papers, No. 488*
50. Vizek, M. (2010): "Short-run and Long-run Determinants of House Prices in Eastern and Western European Countries", *Privredna kretanja i ekonomska politika 125/2010*
51. Youngzhou, H. (2010): "Housing price bubbles in Beijing and Shanghai? A multi-indicator analysis", *International Journal of Housing Markets and Analysis, Vol. 3, No. 1, pp. 17-37*
52. Zemčík, P. (2010): "Is There a Real Estate Bubble in the Czech Republic?", *CERGE-EI Working Paper Series, No. 390*

Online Sources

Articles

Lott, T.: "1991 here we come", *The Telegraph, December 8, 2007, as obtained from http://www.telegraph.co.uk/news/uknews/1571886/1991-here-we-come.html on December 21, 2011*

Mesterhazy, A.: "The Impact of the Financial Crisis on Central and Eastern Europe", *217 ESCEW 10 E bis, 2010 Annual Session, Committee Report, NATO Parliamentary Assembly, as obtained from http://www.nato-pa.int/default.asp?SHORTCUT=2079 on December 21, 2011*

Organizations

Central Intelligence Agency – The World Factbook (https://www.cia.gov/library/publications/the-world-factbook/index.html)

Housing Finance Information Network – Real Estate Price Indicators section
(http://hofinet.org/themes/theme.aspx?id=92)

EUROCONSTRUCT – Press Information
(http://www.euroconstruct.org/pressinfo/pressinfo.php)

EIRO online – Survey Reports
(http://www.eurofound.europa.eu/eiro/surveyreports.htm)

National Central Banks

Czech National Bank – Statistics
(http://www.cnb.cz/cs/statistika/)

National Bank of Slovakia – Statistics
(http://www.nbs.sk/en/statistics)

Oesterreichische Nationalbank – Statistical Data
(http://www.oenb.at/en/stat_melders/datenangebot/datenangebot.jsp)

Magyar Nemzeti Bank – Statistical Time Series
(http://english.mnb.hu/Statisztika/data-and-information/mnben_statisztikai_idosorok)

Narodowy Bank Polski – Statistics
(http://www.nbp.pl/homen.aspx?f=/en/statystyka/statystyka.html)

National Statistical Offices

Czech Statistical Office – CSU
http://www.czso.cz

Statistics Austria
(http://www.statistik.at/web_en/)

Central Statistical Office – GUS
(http://www.stat.gov.pl/gus/index_ENG_HTML.htm)

Hungarian Central Statistical Office – KSH
(http://www.ksh.hu/?lang=en)

Statistical Office of the Slovak Republic
(http://portal.statistics.sk/showdoc.do?docid=4)

International Statistical Databases

Eurostat
(http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/)

OECD.StatExtracts – Statistical database of OECD
(http://stats.oecd.org/)

Appendix

Appendix I – Dataset overview

Housing prices

Austria – Existing apartments in the whole country excluding Vienna; Price Index with 2000=100, recalculated by author; Calculation based on data from Real Estate agencies association; Published by OeNB
Source: BIS (http://www.bis.org/statistics/pp.htm)
Nominal price per square meter for Q4 2011 estimated based on personal interviews and internet research.

Czech Republic – Existing apartments in the whole country including Prague; Price Index with 2005=100; Data based on transfer tax returns from the Ministry of Finance; Published by Czech Statistical Office
Source: CSO (http://www.czso.cz/csu/redakce.nsf/i/ceny_bytu)
Nominal price per square meter taken from CSO and calculated for missing observations based on the index (http://www.czso.cz/csu/2011edicniplan.nsf/p/7009-11)

Hungary – Existing all types of dwellings in Budapest; Price Index calculated by author at 2005=100; Calculation based on data provided by association of Real Estate agencies; Published by MNB
Source: BIS (http://www.bis.org/statistics/pp.htm)
Nominal price per square meter from BIS

Poland – Existing apartments in 10 large and medium cities; Index calculated by author at 2005=100; Calculation based on asking prices from Real Estate agencies; Compiled by private sector; Published by PNB
Source: BIS (http://www.bis.org/statistics/pp.htm)
Nominal price per square meter from BIS

Slovakia – Existing apartments in the whole country including Bratislava; Index calculated by author at 2005=100; Calculation based mostly on asking prices; Published by NBS
Source: NBS (http://www.nbs.sk/sk/statisticke-udaje/vybrane-makroekonomicke-ukazovatele/ceny-nehnutelnosti-na-byvanie/ceny-nehnutelnosti-na-byvanie-podla-typu-bytu-a-domu)
Nominal price per square meter from NBS

Housing loans interest rate

Austria – Interest rate on loans for house purchases in EUR to households (incl. nonprofit institutions). New business
Source: Oesterreichische Nationalbank (http://www.oenb.at/isaweb/dyna2.do?go=initIndikatoren&definitionLaden=false&hierarchieIdSelected=23)

Czech Republic – Interest rate on loans for house purchases in CZK to households (incl. nonprofit institutions). New business. For period 2002-2004 interest rate on all loans in CZK to households (incl. nonprofit institutions)
Source: Ceska Narodni Banka (http://www.cnb.cz/docs/ARADY/HTML/index.htm)

Hungary – Average agreed interest rate of HUF loans to households weighted by the amount of new business – Loans for house purchase
Source: Magyar Nemzeti Bank (http://english.mnb.hu/Statisztika/data-and-information/mnben_statisztikai_idosorok)

Poland – Average interest rates on new business, PLN denominated; Households and nonprofit institutions serving households; Loans for house purchase total.
Source: Narodowy Bank Polski (http://www.nbp.pl/homen.aspx?f=en/statystyka/oproc/mir_new/mir_new.html)

Slovakia – Average interest rates on new business, SKK (since 2009 EUR) denominated; Loans to households for house purchase, total.
Source: Narodna Banka Slovenska (http://www.nbs.sk/sk/statisticke-udaje/menova-a-bankova-statistika/urokova-statistika/bankova-urokova-statistika-uvery)

Population growth (data obtained for levels)

Austria – Population at the beginning of the quarter since 2002 by municipalities and age Q
Source: Statistics Austria (National Statistical Office) (http://www.statistik.at/web_en/statistics/population/population_stock_and_population_change/index.html)

Czech Republic – Vital Statistics of the Czech Republic: 1992 - 2011, absolute monthly figures; Mid-period population
Source: Czech Statistical Office (http://www.czso.cz/csu/redakce.nsf/i/oby_cr_m)

Hungary – Population, vital events; Population at the end of the period
Source: Hungarian Central Statistical Office (direct communication)

Poland – Population, vital events; Population at the end of the period
Source: GUS – Central Statistical Office (direct communication)

Slovakia – Movement of population (absolute data) (2000Q1 - 2011Q4); Mid-year population
Source: Statisticky Urad Slovenskej Republiky (http://www.statistics.sk/pls/elisw/objekt.send?uic=1466&m_sso=2&m_so=7&ic=31)

Average nominal wage

Austria – Annual Personal Income; Gross annual income of employees excluding apprentices; Linear interpolation used to obtain quarterly data
Source: Statistics Austria (National Statistical Office) (http://www.statistik.at/web_en/statistics/social_statistics/personal_income/annual_personal_income/index.html)

Czech Republic – Average gross monthly wage, excluding public officers; Nominal wage in CZK; Full time equivalent
Source: Czech Statistical Office (http://www.czso.cz/csu/redakce.nsf/i/pmz_cr)

Hungary – Average gross labor income (HUF per capita per month); Enterprises with more than 4 employees
Source: Hungarian Central Statistical Office (http://statinfo.ksh.hu/Statinfo/themeSelector.jsp?page=2&szst=QLI&lang=en)

Poland – Average monthly gross wage and salary in national economy including mandatory contribution to social security paid by the employee
Source: GUS – Central Statistical Office (http://www.stat.gov.pl/gus/5207_ENG_HTML.htm)

Slovakia – Average nominal monthly wage of an employee in EUR; Since 2006 including armed forces.
Source: Statisticky Urad Slovenskej Republiky (http://www.statistics.sk/pls/elisw/objekt.send?uic=1411&m_sso=2&m_so=15&ic=40)

Unemployment

All countries – Harmonised unemployment rates (numbers of unemployed persons as a percentage of the labour force); The Labour Force Statistics (MEI) dataset based on Labour Force Surveys
Source: OECD (http://stats.oecd.org/)

GDP growth

All countries – Real GDP (expenditure approach) growth rate; Percentage change over same quarter previous year
Source: OECD (http://stats.oecd.org/)

Long-term Interest rate

All countries – Yield on 10-year government bonds on the secondary market or government securities of equivalent characteristics
Source: OECD (http://stats.oecd.org/)

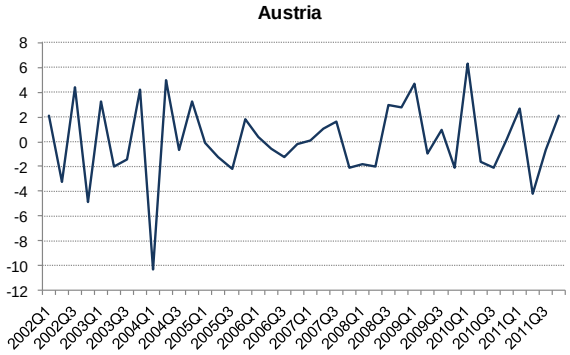
Labour Cost Index

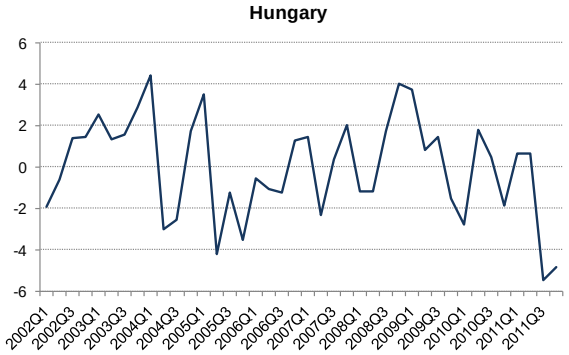
All countries – Labour Cost Index (LCI) shows the short-term development of the total hourly costs incurred by the employers of maintaining their employees; Index: 2008=100, recalculated by author; Nominal values adjusted by Core inflation
Source: Eurostat (http://epp.eurostat.ec.europa.eu/portal/page/portal/labour_market/labour_costs/database)

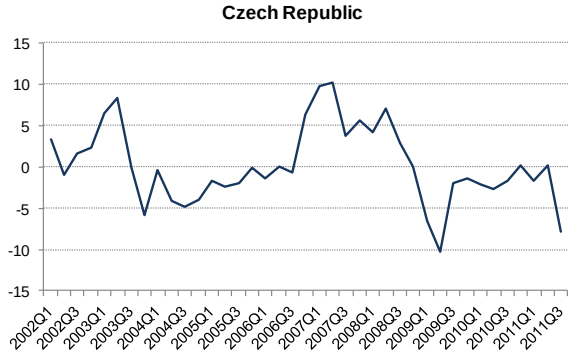
Core inflation

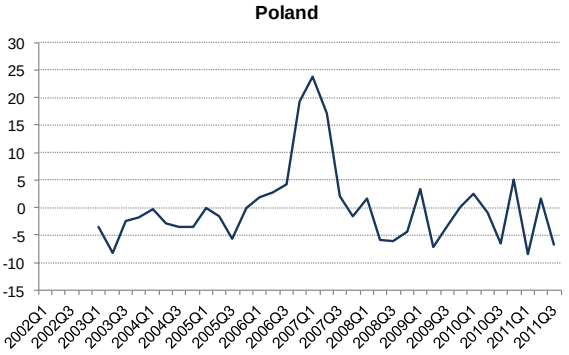
All countries – Consumer prices (all items non-food, non-energy); Percentage change from previous period
Source: OECD (http://stats.oecd.org/)

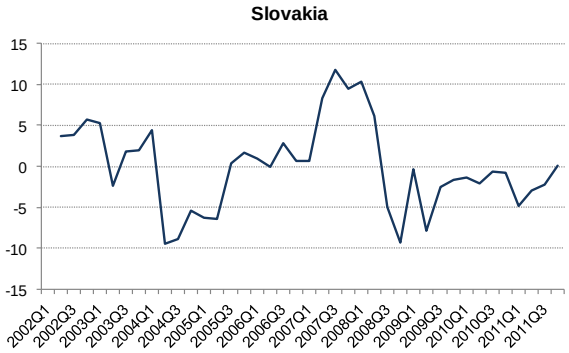
Appendix II – Residuals for FE Panel data regression







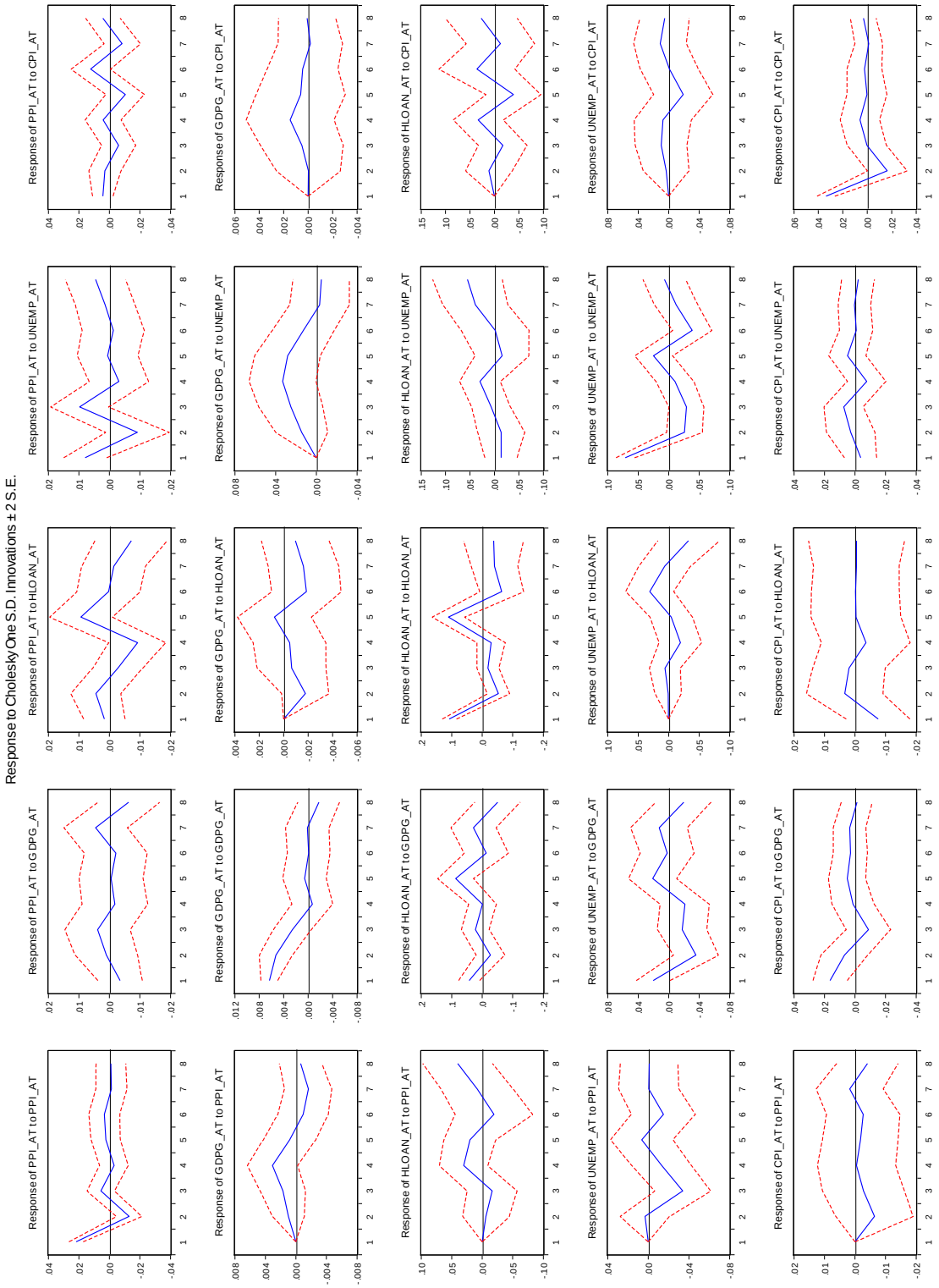




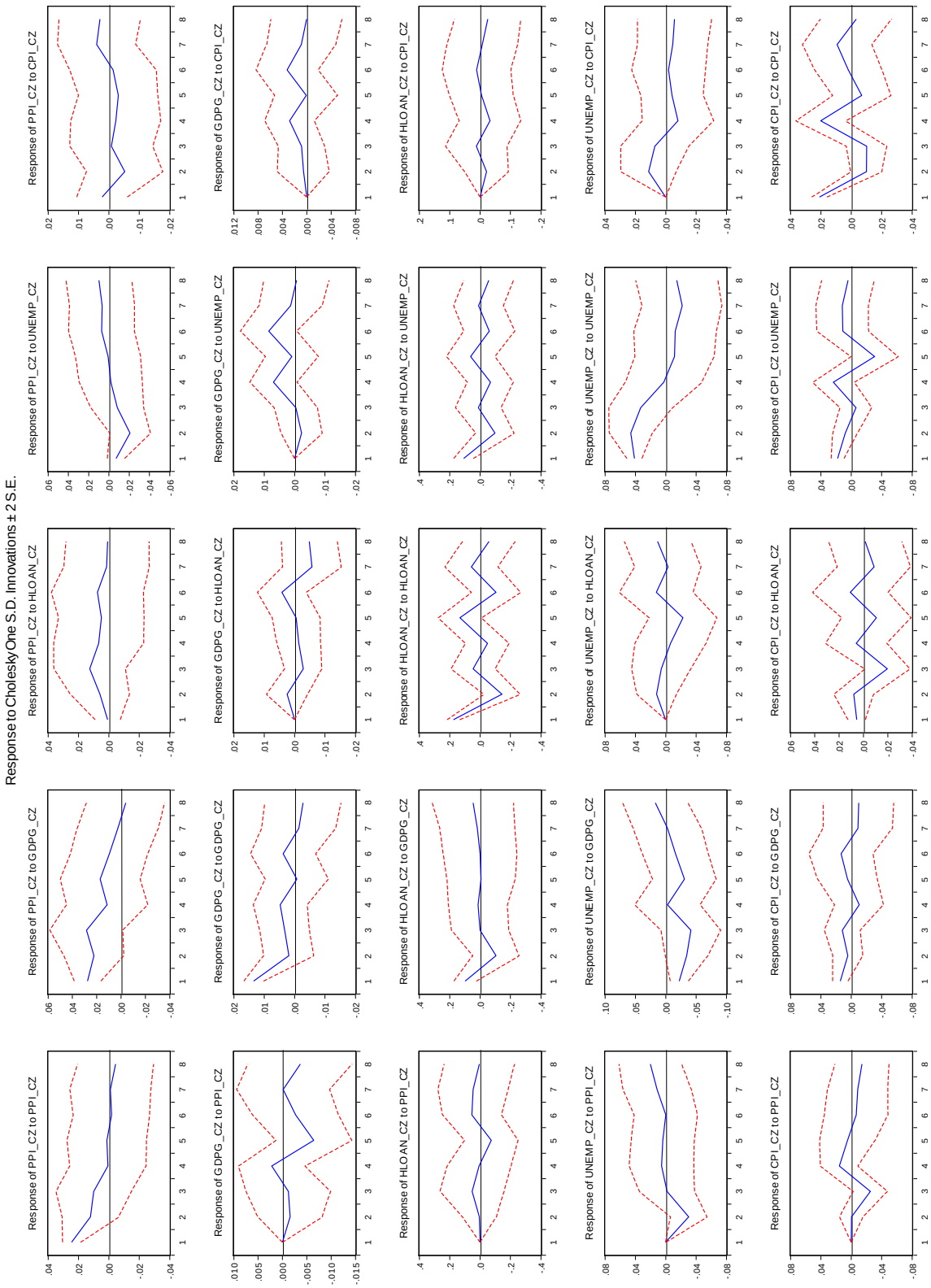
Appendix III – Impulse response functions

1 Standard deviation shock ± 2 asymptotic standard errors (5% confidence level)

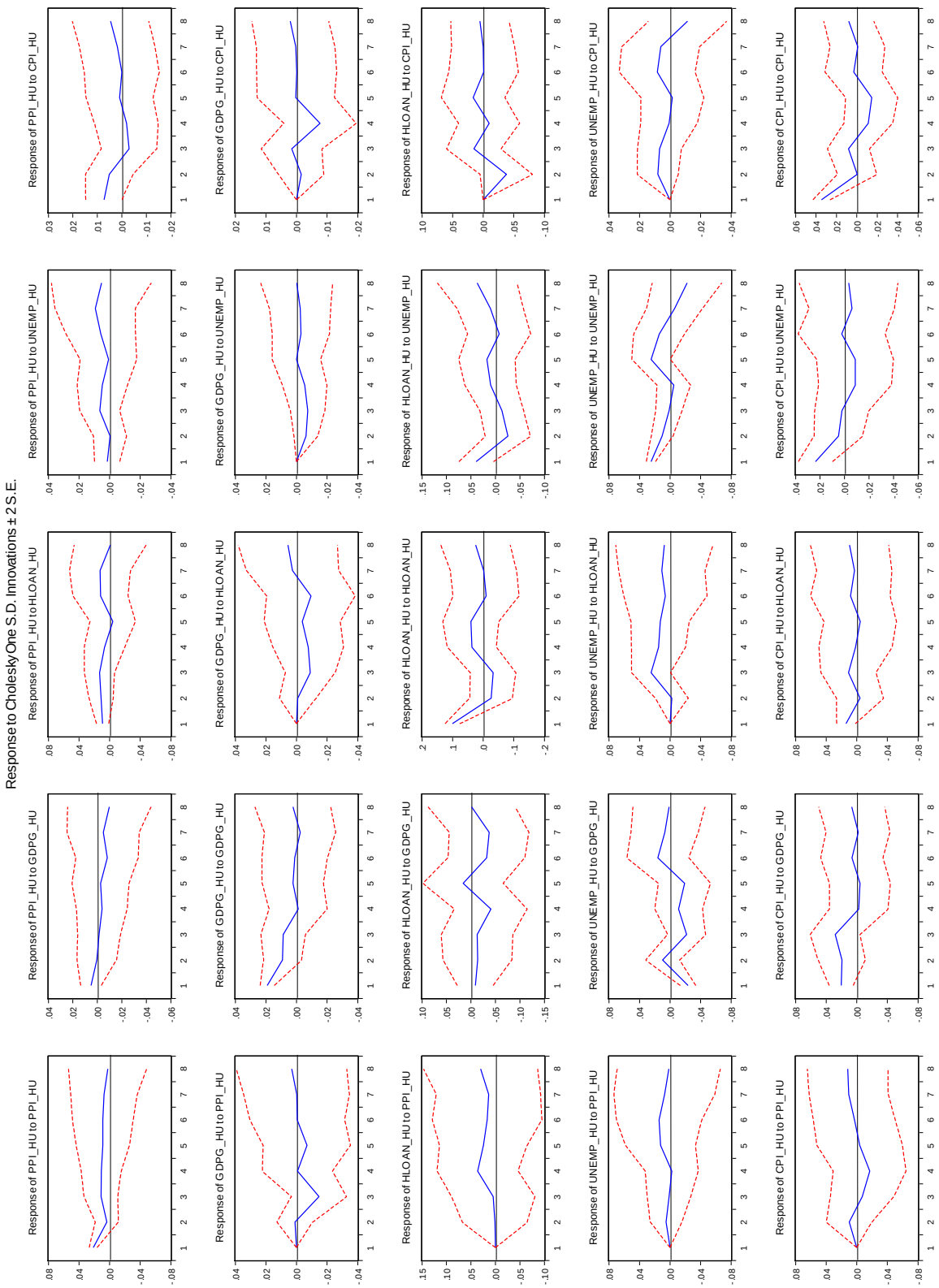
Austria



CzechRepublic



Hungary


Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of PPI_HU to PPI_HU
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Response of PPI_HU to UNEMP_HU
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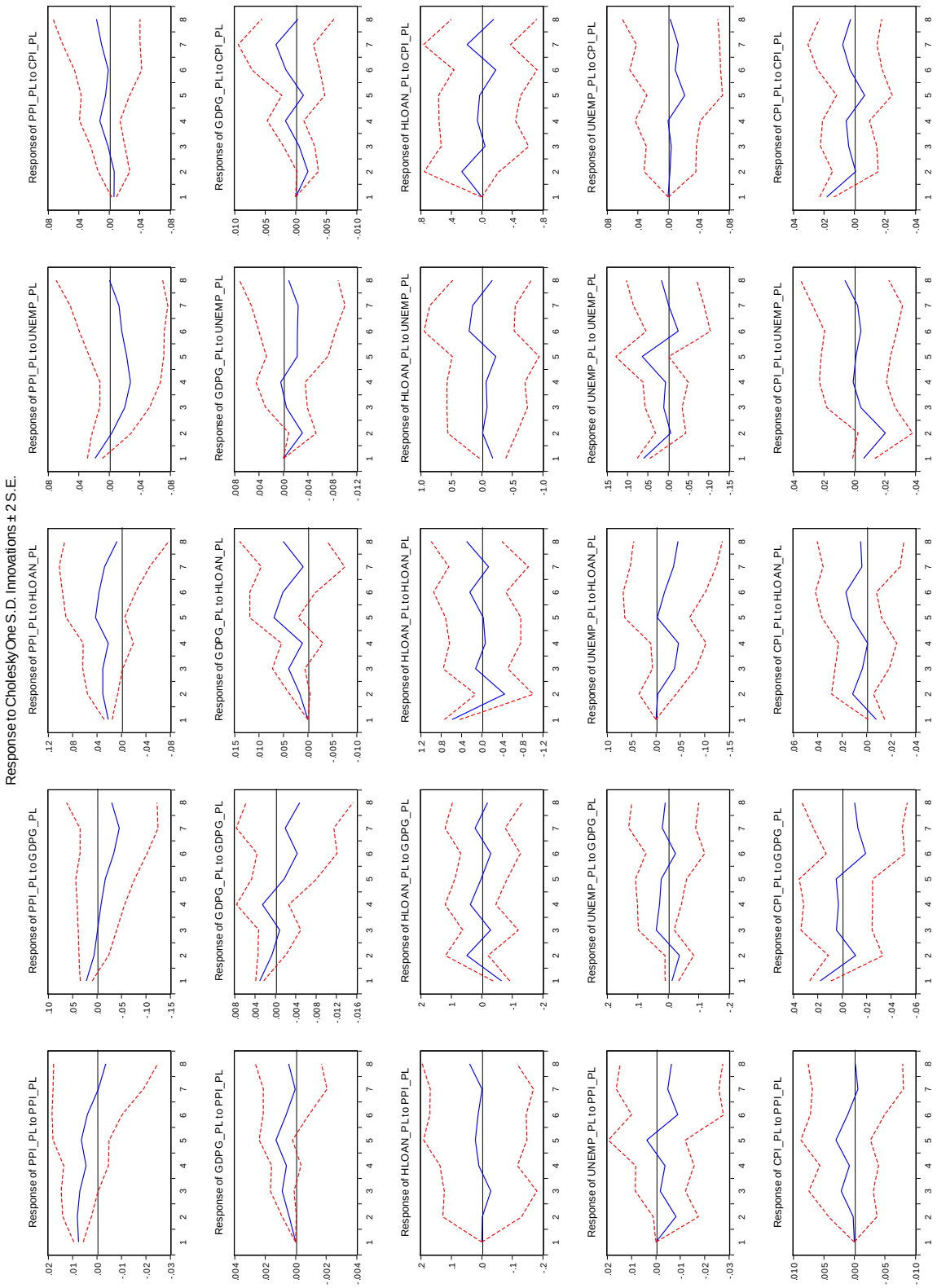
Poland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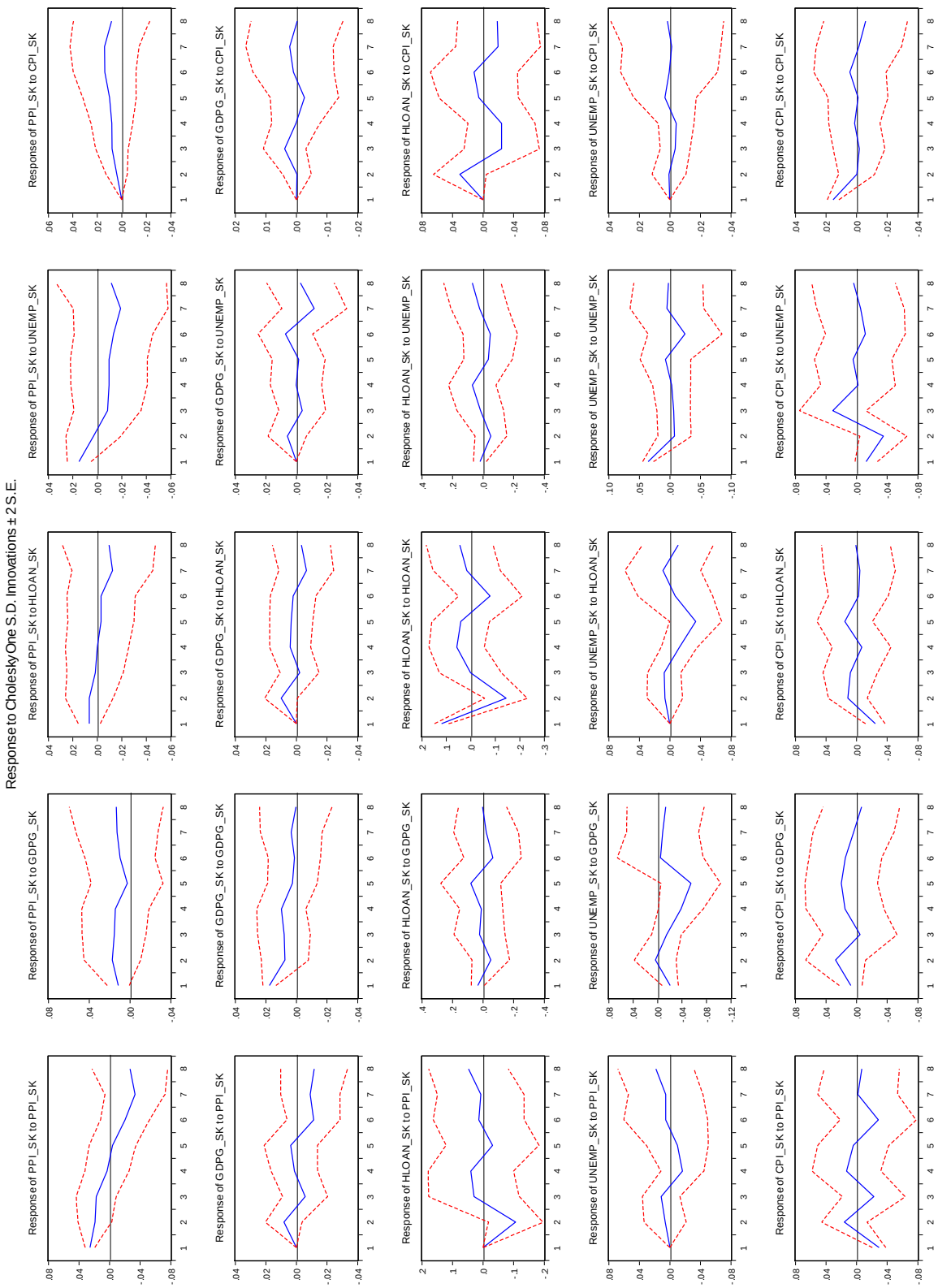
Slovakia


Response to Cholesky One S.D. Innovations ± 2 S.E.
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