TESTING POTERBA'S ASSET-MARKET APPROACH TO MODELLING THE HOUSE PRICE DYNAMICS

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Abstract

For years the housing market sector has been an ardent issue of both researchers and the non-academic public. House prices are a continuous preoccupation for people, since they directly influence our daily lives and for many people in Europe, the house they live in is the main acquisition of their lifetime. The purpose of the current paper is to test whether the asset market model of house price dynamics proposed by Poterba (1984) holds. I show that the arbitrage equation suggested by Poterba (1984) does not fully describe the short run house price dynamics and that people do not form rational expectations. The public rather has adaptive expectations regarding the evolution of house prices and rents, since current price to rent ratios can be predicted based on past price to rent ratios. I find that in Bulgaria, Lithuania and the UK there is seasonality, which is why the arbitrage equation might not work .The tests are performed using four panels with different cross-sectional combinations of the following six European countries: Bulgaria, Czech Republic, Estonia, Lithuania, Poland and the UK. The econometric method is two stage least squares and the data is quarterly time series from 2000 until 2006.

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Introduction

For years the residential housing market sector has been an ardent issue of both researchers and the non-academic public. House prices are a continuous preoccupation for people, since they directly influence our daily lives and for many people, the house they live in is the main acquisition of their lifetime.

The purpose of the current paper is to test whether the asset market model of house price dynamics proposed by Poterba (1984) holds. In what follows, I show that the arbitrage equation suggested by Poterba (1984) does not fully describe the short run residential house price dynamics and that people do not form rational expectations. The public rather has adaptive expectations regarding the evolution of house prices and rents, since current price to rent ratios can be predicted based on past price to rent ratios. The tests are performed using four panels with different cross-sectional combinations of the following six European countries: Bulgaria, Czech Republic, Estonia, Lithuania, Poland and the UK.

The sample forms a unique combination of countries in terms of economic development and historical background. On the one hand, the UK has long been an independent country whereas the rest are all former communist countries. Therefore, I build one panel which contains the UK and one which does not in order to make a comparative analysis. Furthermore, Lithuania an Estonia are analyzed separately in another panel of the total of four panels, both of them being former republics of the Soviet Union. In the last panel I pool together the Baltic countries with Bulgaria, since they all have a fixed exchange rate system in common. Moving on to the economic development diversity, the UK stands out with $ 35.300 GDP per capita (PPP) (Central Intelligence Agency). Bulgaria has the lowest GDP per capita in the sample, namely $ 11.800, which represents approximately a third of the UK's GDP per capita and around half of the GDP per capita of the next two countries after the UK in terms of GDP per capita: Czech Republic with $ 24.400 and Estonia with $ 21.800. Last but not least, Lithuania and Poland are comparable in terms of GDP per capita (PPP), the former has $ 16.700 and the latter $ 16.200. Their GDP per capita is approximately half of the UK's. Given the differences in terms of economic development, I can make comments on how the model works when I include the UK in the sample, as opposed to the situation when I only analyze the other 5 countries.

My work adds new information to the existing literature because according to my knowledge, Poterba's arbitrage model on house prices has never been tested on European countries. Furthermore, I investigate the issue of seasonality in all six countries since according to Tenreyro (2007) this might be a reason why the theoretical model is not supported by the data in my sample. Also, the econometric method is different from previous papers (Mayer & Sinai 2007, Himmelberg et. al 2005) for the reason that I employ two stage least squares as opposed to using ordinary least squares estimation method, in order to account for the endogeneity of the user cost variable and also to account for of the omitted variable bias.

My thesis is divided in four chapters. In the first chapter I present in one section the literature review on the topic of house price dynamics and the main work on which I build my thesis, namely Poterba (1984). In the second chapter, the data description and the necessary transformations that my data is subjected to before actually running the tests are described. Next, In Chapter 3 I explain the two econometric models that I am testing and also discuss the methodology employed. Last, Chapter 4 is dedicated to interpreting the results and discussing the limitations of both the theoretical and econometric model that I am testing.

Chapter 1.Previous works and theoretical model

1.1. Literature review

The existing literature on the house price dynamics described through the user cost approach investigates possible factors, besides market fundamentals, that can explain the short run change in prices. In what follows, I will list some works which have identified the subsequent causes: psychology through backwards looking expectations, credit availability, inflationary expectations, seasonality and high transaction costs.

Mayer and Sinai (2007) assess the role of the market fundamentals and psychology in explaining the price dynamics in US between 1984-2006. Their baseline model starts from the user cost formula found in Hendershott and Slemrod (1983) and Poterba (1984) but it is rearranged so that the price to rent ratio equals the inverse of the user cost. The justification for this expression is that due to the fact that the price is determined both by supply and demand, the price rent ratio conditions only the asset market factors (i.e interest rate, depreciation, taxes, maintenance) to explain how current and expected future rental values are capitalized in prices. Adding to the user cost formula vectors that proxy for the availability of capital, for backwards looking behavior and inflationary expectations, they find that fundamentals can explain only the 1995-2006 boom and that obvious behavioral variables like the inflation rate and one –year backwards looking price expectations have little explanatory power. Furthermore, financial factors like credit availability do not explain the 1980’s boom, but they prove significant during 1995-2000. To continue, there is evidence that medium term price expectations (five year lagged price appreciation rate) have a high impact on the price to rent variations in the MSA’s (Metropolitan Statistical Areas) and they are connected with the use of subprime mortgages.

The theory of inflationary expectations is also supported by other authors. Case, Quigley and Shiller (2003) believe that homebuyers' price appreciation expectations are determined by the recent appreciation rates. They say that even after a long boom period, home buyers still expect a double digit house price appreciation. Their analysis relies upon annual panel data of 14 countries observed during 25 years and a panel of US states with quarterly observations between 1980's and 1990's.

Another author who questions the veracity of the arbitrage relationship found in Poterba (1984) and other more recent authors like Stein(1995), Krainer (2001), Ortalo-Magne and Rady (2005) is Silvana Tenreyro. She finds evidence of housing price seasonality in the UK, France and Belgium and no seasonality in US, Denmark, Norway and Australia. She tests for seasonality using two approaches. One of them is the regression of seasonal dummies on the annualized growth rate number of transactions and the other is the regression of the same dummies on the growth of price index. The presence of seasonality is a puzzle from the point of view of the arbitrage relationship because in efficient markets, forward looking buyers would shift their acquisitions to the period when prices are known to be smaller, which would decrease the price difference between seasons.

Another explanation for the failure of the arbitrage relationship is given by Vebrugge and Garner (2007).Their paper calculates user costs and rents for the same structure, for the five largest cities in United States. They are using the rental equivalence method to predict rents and the property value of the median house in their sample to construct user costs. Price expectations are modeled following the method of Verbrugge (2007a), which employs forecasts of four-quarter-ahead regional house price appreciation. Given this, they explain that the divergence between rents and user costs is due to unexploited profit opportunities and therefore the implied large transaction costs assumed by the following sequence: buy-earn rent on the property –sell and sell-rent from someone else for one year- repurchase.

Next, I will introduce the paper on which I found my research, namely "Tax subsidies to owner-occupied housing: An asset market approach" by Poterba (1984). According to this paper the short run change in prices is a relationship between rents and the home owners' user cost.

1.2. The economic framework

This paper bases its empirical results on the asset market approach suggested by Poterba (1984). I chose this particular paper because it rises an interesting question of whether short run house price dynamics can be explained by the fundamentals, in the context of rational expectations. In broad terms, his model is useful in analyzing the effect of inflation and tax policy on the relative price of houses and on the housing stock. The main focus of Poterba's paper is on the long-run and short run consequences of a change in the user cost .

The underlying logic of the model assumes that a rational home buyer will want to pay a price equal to the present value of the future service stream of the house. However, the future services will depend on the evolution of the housing stock, since its marginal value of a unit will decrease as the housing stock increases. Furthermore, the change in house prices is very much related to the expectations about the future production in the construction sector. All of the above is possible under the assumption that the public possesses perfect foresight. His study refers to the price of the house structures that have a constant quality, therefore leaving aside the price of the land. Also, the model takes into consideration only the market for new construction and it subscribes to the previous works of Kalchbrenner [1973], Kearl[1975,1979], and Sheffrin [I979].

To continue, the housing services supply is a function of production :

HSs = h(H),

where H represents the stock of housing structures and the housing services demand depends on the real rental price R of those services :

HSd = f(R), f R <0.

Taking into consideration that the housing stock is fixed in the short run, there will be an equilibrium price given by the following relationship:

HSs = HSd .

The market clearing rental price will be calculated as R= R(h(H)), R ‘ <0, where R is the inverse demand function of the housing services. For simplification purposes, I will use R(H) as the marginal value of services generated by the housing stock.

Starting from the above relationships, Poterba reaches a final model of the supply and demand of the housing market, which describes the dynamics that governs it. The supply equation describes the net change in the housing stock as the output of an investment function from which we subtract the number of buildings out of use dues to depreciation.

$\dot{H} = f(P) + d * H$, where

H= housing stock

$f(P)$ = investment function

P= the real price of a unit structure

d = rate of depreciation of the housing stock

The demand side captures the change in real prices as the difference

$\dot{P} = -R(H) + uc * P$, where

R(H) = the marginal value of services generated by the housing stock

uc = the user cost

Assuming that the interest rate and the opportunity cost of buying a house are identical, the author finds for the user cost the following expression:

$uc = d + m + (1 - t_i) * (i + t_p) - gain^e$, where

d = depreciation rate of housing stock

m = fraction of current value of the house representing maintenance and repair expenditures

t_i = marginal income tax rate

i = the opportunity cost

t_p = rate of property tax liabilities

$gain^e$ = expected gain or real house price appreciation

$\dot{H} = 0$ and $\dot{P} = 0$ represent the demand locus and the supply locus respectively. The first one describes the situation in which there is no net change in housing stock supply because the output of investment equals the depreciation amount of housing stock. The supply locus reflects the situation when there is no change in real prices because the home owners expect no real capital gain, which is consistent with the market assumed by Poterba (1984), that being an owner occupied housing market.

So far I have presented the market fundamentals found in the literature of housing market and these are identified as: rent, interest rate, income and property taxation and expected capital gains. Also, I have indicated other factors which can influence the short run change in house prices and therefore can cause prove that the arbitrage relationship is incomplete.

Chapter 2.Data

In the previous chapter I have briefly discussed the main theoretical and empirical works which I am investigating in this thesis. In this chapter I will describe the data I am using for tests and the transformations that are performed on it.

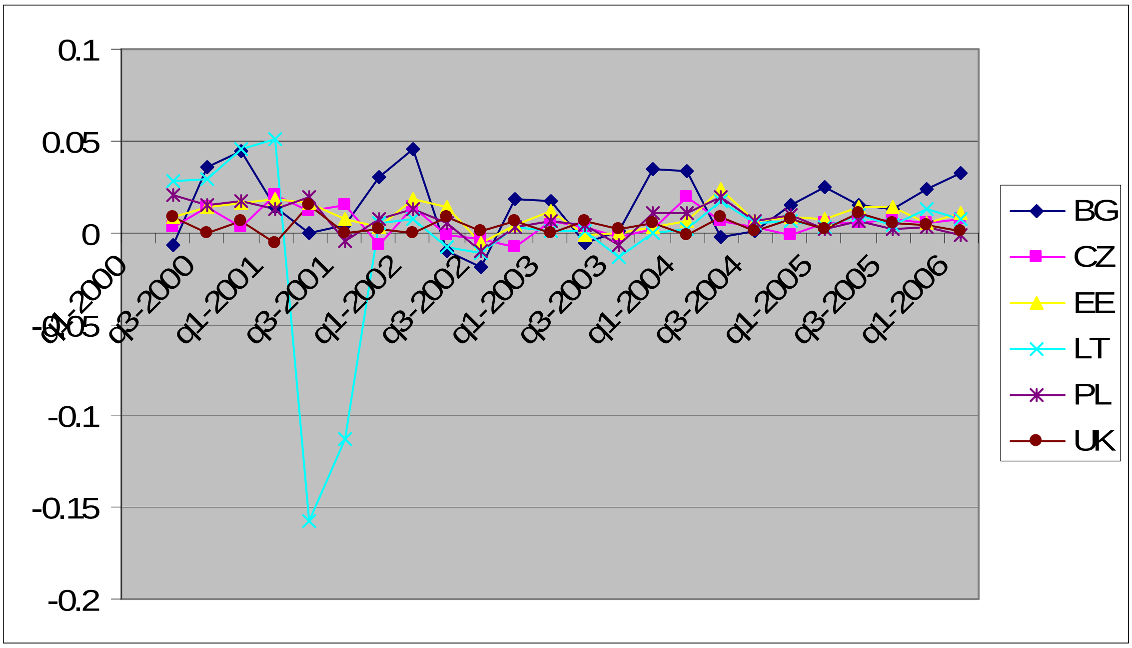
2.1. Data description

As a measure of inflation, I use the Harmonized Consumer Price Indexes (HICP's) reported by Eurostat for each country in my sample1. The HICPs are Laspeyres-type indices. The index measures "pure price changes" using a harmonized methodology (Eurostat). The prices taken into account are those actually faced by consumers. The products covered by these indexes are those used to calculate the household final monetary consumption expenditure (HFMCE) in the national accounts, as they are defined by the European System of Accounts. They express the expenditures of goods and services made by residents and nonresidents within the territory of one country. The indexes were computed starting with 1996 and have a monthly basis, but I am only using the period 2000-2006 because these are the years for which I could find data for all my variables. In Bulgaria's case the mean and the median value are approximately the same, respectively 0.014 per quarter. These values are much lower in Czech Republic, of only 0.005 per quarter. In Estonia, the mean value is 0.009 per quarter while in Lithuania the mean values is negative -0.001 but the median is 0.004. In Poland both statistics are around 0.006 per quarter and finally in the UK they are around 0.004 per quarter. Overall, Lithuania and the UK exhibit the lowest inflation, Bulgaria being the country with the highest inflation in my sample. The extremes values are -0.15 in Lithuania in the second

[1] They assess inflation convergence according to Article 121 of the Treaty of Amsterdam (Article 109j of the Treaty on European Union).

quarter of 2001 and the peak is found in Bulgaria in the first quarter in 2002 and it is 0.045. For a overall look, please see Fig 1 below:

Figure 1- Inflation

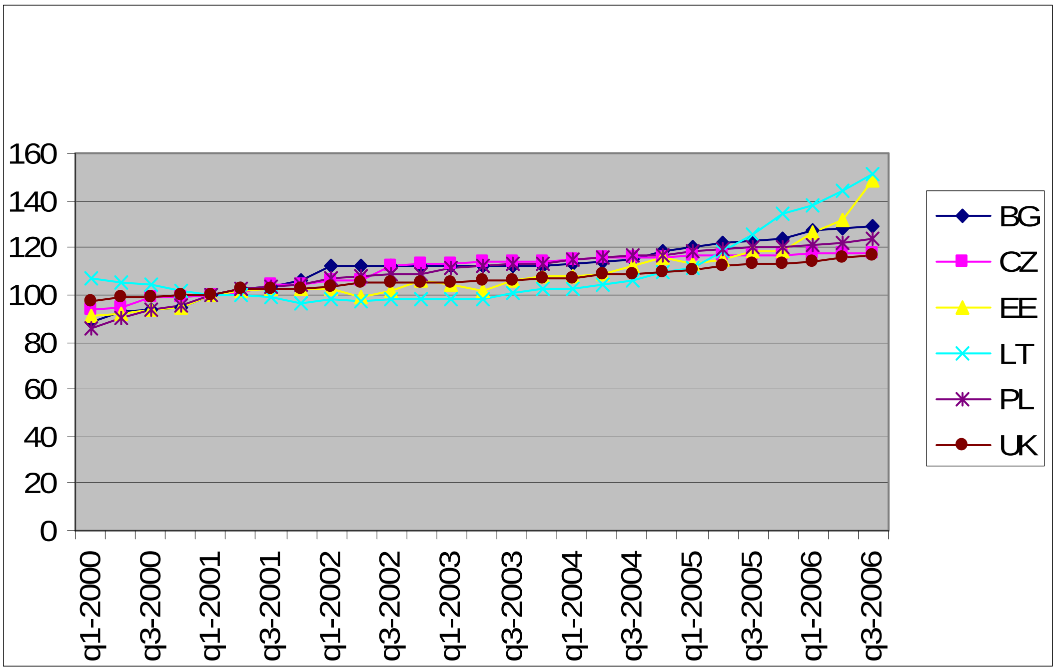


Source: Author's calculations

The weights of subindexes in HICP vary from country to country .The indexes of actual rentals and maintenance expenditures are such subindexes. The rent index appears to be smooth and generally exhibits similar behaviors in all the countries, only Lithuania and Estonia stand out of the crowd (see Fig. 2 bellow), since the rent index is a bit sharper than the rest of cases: in Estonia it appreciates by 72 percentage points from 2000q1 until 2000q4 and in Lithuania by 52 percentage points in the same period.

As a measure of interest rate I chose the long term government bond yield which is a less risky financial instrument, which is required by the simple theoretical model, as Poterba (1984) calls it, which assumes that risk and uncertainty play no role .He states however that the short term interest rates enter the arbitrage equation, not the long term given by mortgages. His explanation is that the long term interest rate (mortgage) affects prices because it displays information about future expected user costs, but in the short run, in a riskless economy, the arbitrage equation should hold even when interest rates are low (hence the short rates) and therefore use costs are high. One period return on houses must equal the

Figure 2- Rent Index

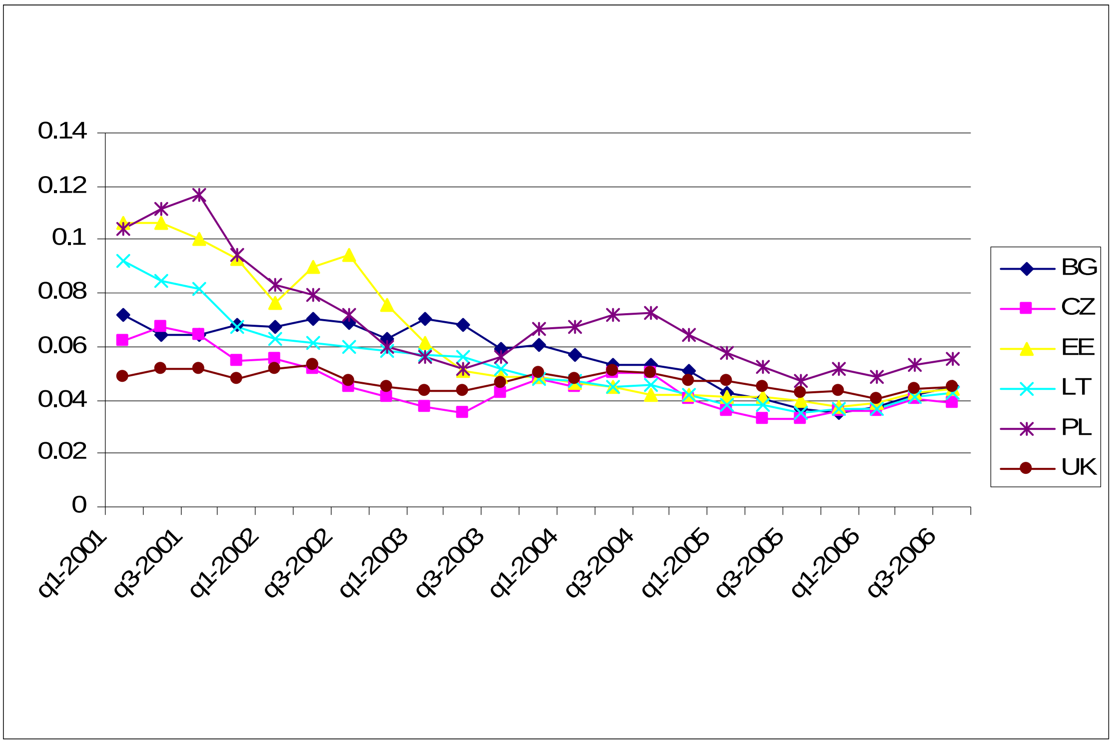


Source: Eurostat

return on alternative assets, this being the short term interest rate. However, my measure of interest rate is somewhere in between, the long term government bond yield being much closer to the short term interest rates2 than the mortgage rate. Overall, the interest rate decreased between 2000 and 2006, so that if in the beginning of period Poland, Estonia and Lithuania had the highest yield, by the end of 2006 all the countries have yields around 0.04 approximately, the smallest value being recorded in the Czech Republic and the highest one in Poland (See Fig. 3 below).

[2] The 3 months money market yield .

Figure 3-Long Term Government Bond Yields



Source: IFS

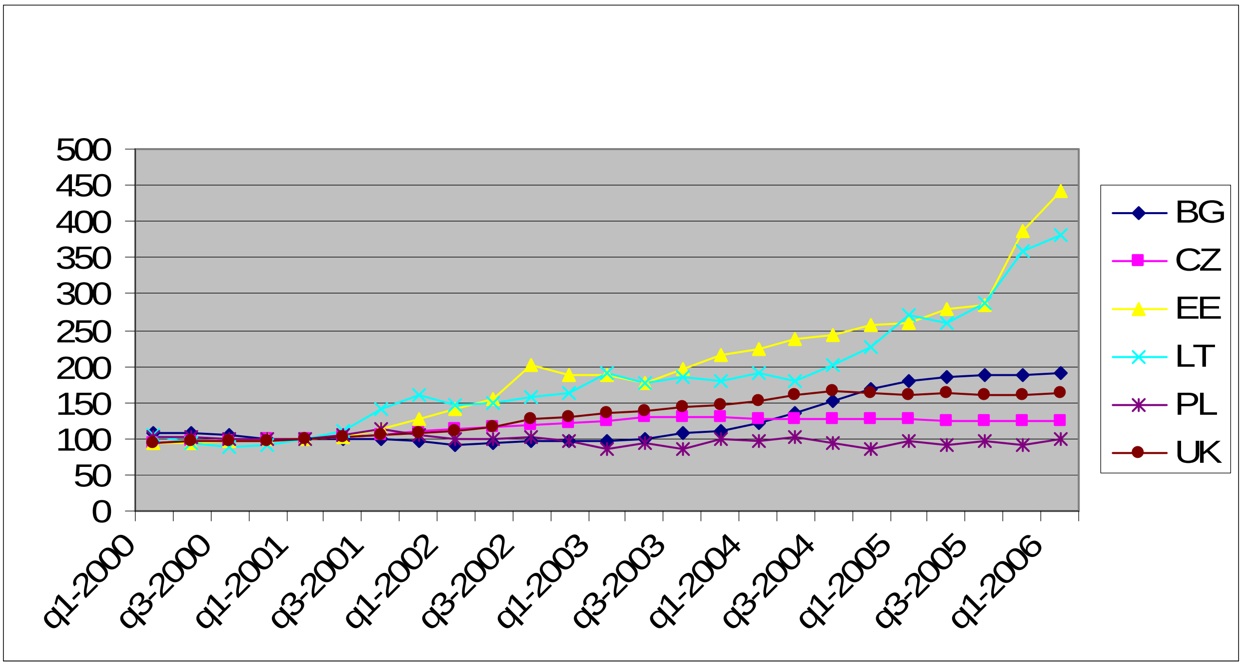
Of all the variables, the real price index shows the greatest volatility and different behavior across countries. Again, Lithuania and Estonia stand out of the crowd, like it happened in the case of the rent index which increases faster also in these two countries, compared to the rest of the sample. This is true also for the price index, which indicates that in these countries the real price increased by approximately 4 times between 2000-2006. Bulgaria is the next country which shows a higher real price appreciation, especially in the last two years 2005 and 2006. The least active markets are Poland and Czech Republic (see Fig. 4 below)

When it comes to income taxation, we can notice that during this period Poland had the highest income tax rates followed by Lithuania, the UK and Czech Republic, which in the middle range, and Bulgaria exhibiting the lowest income taxation3. In my estimation I use the tax rate which applies to a married couple, who earn 100% of the average wage and have no

[3] See Appendix 3, Fig 6.

children because my intuition is that especially in the continental countries, these are the categories more prone to buy a house.

Figure 4- Real Price



Source:Eurostat

Moving on, data about property taxes comes from various sources. Bulgaria has an annual property tax of 0.15%[4] (Foreign Tax Returns Ltd.) of the property book value. In Czech Republic there is no tax rate on the real property, there is only a land tax which was introduced in 1993 .The same happens in Estonia, where there is no property tax, only a land tax, which was introduced in 1993 (Trasberg 2008). In Latvia, there is an annual real property tax of 1.5% of the cadastral value of the property, introduced in 1997[5].To continue, in Lithuania only legal entities pay a property tax of 1% annually (Deloitte 2008). Poland does not have a property tax based

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[4] This tax was established by the Law of Property Tax(1952), according to Almy (2001)

[5] The Law on Real Property Tax, adopted on 4 June 1997, in effect as of 1 January 1998 (Klavins & Slaidins 2008).

on market value (Brzeski 2004). The property tax in the UK is the Council Tax (Advice Guide 2008), which is not a tax rate that applies to the market value of the property, but it is a local tax established annually by local authorities. The properties are put into 8 categories which are called valuation bands since 1991. Each property is valued at April 1991 prices and put into a valuation band. There are several exemptions from this tax. Overall, none of the countries have a property tax based on the market value of the property, therefore I cannot include them in the arbitrage equation as it is given by Poterba(1984).

In this section I have described the main trends of the variables employed. Therefore, the rent index has been increasing during 2000-2006 and the same applies to the real price index. The long term government bond yield has shown a downward trend in all the countries in the sample. The income tax rate does not exhibit large swings and when it comes to property tax, none of the countries have a property tax rate which applies to the market value of the property. Having this in mind, I proceed to the needed data transformations before testing the model.

2.2. Data transformation

The main changes regard the modification of data frequency in Eviews, from monthly to quarterly and making the first quarter of the year 2001 the base period for all the indexes. I needed to change base period in order to compute the user cost ratio which I will use later on in the empirical test. In order to calculate the base period I must have data about all its components and in some case, I have data of the interest rate starting with the first quarter of the year 2001. Furthermore, in this section I show how I constructed the price rent ratio, the user cost ratio and expected gain.

To start with, the harmonized consumer price index, actual rentals and maintenance are indexes taken from Eurostat and have monthly frequency. With the help of Eviews I convert these indexes to quarterly frequency, averaging the monthly observations. The base period was the year 2005 and I changed it to first quarter of 2001.

The price variable for the continental countries was expressed as index of nominal prices in national currency. The base year was 2000 and I changed it to 2001 like in Appendix a).I used HCPI to transform it into real price index. The price variable for the UK was expressed in levels in national currency and it had monthly frequency. I used Eviews to convert it to quarterly data (by average method) and then I obtained the nominal price index 6 by dividing the current nominal price to the nominal price in 2001. After obtaining the nominal price index I transformed it into real price index.

[6] The base period is the first quarter of 2001

I constructed the price to rent ratio dividing the price index by the rent index. Poterba (1984) assumes that people have the strongest form of rational expectations, respectively perfect foresight. This implies that people have all the necessary information today to precisely predict tomorrow's price. Given this, the expected gain was calculated as follows:

$$gain^e = \frac{P_{t+1} - P_t}{P_t},$$

where P_t is price in the current period, t= 2000, …, 2006.

The user cost formula is :

$uc = d + m + (1 - tax) * irate - gain^e$, d = 0.02 and m = 0.0004[7],

where uc = user cost

d = depreciation

m = maintenance and repairs

tax = income tax

irate = long term government bonds

$gain^e$ = expected gain

The income tax had an annual frequency therefore I choose to keep the tax constant for each quarter, according to the annual average, so it only changes across years.

The most important changes described above are the construction of three variables: price to rent ratio, user cost ratio and expected gain. In the next chapter I will present the two econometric models that I use for tests along with methodology.

[7] The value was calculated as a percentage of the real house prices based on data from Households Survey in UK (2000-2006) and real house prices in UK (quarterly frequency). Because there is no data regarding maintenance expenditures in the rest of the countries in the sample, I applied the same percentage to all the countries.

Chapter 3.Empirical model

This chapter is dedicated to presenting the two econometric models chosen to test the theoretical model suggested by Poterba. I will explain the transition from the initial theoretical model to the actual relationship that I am *testing*. In terms of methodology, I use four panels for each model and run the two stage least squares regression and ordinary least squares as well. However, for reasons that I will explain later on, two stage least squares is more appropriate to use, and my results will be based on TSLS estimators.

3.1. The econometric models

To start with, I present the main equation which triggered the idea of my thesis, and I describe the subsequent mathematical transformations that lead me to the actual model to be tested. Thus, Poterba's arbitrage equation can be rewritten as follows:

$$P_{t+1} - P_t = -R_t + uc_t * P_t$$

In equilibrium, $R_t = uc_t * P_t$ which can be rearranged as $\frac{P_t}{R_t} = \frac{1}{uc_t}$.Given my variables, the price rent ratio that I constructed has the following form $\frac{P_{t,2001q1}}{R_{t,2001q1}} = \frac{1}{uc_t}$, where $P_{t,2001q1}$ is the price index with the base first quarter of the year 2001 and $R_{t,2001q1}$ is the rent index with the base first quarter of the year 2001.This means that :

$$\frac{P_{t,2001q1}}{R_{t,2001q1}} = \frac{P_t}{P_{2001q1}} * \frac{R_{2001q1}}{R_t} = \frac{P_t}{R_t} : \frac{P_{2001q1}}{R_{2001q1}}$$

To continue, if $\frac{P_t}{R_t} = \frac{1}{uc_t}$ (1) and $\frac{P_{t,2001q1}}{R_{t,2001q1}} = \frac{1}{uc_t}$ (2) , then dividing (1) to (2) would give :

$$\frac{P_t}{R_t} : \frac{P_{2001q1}}{R_{2001q1}} = \frac{1}{uc_t} : \frac{1}{uc_{2001q1}} \qquad (3)$$

which is in fact:

$$\frac{P_{t,2001q1}}{R_{t,2001q1}} = \frac{uc_{2001,q1}}{uc_t} \qquad (4)$$

I define $\frac{P_{t,2001q1}}{R_{t,2001q1}}$ = *prratio* and $\frac{uc_{2001q1}}{uc_t}$ = *ucratio*.

My baseline model becomes :

Model 1: $prratio_t = a_1 + a_2 * ucratio + + error_t$

If rents are equal to the inverse of the user cost, then according to equation (3), I expect $a_2 = 1$[8] and Poterba's (1984) findings regarding the house price dynamics are confirmed.

The second model is testing for backward looking behavior, in the form of adaptive expectations against the alternative of rational expectations, which tests whether current price is determined by past prices. Therefore, I expect $a_3 \neq 0$. The model specification is:

Model 2: $prratio_t = a_1 + a_2 * ucratio + a_3 * prratio_{t-1} + error_t$,

where t=current value and $prratio_{t-1}$ = first lag of *prratio* .

[8] b=1 even if $\frac{P_t}{R_t} = \kappa \frac{1}{uc_t}$, where $k \neq 1$, but $a_2 \neq 1$ is a clear proof that either equation (1) or (2) are false, or both are false.

If I find evidence that the second model works better than the first one in terms of robustness and that $a_3 \neq o$ and it is statistically significant, it means that people do not form rational expectations, and therefore, my data does not support the theory.

3.2. Methodology

In order to estimate the above models(*Model 1* and *Model 2*) I form 4 unbalanced panels: panel 1 includes all the countries, panel 2 is only comprised of the 5 European continental countries, since I wish to investigate whether my results change if I exclude the most developed country in the sample. *Panel 3* includes the Baltic countries Estonia and Lithuania, and panel 4 is composed of Estonia, Lithuania and Bulgaria. The reason for grouping the countries in this fashion relies upon the fact that in panel 3 there are countries with a similar historic background (they were both part of the Soviet Union and gained independence in 1991). Also they are among the wealthiest countries of the former Soviet Union's republics (Zayac and Brown, 2007). Last but not least, *Panel 4* gathers countries which have a fixed exchange rate and I wish to investigate if there is a difference in the results, given that such a system "lowers inflation expectations to the prevailed level of the anchor country" (McDonough, 1996) , which in this case is Euro zone because the currencies are pegged to Euro.

Both models are estimated using two stage least squares because this method will give consistent results even if the explanatory variables have measurement error or omitted variable bias. Measurement error is due to the fact that I assume rational expectations and I build expected gain assuming that $E_t P_{t+1} = P_{t+1}$, and therefore $gain^e = \frac{P_{t+1} - P_t}{P_t}$. Because

$gain^e$ is part of *ucratio* , I will instrument *ucratio* by its first and second lag in both model 1 and model 2. *Model 2* has one more explanatory variable, the first lag of *prratio*, which is endogenous because there are variables that most probably affect the price – rent ratio (i.e. – the risk premium) and are not included in the regression, so my regression suffers from omitted variable bias. Therefore, I instrument the first lag of *prratio* by its second lag. Although TSLS has an advantage over OLS when there is heterogeneity, as OLS would give biased and inconsistent estimators, the cost of using TSLS is that the asymptotic variance of the IV estimator is always larger than the one of the OLS estimator (Wooldridge, 2001), and therefore,I might get insignificant results.

To continue, the IV's must meet two important conditions: they must be correlated with the variable that they are instrumenting and uncorrelated with the error term. In my case, the first and second lag are obviously correlated with the *ucratio* and also, the second lag of *prratio* is correlated with the first lag or *prratio* which appears in model 2. The second condition cannot be tested though, so I have to assume that my chosen instruments are not correlated with the error term. Also, the number of IV's has to be at least equal to the number of endogenous variables and in the present paper this condition is met. Because I use more IV's than endogenous variables, I will run an overridentification test.

Furthermore, in order to obtain consistent estimates, I use White period standard errors due to the fact that I employ time series and I expect that there is correlation between observations across time.

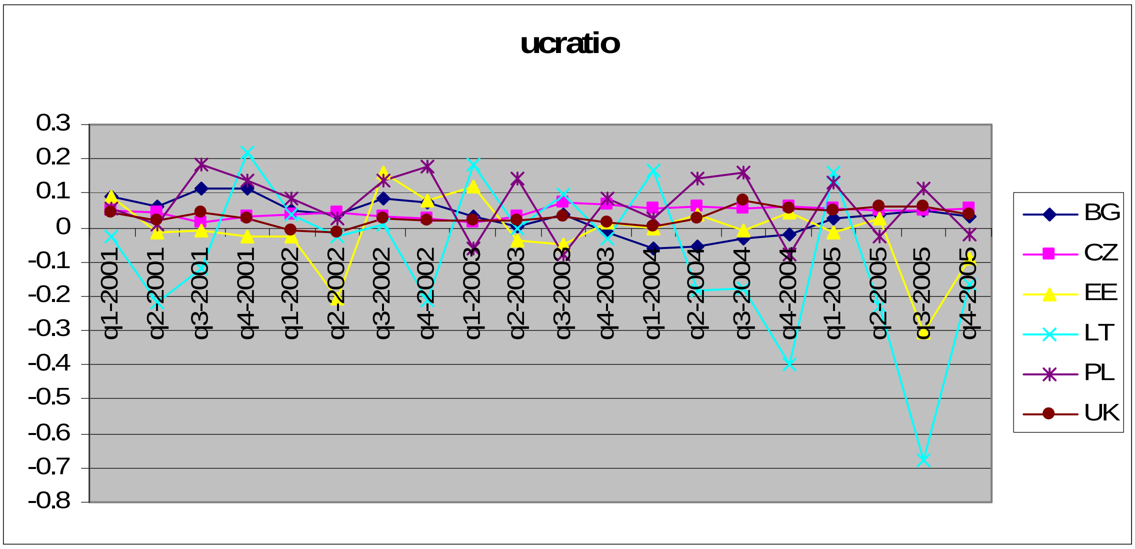
Next, in estimating *Model 2* I choose three different specifications: fixed effects, fixed effects and GLS and simple GLS. For Model 1 I am using two specifications: fixed effects and GLS and GLS since this model does not perform as well as model 2 and there is no point in further investigation.

The reason for employing cross-section fixed effects (Within- TSLS) is that they account for individual characteristics of each country in the panel and they remove the cross-section specific mean, performing the specified regression on the demean (Eviews 5 Users Guide, p.847). Hence, they are useful to see what is the coefficient on *ucratio* due to house price fundamentals only and not due to each countries' specificities. The advantage of the Within-TSLS estimator consists of allowing for country individual effects and therefore making the estimator more efficient, but at the same time the regression loses degree of freedom and the problem of multicollinearity might appear.

Furthermore, the feasible GLS specification of cross-section heteroskedasticity "allows for different residual variance of each cross section" (Eviews 5 Users Guide, P.848). This might turn out to be important since a quick glance at the Fig. 5 bellow shows how different is the behavior of *ucratio* in the 6 countries of the sample. The FGLS estimator uses a combination between the fixed effect (FE) and random effect estimator (RE). On the one hand, the shortcoming of the RE estimator is that it assumes individual effects not to be correlated with the error term, which in this context is highly unlikely. On the other hand, the RE estimator allows for time invariant characteristics, while the fixed effects rules them out. However, the FGLS estimator "overcomes" the difficulty to which the RE estimator is subjected while "accommodating" the one encountered by FE (Greene, 2002, p.303). Hence, in the context of instrumental variables, the FGLS estimator is consistent and efficient, whereas the simple IV estimation is consistent but not efficient (Greene, 2002).

Overall, there are many advantages of using panel data: it enables the study of different issues where data is available for a short period (T is small) by increasing the sample size to N*T, where N is the number of cross-sections. Moreover, it increases the precision of estimation because of larger samples, it deals more effectively with heterogeneity problems by allowing for RE, and it makes it possible to control for cross section fixed effects, which are common to each cross- section, but may be different between cross- sections.

Figure 5-UCRATIO



Chapter 4. Findings

In the third chapter I presented 2 models which I am testing and I described 4 panels. Also, I explained why my method of estimation is two stage least squares. In this chapter I interpret my results based on *Model 2*, since the estimations in *Model 1* suffer from serial correlation, and therefore, I cannot make inferences**.**

4.1. Results

Overall, in *Model 2*, the coefficient of interest across panels ranges from -0.004 to 0.006, taking into consideration only the statistically significant results from the two stage least squares estimations. *Model 1* behaves very poorly under all specifications in the sense that the model suffers from serial correlation so I need to introduce in the regression the first lag of the dependent variable and hence use *Model 2*, in order to solve the serial correlation problem. Given that *Model 1* exhibits autocorrelation in the residuals, I cannot make inferences about the magnitude of the coefficient, so hereafter I will only analyze the outcome of estimating *Model 2* by two stage least squares.

4.1.1. Panel 1 and Panel 4

I will comment on the results of *Panel 1* and *Panel 4* altogether because the results are comparable given that in both panels the FGLS estimator proved significant at 5% significance level.

In *Panel 1*, the FGLS estimator of *ucratio* is -0.004 significant at 5% significance level, which means that, ceteris paribus, for every increase of one point of *ucratio*, the price ratio decreases by 0.004 points. This indicates a very small effect of *ucratio* on *prratio*, given that the standard deviation of *ucratio* is 11.72 (Table 6, Appendix 4).

To continue, I will explain why I get a negative sign on *ucratio*. Ucratio was defined as the ratio of the user cost in period t and the user cost in the first quarter of the year 2001. I notice that in the first quarter of 2001 the user cost was positive in all countries except Lithuania, after which it started to decline and have negative values. Therefore, the negative sign is due to the fact that in most countries after 2001 the user cost takes negative values in many periods, as opposed to the base period (first quarter of the year 2001) when it is positive. What we are looking at is a gradual decline in the user cost. Next, I will elucidate on the reasons for which the user cost is declining.

Looking at the graph of the user cost across countries and adding a trend line for each of them we can see that besides the UK and Czech Republic, in the rest four countries this variable has a downward trend. This pattern can be mainly explained by two factors which enter the user cost formula with a negative sign: interest rates and the expected gain. However, as I already mentioned, interest rates have been declining, so overall, the effect of interest rates on the user cost is positive[9.] Thus, the only factor which drives down the user cost is, in fact the expected gain. Expected gain is increasing in the majority of countries in the sample except for the UK and Czech Republic where the expected gain has downward trend (Fig. 8, Appendix 3).

To continue what is different in *Panel 4* from *Panel 1*, is that in the former, the price rent ratio takes higher values than in the latter, given that we have seen in the data description section that the price index increases very rapidly in Estonia, Lithuania and Bulgaria, which are exactly the countries which form *Panel 4*. In *Panel 4*, the coefficient of -0.001 on *ucratio*

[9] Also, in the actual form of the arbitrage relationship Poterba accounts for the change in house price dynamics due to a change in the interest rate, but not all the houses are bought with mortgages, so it is the case that sometimes i=0 and Poterba has not allowed for this in his equation, this could add to the reasons for which sometimes I obtain negative user costs.

means that ceteris paribus, one point decrease in the *ucratio* determines 0.001 points increase in *prratio*.Thus, in *Panel 4* the effect of *ucratio* on *prratio* is even smaller than in panel 1.

All in all, the small relative value of the user cost ratio, *ucratio*, shows that the fundamentals do not explain a great deal of the relative price rent ratio, *prratio*, and moreover, that past price determines the relative price rent ratio, which translates into the fact that people have adaptive expectations rather than rational expectations. Also, what drives the user cost downward is the expected gain, the way in which people form their expectations about the future has a major significance on the behavior of the user cost and therefore on *ucratio*.

4.1.2. Panel 2 and Panel 3

To continue with the third panel, the two stage least square estimation revealed quite different results from the ones obtained for *Panel 1*or *Panel 4*. First, the estimated coefficients of *ucratio* are positive in both FE effects and FGLS specifications, and they average around 0.006. Second, this time only the FE estimator was significant, although both are similar in magnitude. This panel gives the most robust estimates of the user cost of all four panels since changing the sample does not affect the size of the coefficient a great deal, nor does changing the instruments used. Given the small number of observations, I cannot limit the sample a lot, but changing it from 2000q1-2006q4 to 2001q1-2006q4 does not affect the size of the coefficient. Also, changing the instruments of *ucratio* from the first and second lag to only the first lag again does not change significantly the value of the coefficient on *ucratio*.

One possible explanation for obtaining the most robust in this case is that *Panel 3* is comprised of Estonia and Lithuania, which are similar from many points of view: they are both former republics of the Soviet Union, they are comparable in terms of the economic development, they joined EU in the same year and as mentioned in data description, the price and rent behavior exhibit the same pattern. Therefore, there is reduced heterogeneity, and the estimation is more consistent. Still, the estimation results do not offer support in favor of Poterba's theory because of the small magnitude of the coefficient of *ucratio* and due to the fact that again, the first lag of price has been found statistically significant and its coefficient is 1.05 (in the case of FE estimator). This value fully explains the variation in *prratio*.

In *Panel 2* the FE estimator has approximately the same value as in *Panel 3*, but it is different from the FGLS estimator, although the latter is not significant. Again, the sample is more homogenous without the UK and the FE estimator turned out significant at 5% significance value. As in *Panel 2*, the coefficient on *prratio* is also significant which once more is proof that the assumption of rational expectations is not correct.

Comparing the results obtained by TSLS and those of OLS, I notice major differences both in signs and magnitudes and therefore, OLS was biased and inconsistent, whereas TSLS is consistent under the FE specification and FGLS, being more efficient in the latter case. Thus, it was a good decision to use instrumental variables in my estimations.

All in all, the estimations show that the coefficient on *ucratio* differs from 1 and that the first lag of *prratio* is statistically and economically significant. Therefore, people form adaptive expectations instead of rational expectations and the data does not support the theory suggested by Poterba in 1984.

4.2. Limitations

In the previous chapter I found that people form adaptive expectations rather than rational expectations when it comes to house prices. However, the model suggested by Poterba and tested in the current paper has some intrinsic limitations, which might have caused its rejection. Also, the method of testing, together with statistical limitations might have contributed to this outcome too. In what follows I will, explain which are these possible causes and how they affected the results.

I will start first with the shortcomings of the theoretical model. Examining the data, I notice that in this simple approach, where I do not take into consideration risk and uncertainty and do not include property taxes due to the fact that they do not apply to the market value[10] , the component of the user cost which shows the greatest volatility is the expected gain (Fig. 2, Appendix 3), which I constructed as being one month ahead growth rate. Being very volatile (far more than the rest of the variables, i.e interest rate, income taxes, rents[11])and due to its weight in the user cost, it has a great impact on it[12]. Therefore, it matters whether, from the very beginning, the assumption of rational expectations is the correct one, when it comes to property prices. Other authors too have proved that residential markets are not efficient and that the price can be predicted by past prices. Case and Shiller (1989) report that house prices are positively correlated in the short run. Moreover, prices can be used to forecast excess returns.

[10] in the case of Bulgaria , Czech Republic , Poland and the UK there are not market based property taxes and the rest of the countries do not have property taxes at all, only land tax.
[11] Depreciation and maintenance are fixed by the assumption of the econometric model so they do not affect the volatility of the user cost.
[12] One can compare the graph of the expected gain in Fig. 2 in Appendix3 and the graph of user cost in Fig. 3 (appendix 3) and notice the striking resemblance. Notice that the expected gain enters in the user cost equation with a negative sign.

In addition to this, and given the context of the six selected countries, the economic development of a country might determine how expectations are formed and in turn, this can influence the perception about future price behavior. To continue, it makes a difference whether the country is a developing country (like Bulgaria before EU accession and even nowadays given that it takes time to adjust to the EU standards and therefore there is a transition period when prices are expected to rise in order to reach EU level) or an already mature economy (like the UK, where prices are rising less rapidly as opposed to Lithuania, Estonia and Bulgaria).

Moving on from the rational expectations assumption, another possible cause for failing to prove that the arbitrage relation works is the no risk and uncertainty assumption. Even if mathematically the model might be proved correct, in fact, when it is being tested, actual price data (coming from banks that sell mortgages or from real estate agencies) is used and this already contains the risk component. Hence, from the very beginning there is an upward bias in the prices used for estimations and this might explain why the user cost calculated according the theory does not actually explain much of the net change in prices.

To continue, the transaction costs between owning and renting might be an obstacle to the realization of the arbitrage. One can switch from owning to renting relatively easily while the opposite is not necessarily true due to transaction costs like: duty stamps and taxes on capital gains stemming from the resale of real estate property. So, in order to exploit the benefits of arbitrage, one should be able, in the context of this paper, to buy and sell residential properties each quarter and to move in and out of a rented apartment each quarter, given that in my calculations I used actual rent [13] and not imputed rent[14]. However, transaction cost like the one mentioned above can prevent a person from buying and selling a house frequently.

Another factor that can add information to the arbitrage relationship discussed in the present paper is credit availability. It is true that interest rate, which is already accounted for in my regressions, could be a proxy for credit availability, taking into consideration that higher interest rates might express little credit availability and vice versa. However, the magnitude of interest rate is not a straightforward indicator of the supply of credit, in the sense that high nominal interest rates can be caused by a high inflation rate. Having said this, a more direct measure of credit availability could explain to a certain extent the short run dynamics of house prices.

Finally, recent literature has emphasized the importance of another factor: seasonality (Terneyro, 2007). This might be, in fact one of the plausible reasons for which the data used in this paper does not support the theory. Adopting the method suggested by (Terneyro, 2007), which is to run a regression on quarterly seasonal dummies on price growth in the current quarter, I find that there is seasonality in Lithuania, Bulgaria and the UK. More exactly, in the UK's case the prices are rising in the first quarter as compared to the base period, the fourth quarter. In Lithuania, prices are declining in the second quarter in comparison with the base period, the fourth quarter. Last but not least, in Bulgaria prices are rising in the first three quarters when compared to the base period, which the fourth quarter of the year . In Appendix 5 I will present in detail the methodology used for the investigation of seasonality.

[13] The actual rent is the amount of money paid when renting an apartment.
[14] The imputed rent is the amount of money for which a homeowner would rent his/her apartment where he/she is currently living.

Conclusions

This paper investigates the short run house price dynamics suggested by Poterba (1984). More exactly, I am testing whether the house price fundamentals fully explain the house price dynamics. The topic is important given that for many people a house acquisition is one of the most important expenditures that they make in their lifetime.

The countries subjected to analysis are: Bulgaria, Czech Republic, Estonia, Lithuania, Poland and the UK. They are diverse from the point of view of economic development, the UK being the most developed and Bulgaria the least developed. Apart from the UK, the rest of countries have a somehow similar historical background, since they are former communist countries. This diversity allows me to make interesting inferences with respect to the house price dynamics, rents, user costs and expected future gains. Among the trends we can notice inspecting the data, the price and rent index give valuable information about he house price dynamics. Prices seem to be increasing very fast in Estonia, Lithuania and Bulgaria which determines an upward trend on the expected gain. Of all the countries, the UK and Czech Republic are standing out of the crowd since the user costs are increasing and expected gain is decreasing. Rents are augmenting steadily in Estonia and Lithuania, which in combination with the fast escalating prices, drives the price to rent ratio up faster than in the rest of the countries.

In terms of methodology, I form four different panels and employ two models in order to test the theoretical findings of Poterba (1984). The first model is simply the arbitrage equation rewritten: in equilibrium, the price to rent ratio equals the inverse of the user cost. Model 2 tests for backward looking behavior, because the panels become dynamic ones, since I add the first lag of the dependent variable. The econometric method used in the regressions is two stage least squares since I wish to account for measurement error and omitted variable bias. Overall, I find the data does not support the theory and that people do not form rational expectations. They rather for adaptive expectations since current price to rent ratios can be explained by past price to rent ratios. Also, the way in which people are assumed to form expectations is very important since the expected gain is part of the user cost and it seems to have a great impact on it: whenever the expected gain goes down, the user cost goes up and the opposite. Moreover, the expected gain is one of the most volatile components of the user costs. Among the reasons for which the arbitrage equation does not work, I investigate more thoroughly the case of seasonality and find that indeed, there si seasonality in Bulgaria, Lithuania and the UK.

However, there are issues which can be further investigated. The property tax was not included in the model because none of the countries has a market based property tax, as it appears in the arbitrage equation. Thus, we need to accommodate the reality to the theory by considering also the case in which property tax does not represent a percentage of the market value of the house. Also, in the Eastern European countries data limitations proved significant, but future papers can benefit of greater data availability. Last but not least, for more precision, one could employ micro data instead of macro aggregated data as it is the case for the house price variable and income taxation variable.

To conclude, the housing market is always a topic worth looking into, given that houses are directly connected to our daily lives, but also because the house price behavior gives light on how people form expectations. My thesis proved that people form adaptive expectations and therefore, that they have a backward looking behavior.

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Appendix 1- Derivations

a) If $I_{t2005} = \frac{I_t}{I_{2005}}$, then $I_{t2001} = \frac{I_{t2005}}{I_{j2005}}$, where j=2001 and t is the current value

Proof:

$$I_{t2001} = \frac{I_t}{I_{2001}} = \frac{I_t}{I_{2005}} \times \frac{I_{2005}}{I_{2001}} = \frac{I_{t2005}}{I_{j2005}}$$

b) We denote by P the price index.

$$I_{t2001real} = \frac{P_{tnominal}}{HICP_t} \times \frac{HICP_{2001}}{P_{2001nominal}} = P_{t2001nominal} \times \frac{HICP_{2001}}{HICP_t},$$

where $I_{t2001real}$ is the real price index with year base 2001, $P_{tnominal}$ is nominal price in period t and t=2000,..,2006

c) Expected gain is calculated as it follows:

$$gain^e = \frac{I_{t+1,2001} - I_{t,2001}}{I_{t,2001}} = \frac{\frac{P_{t+1}}{P_{2001}} - \frac{P_t}{P_{2001}}}{\frac{P_t}{P_{2001}}} = \frac{P_{t+1} - P_t}{P_t},$$

where I_{t2001} is the real price index in current period with 2001 as base year.

Appendix 2- Definitions

HICP= Harmonized Consumer Price Index, montlhy, 2000-2006, Eurostat

Maintenance and repairs index = monthly , 2000-2006 , Eurostat

Rent index = montlhy, 2000-2006, Eurostat

Long term government bond yield = Bulgaria 2000q1-2006q4,Czech Republic 2000q2-2006q4, Estonia 2000q1-2006q4, Lithuania 2001q1-2006q4, Poland 2001q1-2006q4, the UK 2000q1-2006q1, the UK 2000m01-2006m12

nominal price index = Bulgaria 2000q1-2006q4, Czech Republic 2000q1-2006q4, Estonia 2000q1-2006q3, Lithuania 2000q1-2006q3, Poland 2000q1-2006q3 .The price data is used by Egert B. And Dubravko Mihaljek in "Determinants of House Prices in Central and Eastern Europe", BIS working paper no. 236, found at the web address http://www.bis.org/publ/work236.pdf?noframes=1.

Nominal prices in national currency = the UK 2000q1-2006q4 and 2000m01-2006m12, Nationwide

Income tax for a married couple with no children earning 100% of the average wage = annual data 2000-2006, Eurostat

real GDP growth rate = annual 1998-2007, Eurostat

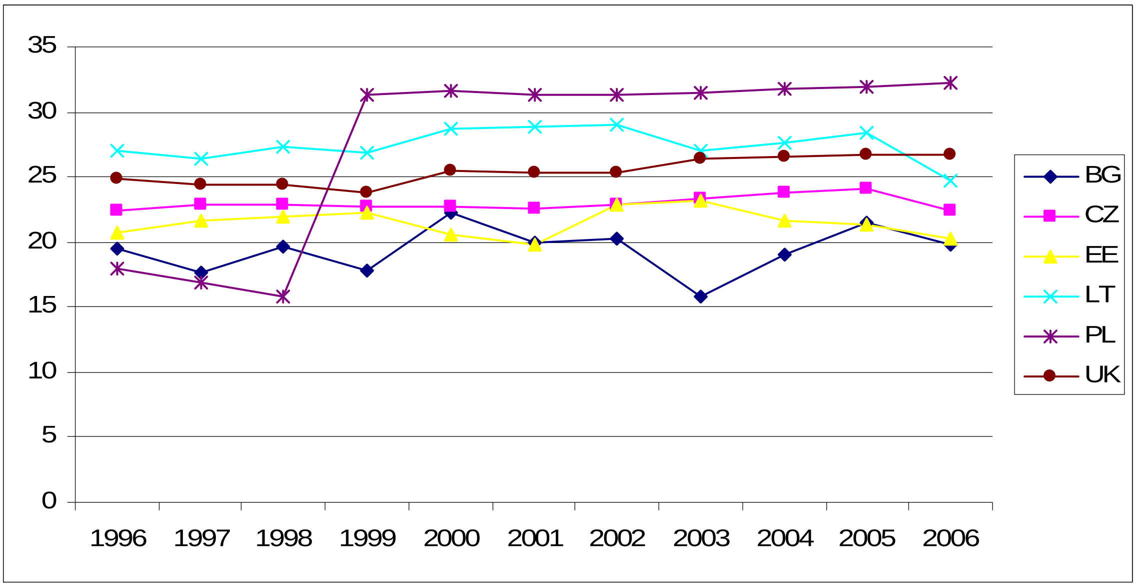
labour productivity per person employed = expressed as GDP in Purchasing Power Standards (PPS) per person employed relative to EU-27 (EU-27 = 100), annual 1997-2007, Eurostat

Compensation of employees at current prices = annual 1998-2007 , Eurostat

Households expenditure (the domestic concept) per capita PPS = annual, Bulgaria 1997-2005, the rest of the countries 1997-2006, Eurostat

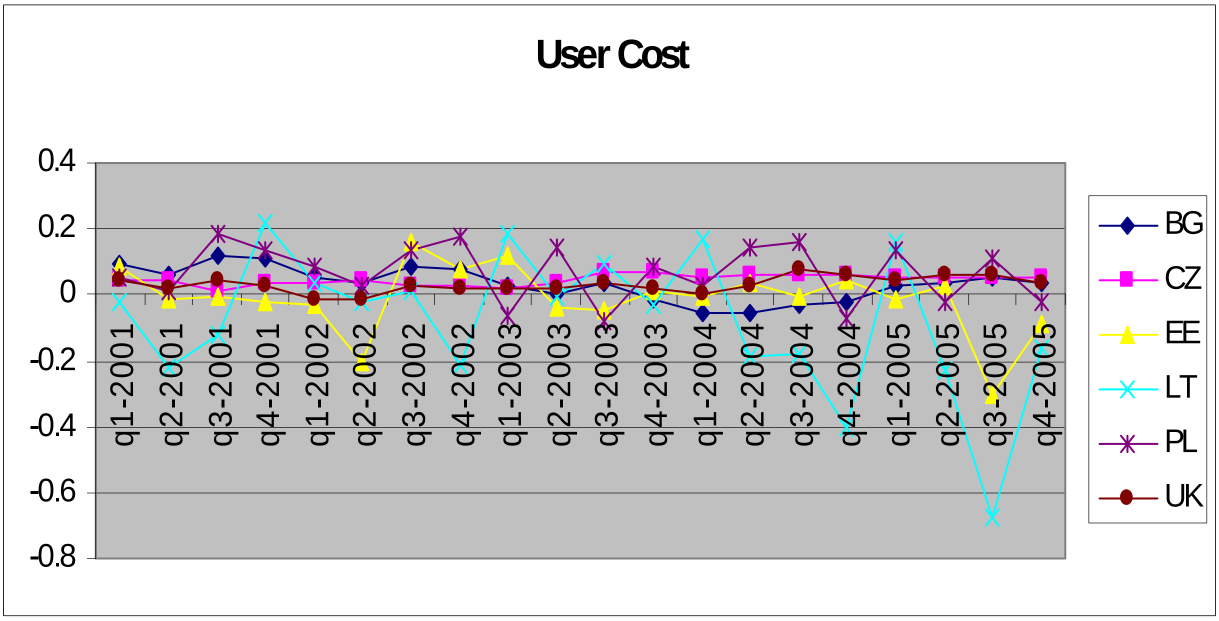
Appendix 3 – Graphs

Figure 6: Income tax for married couple with no children



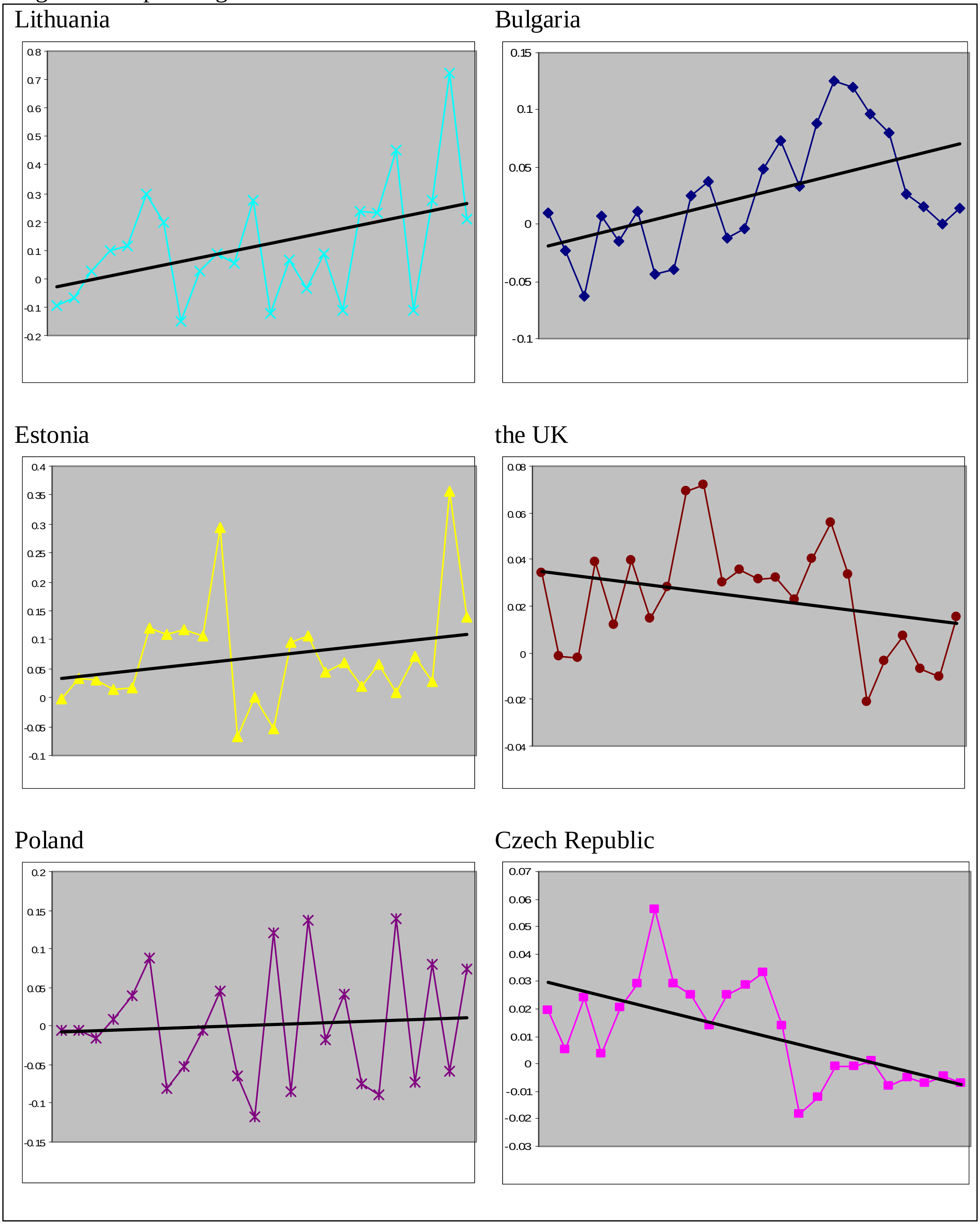
Source:Eurostat

Figure 7- User Cost



Source: Author's calculations

Figure 8- Expected gain



Source: Author's calculations

Appendix 4- Tables

Table 1

	Indicator	*Model 1*		*Model 2*	
		within -TSLS	FGLS-TSLS	within-TSLS	FGLS-TSLS
all countries	*ucratio*	-0.015567 (-0.043198)	-0.14181 (0.077373)*	-0.00264 -0.420756	-0.004544 (-0.002193)**
	prratio	-	- -	1.03538 (0.036547)**	1.056732 (0.020829)**
	R- squared	0.424778	-1.107641	0.935155	0.981903
	No Obs	127	127	127	127
	DW-statistic	0.691592	1.78632	1.893752	1.818977
All without the UK	*ucratio*	-0.00725 (-0.007029)	-0.178934 (0.092636)*	0.006075 (0.00365)**	-0.003206 -0.014704
	prratio	-	-	1.043631 (0.041794)**	1.052078 (0.035939)**
	R- squared	0.532615	0.389049	0.935119	0.991317
	No Obs	102	102	102	102
	DW-statistic	0.173039	0.134469	1.899494	1.794326
Baltics	*ucratio*	-0.003403 (-0.00252)	-0.011711 (0.006332)*	0.00623 (0.002946)**	0.005526 0.004926
	prratio	-	-	1.057908 (0.041803)**	1.051487 (0.043516)**
	R- squared	0.006041	0.5975	0.826859	0.829108
	No Obs	40	40	40	40
	DW-statistic	0.206951	0.294834	1.947234	1.899327
Baltics and Bulgaria	*ucratio*	-0.002627 (-0.001637)	-0.012692 (0.007419)*	0.006808 (0.003034)**	-0.031718 (0.017816)*
	prratio	-	-	1.047506 (0.040841)**	0.986199 (0.039039)**
	R- squared	0.415715	0.097711	0.906424	0.833204
	No Obs	63	63	63	63
	DW-statistic	0.184907	0.15505	1.840968	1.998055

Source: Author's calculations

Table 2

	Indicator	*Model 1*		*Model 2*	
		within -TSLS	FGLS-TSLS	within-TSLS	FGLS-TSLS
all countries	*ucratio*	-0.015567 (-0.043198)	-0.14181 (0.077373)*	-0.00264 -0.420756	-0.004544 (-0.002193)**
	prratio	-	- -	1.03538 (0.036547)**	1.056732 (0.020829)**
	R- squared	0.424778	-1.107641	0.935155	0.981903
	No Obs	127	127	127	127
	DW-statistic	0.691592	1.78632	1.893752	1.818977
All without the UK	*ucratio*	-0.00725 (-0.007029)	-0.178934 (0.092636)*	0.006075 (0.00365)**	-0.003206 -0.014704
	prratio	-	-	1.043631 (0.041794)**	1.052078 (0.035939)**
	R- squared	0.532615	0.389049	0.935119	0.991317
	No Obs	102	102	102	102
	DW-statistic	0.173039	0.134469	1.899494	1.794326
Baltics	*ucratio*	-0.003403 (-0.00252)	-0.011711 (0.006332)*	0.00623 (0.002946)**	0.005526 0.004926
	prratio	-	-	1.057908 (0.041803)**	1.051487 (0.043516)**
	R- squared	0.006041	0.5975	0.826859	0.829108
	No Obs	40	40	40	40
	DW-statistic	0.206951	0.294834	1.947234	1.899327
Baltics and Bulgaria	*ucratio*	-0.002627 (-0.001637)	-0.012692 (0.007419)*	-0.000241 (-0.137113)	-0.001963 (0.000917)**
	prratio	-	-	1.044384 (0.040291)**	1.050233 (0.033869)**
	R- squared	0.415715	0.097711	0.913824	0.340767
	No Obs	63	63	63	63
	DW-statistic	0.184907	0.15505	1.822968	1.422565

Source: Author's calculations

Table 3:Descriptive statistics

Indicator	All countries			All without the UK		
	UC	PRRATIO	UCRATIO	UC	PRRATIO	UCRATIO
Mean	0.020502	1.309914	1.15117	0.017184	1.321907	0.072702
Median	0.037218	1.107527	0.811516	0.037672	1.096172	0.731328
Maximum	0.218448	3.265671	124.5951	0.218448	3.265671	18.3994
Minimum	-0.67758	0.730915	-43.1045	-0.67758	0.730915	-43.1045
Std. Dev.	0.109833	0.466361	11.72946	0.1215	0.509683	5.368671
Observations	136	136	136	110	110	110
Indicator	**Baltics**			**Baltics and Bulgaria**		
	UC	PRRATIO	UCRATIO	UC	PRRATIO	UCRATIO
Mean	-0.03668	1.779545	-1.44289	-0.0082	1.542789	-0.4294
Median	-0.00821	1.80857	0.113012	0.023847	1.520308	0.558976
Maximum	0.218448	3.265671	11.82815	0.218448	3.265671	18.3994
Minimum	-0.67758	1	-43.1045	-0.67758	0.814768	-43.1045
Std. Dev.	0.167926	0.512666	7.658595	0.142831	0.540621	6.760978
Observations	43	43	43	67	67	67

Appendix 5.Seasonality

In what follows I investigate the issue of seasonality in the 6 countries by running a regression of quarterly seasonal dummies on quarterly price growth. The base period of the dummies is the fourth quarter of the year. So, my baseline regression is:

Model 1 : $pricegr_t = a_1 + a_2 * S_1 + a_3 * S_2 + a_4 * S_3 + error_t$, where

$pricegr_t$ =quarterly price growth in period t from period t-1

S_1 = spring dummy

S_2 =summer dummy

S_3 = autumn dummy

$error_t$ = error term in period t

Initially, I run the regression using OLS and the diagnostic tests allow me to make inferences only in the case of Estonia and Lithuania because the regressions do not exhibit serial correlation (according to Breusch Pagan test for serial correlation, until the fourth lag), nor heteroskedasticity (I use White standard errors) and the normality assumption is fulfilled. The results of the regression are those in Table 1 :

Table 4: Seasonality - dependent variable *pricegr*, OLS

	Bulgaria	Czech Republic	Estonia	Lithuania	Poland	the UK
s1	0.022152 (-0.030975)	-0.008211 (-0.013335)	-0.044714 -0.062814	-0.009756 (-0.058487)	0.034573 (-0.050795)	0.020014 (0.009693)*
s2	0.029997 (-0.029252)	0.001395 (-0.012516)	(-0.066262) 0.062448	-0.11182 (0.050333)*	0.0488 (-0.043556)	0.024783 (0.011613)**
s3	0.036781 (-0.031136)	-0.004985 (-0.012094)	(-0.0000347) 0.071813	(-0.003041) 0.061209	0.036981 (-0.046545)	0.019517 (-0.012501)
DW statistic	0.378781	0.52898	1.816183	1.525135	2.995822	0.767197

Note: * 5% significance level
** 10% significance level. White standard errors are reported in parenthesis.

For the rest of the of the countries (Bulgaria, Czech Republic, Poland and the UK) I take care of the serial correlation by taking differences of the *pricegr* and running OLS. This solves the problem only for Bulgaria, Czech Republic and the UK. My second regression is as follows:

Model 2: $D(pricegr_t) = a_1 + a_2 * S_1 + a_3 * S_2 + a_4 * S_3 + error_t$, where

$D(pricegr_t)$ =the first difference of price growth in period t

S_1 = spring dummy

S_2 =summer dummy

S_3 = autumn dummy

$error_t$ = error term in period t

I obtain the results in Table 2:

Table 5:Seasonality- dependent variable d(*pricegr*), OLS

Indicator	Bulgaria	Czech Republic	Poland	the UK
s1	0.058933 (0.014954)**	-0.013196 (-0.010046)	-	0.039696 (0.039696)**
s2	0.048285 (0.020175)**	-0.00123 (-0.009175)	-	0.023726 (0.012649)*
s3	0.038547 (0.01133)**	-0.011365 (-0.009431)	-	0.014252 (-0.011399)
DW	1.879351	2.0081		2.180426

Note: ** 5% significance level
*10% significance level
White standard errors are reported in parenthesis.

In *Model 2*, the estimation for Poland still suffers from serial correlation so I try a different method. The model of my regression becomes:

Model 3: $pricegr_t = a_1 + a_2 * S_1 + a_3 * S_2 + a_4 * S_3 + pricegr_{t-1} + error_t$, where

$pricegr_t$ = quarterly price growth in period t from period t-1

$pricegr_{t-1}$ = the first lag of *pricegr*

S_1 = spring dummy

S_2 =summer dummy

S_3 = autumn dummy

$error_t$ = error term in period t

I estimate this model using two stage least squares because I assume that $pricegr_{t-1}$ is endogenous so I instrument it by its second lag. The second lag of *pricegr* is a valid instrument because it is correlated with $pricegr_{t-1}$. Also, I have to assume that it is uncorrelated with the error term. The rest of the instruments are the exogenous variables: the constant and seasonal dummies. Finally, this estimation method is successful and the diagnostic tests allow me to make a statistical inference. The results of *Model 3* are in Table 3:

Table 6: Seasonality- dependent variable *pricegr*, TSLS

s1	s2	s3	Pricegr t-1	DW
0.015279	0.045445	0.048608	-0.52173	2.03034
(-0.054591)	(-0.037362)	(-0.039307)	(-0.356698)	

Note: White standard errors are reported in parenthesis.

To conclude, my estimations reveal the presence of seasonality in Lithuania, Bulgaria and the UK which according to Teynero might impede on the successful realization of the arbitrage equation suggested by Poterba, because the existence of seasonality indicates that prices fail to adjust according to the dynamics of supply and demand, this consisting in a “price puzzle”(Teynero, 2007).