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CROATIAN NATIONAL BANK

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Abstract

Due to the significant impact that real estate prices may have on overall economic developments, it is necessary to create a reliable index for monitoring the movements of real estate prices. This paper presents the hedonic method, which enables the creation of a real estate price index that in addition to the price takes into account the characteristics of real estate and provides for the estimation of *pure* change in the price of residential real estate between two points in time. This paper also strives to answer several interesting questions such as: has the sharp increase of real estate prices resulted in the purchase of smaller dwellings, how has the growth of real estate prices affected real demand for housing loans and can databases containing the asking prices of real estate be used to create a reliable real estate price index? This paper also indicates the possibility of the estimated regression model being used in the creation of an expert system for assessment of real estate prices of known characteristics.

JEL: D11, C43, R31

Keywords: hedonic index, real estate price index, real estate market

Contents

1 Introduction

Awareness of the importance of the close monitoring of developments in the real estate market has grown over the years in line with the realisation of the impact such movements can have on overall economic developments. Particular stress is placed on the importance of appropriate monitoring of movements in the prices of residential real estate. Residential real estate makes up a major share of households' assets, with expenses relating to housing costs (rent costs and repayment of housing loans) accounting for a substantial share of the overall expenses of households. Accordingly, changes in the prices of residential real estate, rent and interest rates on housing loans greatly affect movements in asset value and in the income and expenditures of households, and thus the movement of aggregate demand and inflation. Prices of residential real estate are susceptible to changes in interest rates, i.e. to changes in the degree to which the monetary policy is restrictive, or expansionary, and can thus affect the monetary policy transmission mechanism. In addition, rent prices should be closely monitored because they have a direct impact on the movement of consumer price inflation since rent prices are included in the basket for the calculation of the consumer price index. Analyses in mature market economies have shown that sizeable fluctuations in the prices of residential real estate affect financial and business cycles, as well as financial stability.

Reliable data are one of the preconditions for appropriate analysis of developments in the real estate market. Real estate price statistics in Croatia are underdeveloped and available statistical data regarding this area need to be improved. However, it should be borne in mind that the calculation of a real estate price index is not an easy endeavour, which is made additionally difficult by the very characteristics of the real estate market. There are more methodological problems in the calculation of the real estate price indices than in the calculation of the majority of other price indices. The main reason for this is that it is impossible to monitor the movement of the price of a housing unit on a continuous basis. A real estate price index should indicate the change in the price of residential real estate of unchanged quality at a given location. Residential real estate, however, is very heterogeneous in terms of size and qualitative and locational characteristics. Therefore, the principle of *pure* price comparison is very difficult to meet in the calculation of a real estate price index. In addition, the price of real estate cannot be determined unless the real estate is sold, because the price is usually determined in the course of negotiations or at auctions, while the price at which it is advertised is not necessarily an adequate indicator of its final selling price. An additional difficulty is that real estate is not sold very often.

One of the methods recommended for the calculation of real estate price indices is hedonic regression. The main objective of this paper is to create a real estate price index using the hedonic method, which enables the assessment of the *pure* price change of real estate at two points in time, that is, purified of the effects of price changes arising from changes in the qualitative and locational characteristics of real estate sold within a relevant period compared with the previous period. A

brief overview of the characteristics of the real estate market in Croatia and of key factors affecting the supply and demand, and thus the movement of real estate prices, is given at the beginning of the paper. The paper goes on to present the main characteristics of the hedonic method for calculating the real estate price index. It demonstrates how the real estate price index of real estate of known characteristics is calculated by using one variant of the hedonic method. Finally, annual price indexes are calculated for four geographically identified real estate sub-markets or *regions*, the City of Zagreb, the Adriatic Coast, Other-urban, Other-rural, which the authors assessed as being characterised by the minimum required homogeneity of real estate characteristics. The *regional* indices are then aggregated to calculate the hedonic real estate price index for Croatia.

In addition to the calculation of the real estate price index, this paper strives to answer several interesting questions:

1 How has the rise in real estate prices affected the average floor space of purchased real estate?

2 How has the rise in real estate prices affected real demand for housing loans?

3 How has the difference between asking and achieved prices of real estate been distributed? This is important for verifying the potential usefulness of real estate databases that register only asking prices, such as data from the press, data from commercial agents, and so on.

Finally, an answer is provided to the following question:

4 Can elements of the analysis carried out in this paper be used for the creation of an expert system for calculating the prices of real estate of known characteristics? There would be a wide scope for the application of such a system: bank supervision, tax administration, etc.

2 Real Estate Market in Croatia

The real estate market in Croatia has been growing more active. It may be noticed that dwelling construction has been recovering, that housing loans play a huge role in the growth of bank placements and that real estate prices are growing. Further in this paper we will strive to describe some of the more important characteristics of the Croatian real estate market and the key factors affecting changes in real estate supply and demand, and thus the movement of real estate prices.

The real estate market in Croatia[1] started developing more rapidly in the mid 1990s after the end of the Homeland War, with the restructuring of ownership relationships and the more intensive sale of dwellings occupied by holders of tenancy rights[2] paving the way. The sale of state-owned dwellings under favourable conditions resulted in there being a large share of privately owned dwellings as compared

1 For more details on the characteristics of the real estate market in Croatia see Bežovan (2004), Tica (2002) and Mihaljek (2005).

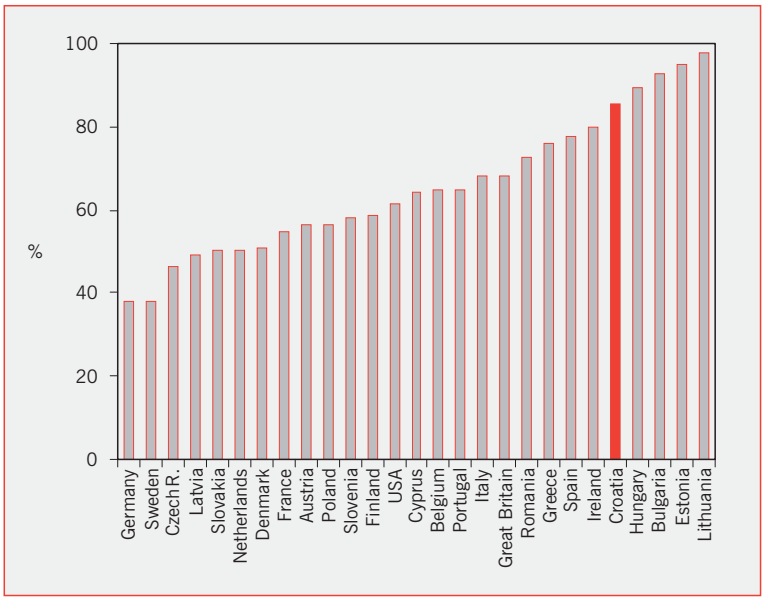
2 By end-2005, 318,011 dwellings were sold to holders of tenancy rights (Statistical Yearbook 2006).

to the overall number of dwellings. According to the 2001 census, 96% of the total of 1.4 million permanently occupied dwellings were owned by households and 86% were owner-occupied. Data for certain Central and Eastern European Countries also indicate relatively high owner occupancy (Figure 1), with Lithuania, Estonia, Bulgaria and Hungary leading the way. In contrast, in most developed countries, as well as in some new EU members, like the Czech Republic, Latvia, Slovakia and Poland, the share of owner-occupied dwellings is much smaller.

The importance of this indicator lies in its reflection of the intensity of the possible impact of changes in real estate prices on the wealth and income of households. The growth of real estate prices increases the wealth of real estate owners, enabling them to use real estate as collateral for additional borrowing, i.e. a rise in consumption. Accordingly, the considerable portion of dwellings that are privately owned in Croatia indicates the real possibility of movements in the real estate market spilling over to household borrowing and consumption.

Before discussing the basic characteristics of the real estate market in Croatia one should review the available data on real estate supply. According to the 2001 census, the number of households in Croatia was higher than the number of occupied dwellings, indicating a shortage.[3] At the same time, however, there were

Figure 1 Share of Owner-occupied Dwellings



Note: Data for Sweden refer to 1990, data for Slovakia, Belgium, Portugal, Italy, Romania, Greece and Spain refer to 1991, data for Cyprus refer to 1992, data for Poland, Slovenia, Great Britain and Hungary refer to 1996, data for Germany, the Czech Republic, Latvia and Bulgaria refer to 1998, data for France and the USA to 1999, data for the Netherlands, Denmark, Austria, Finland, Estonia and Lithuania refer to 2000, while data for Ireland and Croatia refer to 2001.
Source: CBS, *Statistical Yearbook 2005*.

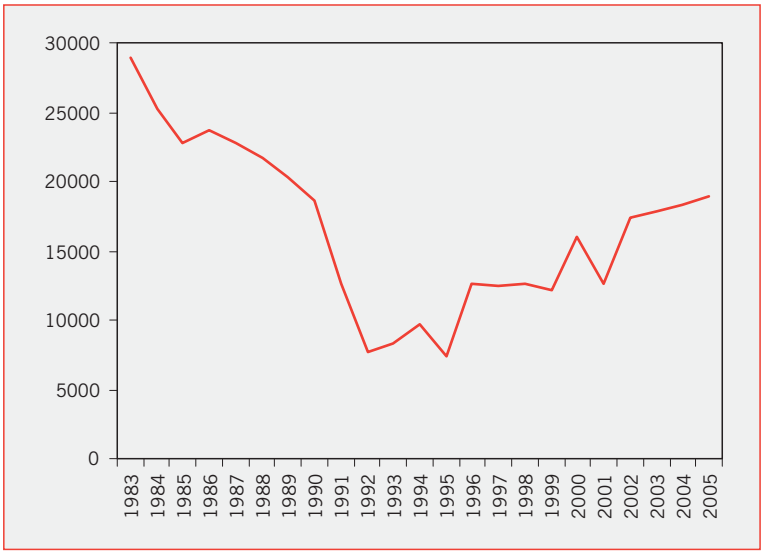
3 In 2001, there were 1,477,377 households, 1,421,623 occupied dwellings (reflecting the fact that 55,754 households had no dwelling) and 196,633 temporarily unoccupied dwellings.

many more temporarily unoccupied dwellings,[4] which gives a different image of the supply of residential real estate. If we were to include temporarily unoccupied dwellings in the supply of dwellings in the market, the number of available dwellings would be higher than the number of households.

The number of residential real estate units was partly affected by the Homeland War,[5] during which, understandably, construction of residential real estate (Figure 2) was weak and limited to areas not affected by the war. Construction of dwellings recovered in the second half of 1990s, following the reconstruction of the demolished housing stock. The construction of dwellings has further intensified in the past few years, partly thanks to the housing policy which aims to solve the housing needs of Croatian citizens through the model[6] of publicly subsidised residential construction (POS[7]) but also due to the increasing interest of private entrepreneurs who recognised the profit-making opportunities in this segment. The latest available data indicate a much higher number of completed dwellings in Croatia in 2005 in comparison with the mid 1990s but still below the figures from early 1980s.

In order to obtain the best possible overview of the situation in the construction of dwellings, it is useful to compare the data available with the relevant data for other countries. Accordng to the average number of completed dwellings per

Figure 2 Completed Dwellings for Permanent Residence



Source: CBS, *Statistical Yearbook 2007*.

4 Temporarily unoccupied dwellings are new, still not occupied dwellings, or dwellings that have been vacated for reasons of relocation or construction works, dwellings that are temporarily unoccupied because they are intended to be sold or let out and dwellings of households that live in another dwelling or at another address, or in another settlement, while the dwelling is temporarily not used or let out.

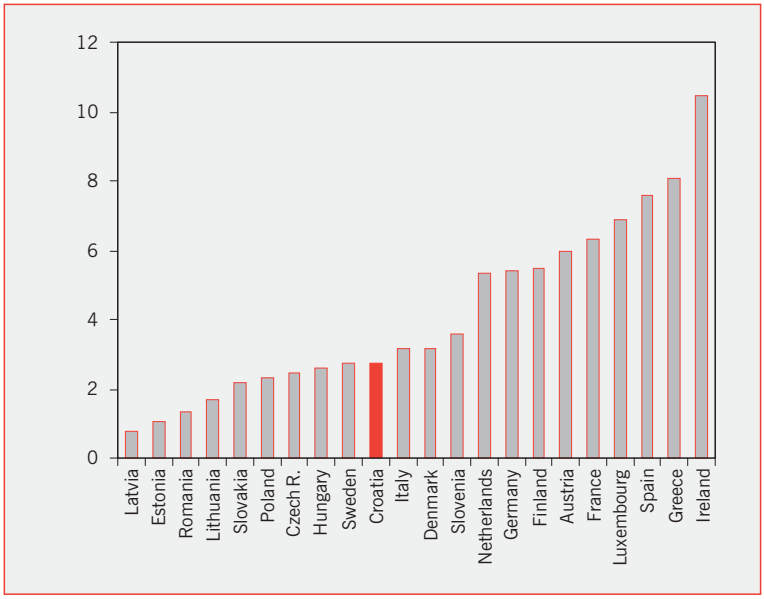
5 In the period between 1991 and 1998, over 22 thousand of dwellings were demolished (Statistical Yearbook 1997, Statistical Yearbook 2000).

6 For more details on housing finance models in Croatia see Tepuš (2004).

7 Applied as of 11 November 2001, following the adoption of the Act on Subsidised Residential Construction (Official Gazette 109/2001).

one thousand inhabitants (Figure 3) Croatia is placed in the middle of a group of selected countries, lagging behind the old EU members. Nevertheless, construction of dwellings is more vigorous in Croatia than in many new EU member states. This rise becomes evident if we compare construction dynamics year by year. By the number of completed dwellings per 1000 inhabitants, Croatia took the last place among the group of new EU members from Central Europe (Slovenia, Hungary, the Czech Republic, Slovakia and Poland) in 1993, climbing to the third place in 1997, while in 2002 it built more dwellings than any of the mentioned countries. Croatia continues to lag behind the developed EU countries, although this difference decreased to a certain extent during the period under review.

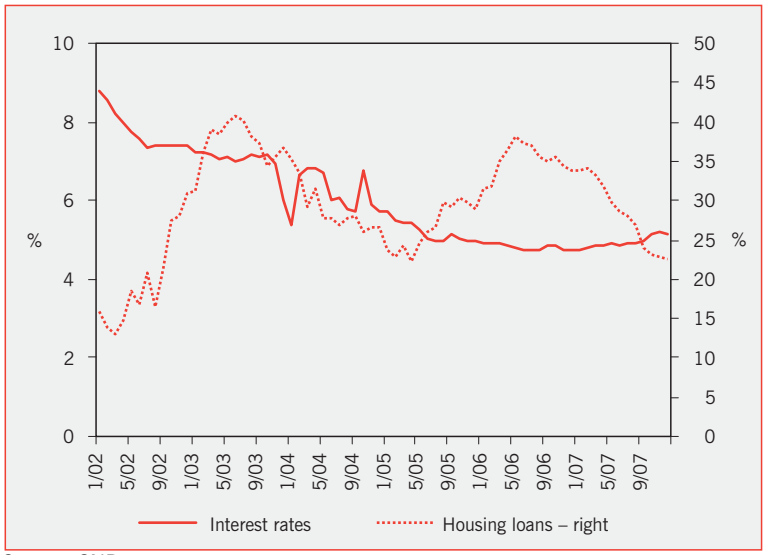
Figure 3 Number of Completed Dwellings per 1000 Inhabitants



Note: The figure was obtained as the average for 1993, 1997 and 2002, for which data were available, except for Italy, France, Luxembourg and Greece, for which only 1993 and 1997 data were available.
Sources: For Croatia, CBS; for other countries Annual Bulletin of Housing Statistics for Europe and North America 2004 (www.unece.org/hlm/prgm/hsstat/Bulletin_04.ht).

The growth of real estate supply has been accompanied by ever-stronger demand, strongly affected in turn by the terms and conditions under which banks grant loans, as banks are the main source of housing finance in Croatia. A relevant factor is that average interest on long-term foreign currency-indexed kuna loans to households fell from 11.0% in 1996 to 6.5% in 2007. Data on interest rates on housing loans to households have been available since 2002, when they averaged 7.8%. In 2006, they dropped to 4.8%, growing mildly ever since. In addition to the decline in interest rates, a favourable contribution to the demand for housing loans came from changes in other financing terms and conditions. Banks now rarely ask for guarantors, accept a wider range of possible instruments of collateral and approve housing loans with longer repayment periods.

Figure 4 Annual Rate of Change in Housing Loans and Interest Rates on Housing Loans



Source: CNB.

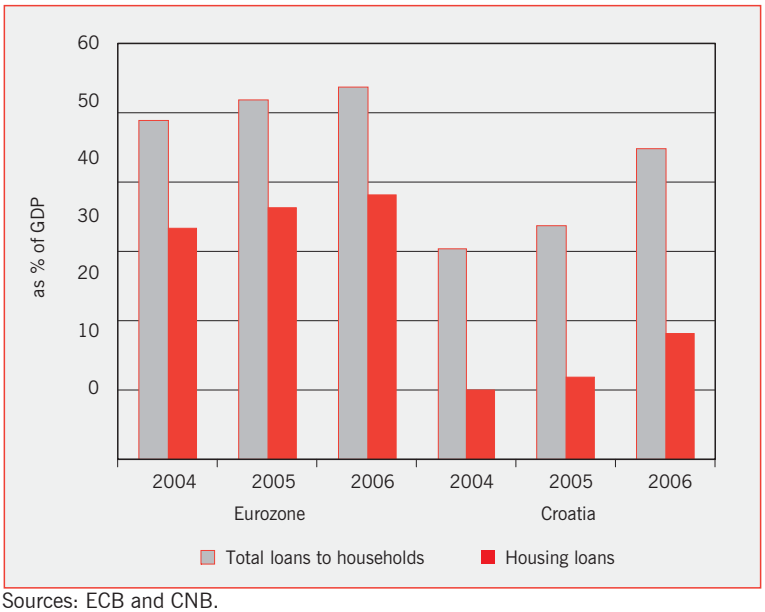
Due to the rise in real estate prices and increasingly more favourable terms and conditions under which housing loans are approved, the past few years have seen vigorous growth in the total amount of housing loans granted. Although their annual growth rate at the end of 2007 was lower than the annual growth rate at the end of 2006 (33.9% in December 2006 as compared to the 22.5% in December 2007), it remained high. The share of approved housing loans in the total amount of approved loans to households has been on the rise over the past few years, exceeding 40% at the end of 2007. Nevertheless, this share still remains much lower than in many developed countries. For comparison, housing loans make up over two thirds of total loans approved to households in the eurozone. It should also be noted that bank exposure to the risks of changes in real estate prices and other possible disturbances in the real estate market rises with the increase in the share of housing loans in total loans to households.

Although bank financing is the most frequent model of housing finance in Croatia, one more housing finance model is on the rise, that of borrowing from housing savings banks.[8] They make state-subsidised loans to savers for real estate purchase. Although the share of total housing savings banks' assets in the total banking sector assets is very low (totalling 1.9% at the end of 2007), the growth of housing savings banks' assets over the past years reflects a rise in their importance as a source of finance for the housing needs of Croatian households.

A relatively limited supply of residential real estate and increased availability of housing loans, paired with lower interest rates, are some of the factors that spurred

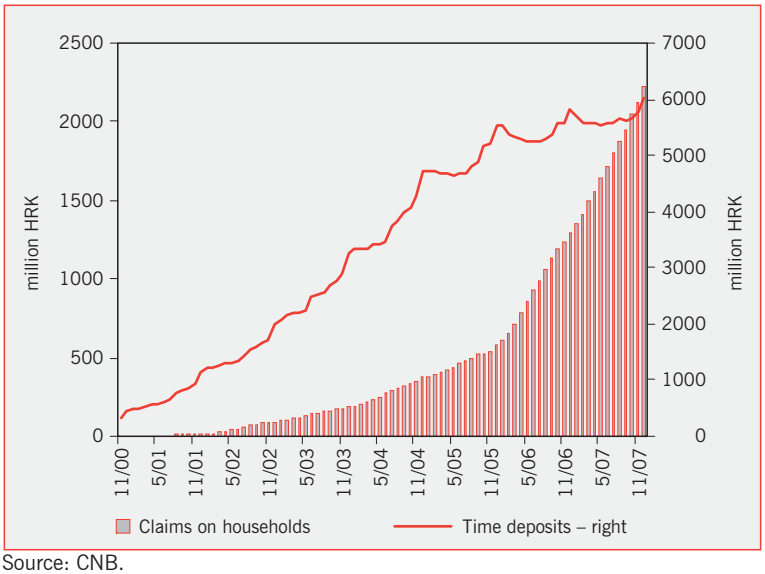
8 Housing savings banks became part of the Croatian financial system with the adoption of the Act on Housing Savings and State Incentive to Housing Savings that entered into force on 1 January 1998 (Official Gazette 109/1997). There are five housing savings banks currently operating in Croatia. According to end-2007 data, their total assets stood at HRK 6.4bn. As regards the structure of their sources of funds, the main source of funds of housing saving banks are time deposits, which together with interest, fees and other liabilities make up 95.6% of the total liabilities of housing savings banks.

Figure 5 Total Bank Loans to Households and Housing Loans



Sources: ECB and CNB.

Figure 6 Housing Savings Banks: Claims on Households and Time Deposits

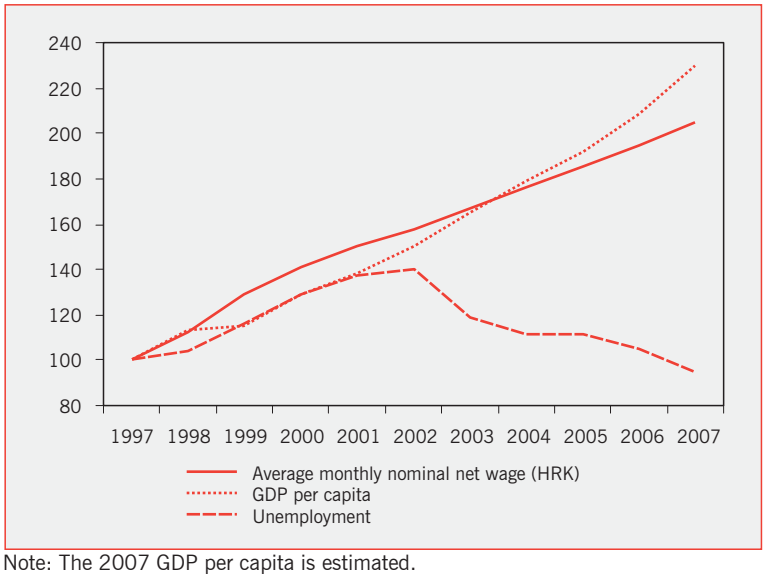


Source: CNB.

the rise of real estate prices in Croatia over the last few years. Of the factors on the demand side that contributed to the rise in real estate prices one should not forget the rise in the standard of living and decrease in unemployment. Nor should the influence of a favourable macroeconomic environment should be neglected, with continued economic growth, low inflation and relatively stable exchange rate over a years-long period supporting the optimistic outlook of households as regards their future income. One should also mention the rising interest of foreigners in the purchase of real estate in Croatia (especially on the Adriatic coast) and expectations of further growth of real estate prices, affected, among other things, by

Croatia's rapprochement to the EU and the alignment of its legislation with European standards.[9]

Figure 7 Indices of Nominal Net Wages, GDP Per Capita and Unemployment, 1997 = 100



Note: The 2007 GDP per capita is estimated.
Source: CBS.

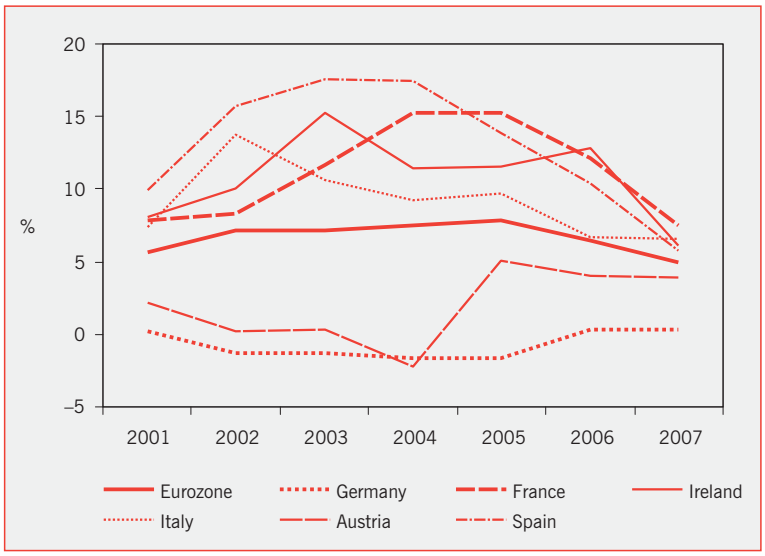
Unbalanced demographic movements and migration from less developed areas to larger regional centres as well as great concentration of the population, especially in the capital, created an imbalance in the supply of and demand for residential real estate. Housing policy in Croatia, subsidised housing savings and the development of the model of subsidised residential construction have been briefly discussed above, while it is noteworthy that a favourable contribution to the demand for real estate also comes from income tax benefits. Interest paid on housing loans and renovation expenses are recognised as expenses allowed for taxation purposes, while first time buyers are exempt from the real estate tax, fully or partially, depending on the size of the dwelling.

The Croatian real estate market is very dynamic when it comes to prices. According to the hedonic price index, the prices of real estate in Croatia rose by 85.9% in the period from 1997 to 2007, growing the most in the last four years. Although still high (9.1%), the annual growth rate of real estate prices in Croatia slowed down in the second half of 2007. This could partly be explained by the slowdown in the annual real growth rate of housing loans in Croatia in 2007, which is one of the indicators of a decrease in demand for real estate. At the same time,

9 As part of negotiations on the Stabilisation and Association Agreement Croatia undertook fully to open its real estate market to EU citizens within four years from the entry into force of the Agreement, which means in February 2009. Croatia will then permit natural persons who are nationals of the Member States of the European Union to buy real estate under the same conditions as Croatian nationals. Legal persons established in Croatia by non-residents have already been, when it comes to purchase real estate, ensured the same treatment as legal persons established by residents, which means they can purchase real estate in the Republic of Croatia without limitations.

there is a mild trend of rising interest rates on housing loans to households, to be attributed to the rising interest rates in Europe and strengthening of the monetary policy in Croatia. Similar movements of real estate prices have also been observed in other European countries. In the eurozone, prices of real estate went up by a total of 70.5% in the period from 1997 to 2006. Data indicate that following strong growth in the period from the mid 1990s to 2005 the growth rate declined in most countries of the eurozone in 2006 and especially in 2007. In 2007, the slowdown in the growth of real estate prices was most prominent in those countries that boasted the most vigorous growth rate over the several previous years, especially Ireland, Spain and France. Such movements were to a very great extent a consequence of the slowdown in the growth of demand for real estate in the eurozone, against the backdrop of rising interest rates on housing loans to households and a slowdown in the growth of mortgage loans in 2007.

Figure 8 Nominal Prices of Residential Real Estate in the Eurozone, annual rate of change



Note: Data for Germany and Spain refer to the entire 2007, while data for the eurozone, France, Ireland, Italy and Austria relate to the first half of 2007.
Source: ECB.

The growth of real estate prices raises the question of the impact of this growth on the ability of citizens to buy real estate. Real estate affordability is often shown by the ratio of the average price of one square meter of floor area to the average monthly nominal net wage, i.e. nominal GDP per capita. An increase in this ratio reflects a decrease in the real estate affordability ratio, and vice versa. The data in Table 1 indicate that (according to the affordability indicator 1) the indicator of real estate affordability in Croatia deteriorated in the past four years because the growth of the average nominal net wage lagged behind the growth of real estate prices. After three years of holding steady (from 2003 to 2005), the affordability indicator 2 deteriorated in 2006 because the growth of nominal GDP per capita also started lagging behind the growth of real estate prices.

Table 1 Indicator 1 and 2 of Real Estate Affordability in Croatia

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Affordability indicator 1	2.56	2.39	2.22	2.19	2.14	2.12	2.14	2.23	2.54	2.67
Affordability indicator 2	0.19	0.20	0.18	0.18	0.17	0.16	0.16	0.16	0.18	0.18

Note: The indicator of real estate affordability 1 is calculated as the ratio of the average price of one square meter of floor space (in euros) and the average monthly nominal wage (in euros), while the indicator of real estate affordability 2 is calculated as the ratio of the average price of square meter of floor space (in euros) and the nominal GDP per capita (in euros). Croatian GDP was adjusted for the estimated value of the grey economy based on Lovrinčević, Marić and Mikulić (2006), with the adjustment for the period from 2003 to 2007 being calculated using the amount of adjustment for 2002.
Sources: *Burza nekretnina*, CBS and CNB calculations.

However, these indicators do not take into account the influence of changes in interest rates, which fell substantially over the past several years. We calculated the degree to which such movements contributed to an increase in real estate affordability by estimating the average monthly repayment of a housing loan[10] obtained for the purchase of a dwelling of 50 square meters of floor area and putting it in relation to the average monthly nominal net wage. Table 2 indicates a reduction in this ratio in the period from 2003 to 2005, which means that the decrease in interest rates on housing loans lightened the loan repayment burden for dwellings of that size although the growth of real estate prices outstripped that of nominal monthly net wages in 2004 and 2005. In 2006, interest rates on housing loans stabilised at a relatively low level, which, paired with only a mild increase in monthly nominal net wages and rapid real growth of real estate prices, resulted in the deterioration of real estate affordability in Croatia. Real estate affordability continued decreasing in 2007 against the backdrop of growth of real estate prices faster than the growth of average monthly net wages and a mild rise in interest rates on housing loans to households.

Table 2 Indicator 3 of Real Estate Affordability in Croatia

	2002	2003	2004	2005	2006	2007
Affordability indicator 3	86.1	81.0	76.7	74.2	81.9	87.0

Note: The indicator of real estate affordability 3 is calculated as the ratio of the average monthly repayment of a housing loan for the purchase of 50 square meters of floor space and the average monthly nominal net wage.
Sources: CBS, Burza nekretnina and CNB calculations.

Finally, we may conclude that the real estate market in Croatia is developing at an increasingly faster rate although its development is accompanied by numerous difficulties, including problems with the regulation of market relations. Many real estate properties lack appropriate ownership documents, which hinders and reduces real estate trading. In addition, the state of the land registry slows down construction projects and sale and purchase of existing real estate, spurring non-compliance with the regulatory framework and building codes (unauthorised construction, etc.). Further, as the market developed, a large number of real estate agencies emerged, whose quality is questionable due to short experience in a rapidly developing mar-

10 Using end-of-period interest calculation and equivalent interest rate.

ket. In addition, until the adoption of the Agency in Real Estate Transactions Act[11] agency in real estate trading in Croatia was not regulated, there was no legal framework regulating the terms and conditions of trading, and the rights and obligations of participants in the real estate market. An additional problem of the real estate market is the often unsatisfying quality of dwellings. New dwellings often need reconstruction and additional works, which affects their prices and hinders sale and purchase. The situation is not much different for existing dwellings, which due to their age, poor quality and equipment, paired with prices that are often not much lower than those of new dwellings, have difficulties in finding new owners. Thus, it may be said that the mismatch between real estate prices and property characteristics is yet another problem of the Croatian real estate market.

3 Construction of a Hedonic Real Estate Price Index

Due to the significant impact that real estate prices may have on overall economic developments, it is necessary to create a reliable index for monitoring the movements of these prices. As already mentioned in the introduction, much greater problems arise when calculating the real estate price index than when calculating the majority of other indices. The main reason for this is that it is impossible to monitor the movement of a particular housing unit over time on a continuous basis.

The real estate price index should reflect the change in the price of residential real estate of unchanged quality at a given location, which means of fixed characteristics or attributes. However, residential real estate is very heterogeneous in terms of size and qualitative and locational characteristics so it is very hard to meet the principle of *pure* price comparison when calculating the real estate price index. Therefore, for successful monitoring of real estate price movements it is necessary to eliminate any biases in the data caused by the fact that, for example, many luxury real estate properties or houses with a view of the sea have been sold within a certain period, which means that the real estate needs to be adjusted for quality.

For monitoring real estate price movements, statistical offices around the world usually use indices which are based on average prices and medians of a square meter of floor space. One of the main advantages of indices based on average prices is simplicity, of both construction and interpretation, while one of their main shortcomings is the already mentioned problem of bias, which means the impossibility of adjustment for quality. Prices of a square meter of floor area of all real estate are equally included in the calculation regardless of the characteristics. The problem of adjustment for quality is also present in indices based on medians, although they are less susceptible to the influence of outliers due to the very definition of medians.

11 The Agency in Real Estate Transactions Act entered into force on 27 October 2007 (Official Gazette 107/2007).

The only method that enables the creation of an index that takes into account the characteristics of real estate is hedonic regression. We will use one of its variants to create the hedonic real estate price index (HREPI) for Croatia. Hedonic methods are based on the idea that certain product characteristics provide pleasure to the buyer and therefore it is necessary to determine the prices of those characteristics (attributes), the so-called implicit prices. After estimating implicit prices, the hedonic product price is derived as the sum of implicit prices of individual product characteristics. In the context of the real estate market, the goal is to express the benefits that the buyer derives, for example, from the floor area of a housing unit, balcony or a certain location in a given city. Further, by comparing implicit prices of characteristic we can investigate buyer preferences more closely. We can, for example, obtain answers to the following questions: how important is it to the buyer that the dwelling is situated in a particular part of the city or does he/she care about the type of the dwelling (dwelling in a block or condominium, dwelling in a house, etc.). The problem is how to formalise this intuitive idea, that is, how to describe the relationship between the price of certain real properties and accompanying characteristics in a function. In addition to the earlier mentioned advantages as compared with traditional methods of price index calculation, the shortcomings of hedonic methods are their relative technical complexity, interpretation difficulties and above all the fact that successful application of such an index requires a database that next to prices includes the characteristics of real estate, which is not common.

3.1 Hedonic Model to Calculate a Real Estate Price Index

In this section of the paper we will shortly describe the model which serves as basis for all calculations in this analysis. Let us assume that we have at our disposal a database containing data for N transactions during the period T (half of a year or a year). If p_{it}, $i = 1,..., N$ are the achieved prices of real estate and i m_i is the corresponding floor area expressed in square meters. Further, locational and qualitative characteristics are known for all real estate sold X_j, $j = 1,..., l$. Finally, information is required on the period in which the transaction was carried out. Then we assume the following dependence of the price of real estate and related characteristics:

$$\ln p_{it} = \alpha + \beta \ln m_i + \sum_{j=2}^{T} \delta_j D_{ij} + \sum_{j=1}^{l} \gamma_j X_{ij} + \varepsilon_i, \quad i = 1,..., N \tag{1}$$

where α and β are real constants, D_j, $j = 1,..., T$ are time dummy variables where $D_{ij} = 1$ if the i th real estate has been sold during the period j, and $D_{ij} = 0$ u in other cases. Further, δ_j and γ_j are regression coefficients, and ε_i random error (white noise[12]).

12 White noise is a series of uncorrelated random variables with zero expected value and equal variance.

It is evident from equation (1) that we want to express the (logarithm) price of real estate as the sum of implicit prices of its (logarithm) floor area and the group of characteristics, where we allow the price to be influenced also by the period in which the transaction was carried out. We assumed that implicit prices of characteristics do not change over time (using fixed coefficients for the same characteristics in the whole sample), but that the changes in prices are fully reflected by coefficients δ_j next to time dummy variables. These coefficients are treated as pure prices of real estate in the sense that they are not affected by the fact that individual real properties might be better or worse located, have more or fewer rooms, etc. They reflect only the fact that the real estate has been sold during a given period. It should be noted that the assumption of constant implicit prices of real estate characteristics across the entire observed period is questionable to a degree, but due to the relative shortage of data in the available database we were unable to estimate the regression parameters for each year individually.

Further, in equation (1) we do not assume the unit elasticity[13] of price in relation to the floor area of residential real estate in advance, which means that it is not necessary for $\beta = 1$, as it is assumed by definition when calculating the index of average prices of square meter of residential real estate. This approach is intuitive because experience tells us that price of real estate that is double in size is usually not twice as high.

3.2 Time Dummy Index as One of the Sub-types of Hedonic Real Estate Price Index

Determining and monitoring real estate prices is not an easy task. It is normally difficult to determine the change in the price of a particular real property over time because the same item of real estate is usually not sold many times.[14] However, by applying the described hedonic method we may determine implicit prices of individual characteristics by which we approximate the price of real estate in different periods.

After estimating the parameters in equation (1) the price of real property with the random characteristics vector (m, X) in period t is approximated as follows:[15]

$$\widehat{p_t} = e^{\hat{\alpha} + \hat{\beta} \ln m + \hat{\delta}_t + \sum_{j=1}^{l} \gamma_j X_j}$$

It is then easy to calculate the relative ratio of real property price with fixed characteristics (m, X) for any two periods t and s:

13 It arises from the log-log model: $\beta = \frac{\partial p}{\partial m} \frac{m}{p}$, which is partial elasticity of price in relation to the floor area.

14 Countries where the rate of change of residence is high are exception to the rule. Thus, for instance, in the US this rate ranges between 17% and 18%, in France between 8% and 9%, which makes it possible to construct real estate price indices based on repeated sales of the same real estate (Gourieroux and Laferrere, 2007).

15 Upper approximation of the price of real estate is generally not equal to the expected price accompanied by known characteristics. For more details on the possible bias of indices computed in this way see, for example, Lye and Hirschberg (2002).

$$\frac{\hat{p}_t}{\hat{p}_s} = \frac{e^{\hat{\alpha}+\hat{\beta}\ln m+\hat{\delta}_t+\sum_{j=1}^{l}\gamma_j X_j}}{e^{\hat{\alpha}+\hat{\beta}\ln m+\hat{\delta}_s+\sum_{j=1}^{l}\gamma_j X_j}} = (\text{after simplification}) = \frac{e^{\hat{\delta}_t}}{e^{\hat{\delta}_s}}. \qquad (2)$$

When calculating the base index parameters are usually standardised so that the value of the base parameter equals 0. Therefore, equation (2) changes to

$$\frac{p_t}{p_0} = \frac{e^{\hat{\delta}_t}}{e^0} = e^{\hat{\delta}_t}.$$

The numbers $e^{\hat{\delta}_t}$ are treated as the value of the base index of real estate prices in the period t. The hedonic real estate price index calculated in this way is called the *time dummy* index. Thus, it is operatively sufficient to estimate the parameters in the equation (1) and monitor the exponents $e^{\hat{\delta}_t}$.

3.3 Hedonic Real Estate Price Index for Croatia

The Croatian National Bank purchased the database used to calculate the hedonic real estate price index from *Burza nekretnina,* an association of real estate agencies. For each real estate, data is collected on the price (asking and achieved), date of sale and geographic/locational and qualitative characteristics (attributes).[16] In this section of the paper, we introduce four hedonic real estate price indices: *City of Zagreb, Adriatic Coast, Other – urban* and *Other – rural.* These regional indices are then aggregated in the real estate price index for Croatia where the shares in the total number of transactions relating to the individual *region* in the available database are used as weights.

In addition to information on the amount of the transaction, the database also contains data on the characteristics of the real estate, which we divided in two groups: geographic/locational and qualitative. The following characteristics are included among the geographic/locational: region, county, place, and part of city/town. The floor area, number of rooms, floor, number of floors, date of construction, time of sale, type of dwelling (dwelling in a block, dwelling in a house or condominium, terraced house , etc.), type of heating, (no) loggia, balcony, telephone, gas, etc. are included among the qualitative characteristics. We additionaly constructed three indicator variables to detect newly-built real estate (not older than five years), attic, ground floor, ground level and basement properties.

For the construction of each of the regional indices we defined a special regression equation. Since the models for all regions did not accept the null hypothesis on the homoscedasticity of the residual, we used the estimation of covariance matrix adjusted for heteroscedasticity.[17] Parameters of regression equations have been estimated by using the OLS-method.

16 The key role in the computation of the real estate price index plays the measure of representativeness of available data on the movement of residential real estate prices so we gave special attention to the analysis of the obtained database and indicated some of the weaknesses we observed (Appendix A).

17 We estimated to covariance matrix by using the so called *Heteroscedasticity Consistent Covariances estimator*. Coveriances estimated in this way do not affect the final estimate of regression coefficients, but do affect t-statistics and thus the selection of variables in the model.

Table 3 shows the annual rates of change for four hedonic real estate sub-indices and the aggregated index for Croatia. In addition, hedonic real estate price indices mentioned in Table 3 and Table 4 are, each individually, compared with the index of average real estate prices of square meter of floor space.

Table 3 Indices of Real Estate Prices in Croatia, annual rate of change

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2006		2007	
											1st half	2nd half	1st half	2nd half
Croatia														
Hedonic index	6.4	0.9	–1.8	6.9	1.9	0.3	12.8	8.8	16.2	13.3	14.9	17.4	17.7	9.1
Index of average prices m²	9.6	0.0	0.3	11.6	1.7	1.6	9.2	10.7	21.6	9.6	19.7	23.5	9.8	9.4
The City of Zagreb														
Hedonic index	6.2	1.9	–1.4	–5.1	6.5	0.7	11.5	10.1	16.9	11.9	16.1	17.8	14.4	9.4
Index of average prices m²	9.0	2.0	1.2	–0.4	3.7	3.6	6.9	9.0	22.5	9.5	19.4	25.6	13.5	5.6
Adriatic coast														
Hedonic index	6.2	–2.4	–6.7	26.5	5.5	8.7	8.9	16.7	14.9	17.2	13.8	15.9	23.8	11.2
Index of average prices m²	2.7	–4.5	–0.9	30.6	11.6	8.2	2.2	25.0	10.6	19.1	5.7	15.5	15.1	22.8
Other – urban														
Hedonic index	11.2	–5.4	3.5	37.2	–6.7	–33.0	40.2	–5.4	24.7	4.0	16.3	33.3	17.4	-8.0
Index of average prices m²	28.8	–2.1	–9.3	96.1	–31.3	–34.6	45.6	–7.6	38.8	4.3	15.5	66.8	18.1	–7.2
Other – rural														
Hedonic index	5.2	6.0	5.6	34.5	–27.3	–5.3	25.1	–19.3	8.2	17.1	6.7	9.6	25.2	9.3
Index of average prices m²	24.3	–3.3	1.5	16.0	–7.4	–9.3	37.7	–9.4	48.9	–15.3	89.1	16.2	–29.6	3.6

Note: The methodology of calculation of the hedonic real estate price index for Croatia requires that for each new calculation of the index (after the expiry of a semi-annual period) all parameters in individual equations of achieved real estate price be reestimated, which in turn requires the revision of the real estate price index for previous semi-annual periods or years. Each update thus changes the indices realised over the previous years. However, each time they are measured more precisely because they are calculated on the basis of more data.
Sources: *Burza nekretnina* and CNB calculations.

Table 4 Indices of Real Estate Prices in Croatia, 1st half of 1997 = 100

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2006		2007	
												1st half	2nd half	1st half	2nd half
Croatia															
Hedonic index	102.2	108.7	109.6	107.6	115.0	117.2	117.5	132.6	144.3	167.6	189.9	161.9	173.3	190.7	189.1
Index of average prices m²	102.1	111.9	111.9	112.2	125.2	127.3	129.4	141.3	156.3	190.2	208.4	185.8	194.5	204.0	212.8
The City of Zagreb															
Hedonic index	101.8	108.1	110.2	108.6	103.1	109.8	110.5	123.2	135.5	158.5	177.3	154.5	162.5	176.8	177.9
Index of average prices m²	102.8	112.1	114.3	115.7	115.2	119.5	123.8	132.3	144.3	176.8	193.5	170.8	182.7	193.9	193.0
Adriatic coast															
Hedonic index	105.1	111.7	109.0	101.6	128.6	135.6	147.4	160.6	187.3	215.2	252.2	203.7	226.7	252.2	252.1
Index of average prices m²	103.8	106.6	101.8	100.8	131.7	146.9	159.0	162.5	203.2	224.7	267.7	215.9	233.6	248.5	286.9
Other – urban															
Hedonic index	108.6	120.7	114.2	118.3	162.2	151.4	101.4	142.2	134.4	167.6	174.3	158.9	176.3	186.5	162.2
Index of average prices m²	101.6	130.9	128.1	116.2	227.8	156.5	102.4	149.1	137.8	191.2	199.5	173.9	208.5	205.5	193.5
Other – rural															
Hedonic index	93.4	98.3	104.2	110.0	147.9	107.6	101.9	127.5	102.9	111.3	130.4	109.7	112.9	137.3	123.4
Index of average prices m²	92.2	114.6	110.8	112.5	130.5	120.8	109.6	150.9	136.6	203.5	172.3	231.6	175.3	163.0	181.6

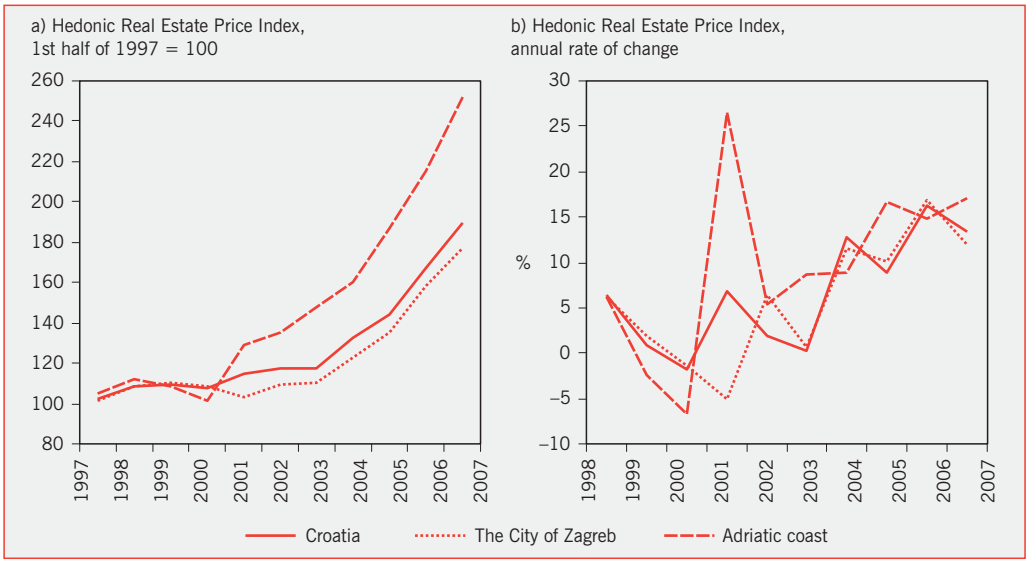
Sources: *Burza nekretnina* and CNB calculations.

According to the hedonic real estate price index (HREPI), the prices of real estate went up by 89.9% in the past ten years, with the strongest growth of 61.6% being observed in the past four years (i.e. in the period from 2004 to 2007). As compared to the previous year, real estate prices in Croatia grew the most in 2006 (by 16.2%), which was the highest annual growth of real estate prices within the observed ten-year period. The annual rate of change of real estate prices slowed down to 13.3% in 2007. The growth of real estate prices was much milder in the

period from 1997 to 2003, totalling 17.5%. The annual rates of change of real estate prices in Croatia measured by the hedonic real estate price index for individual years were lower than those calculated on the basis of the movements of average real estate prices index. This indicates that the change in *pure* price was not as high, i.e. that the index of average prices for those years is biased upwards, which happens when, for instance, a higher number of dwellings was sold in the city centre, or a higher number of dwellings than houses was sold in a respective year in comparison with the previous year, etc.

An overview of the rise of real estate prices by *regions* shows (Table 4) that in the past decade prices grew the strongest along the Adriatic coast. Prices of real estate on the coast grew substantially in 2001, and have been growing uninterruptedly ever since at high rates (8% per annum)[18]. In the period from 1997 to 2007, the prices of real estate in the City of Zagreb went up by 77.3%, growing most vigorously in the last four years (by a total of 56.3%). In other parts of the country, the growth of real estate in the past decade was, generally speaking, weaker than in the City of Zagreb or along the coast (measured by the hedonic index). However, due to lack of data homogeneity and large oscillations in the quality of residential real estate sold, substantial variability was present in annual rates of change of the price of real estate in those parts of Croatia. Therefore, data for other parts of Croatia should be analysed with caution.

Figure 9 Hedonic Real Estate Prices Index for Croatia



Sources: *Burza nekretnina* and CNB calculations.

It is noteworthy that following three consecutive semi-annual periods in which the annual growth rate of residential real estate prices in Croatia ranged between 14.9% (in the first half of 2006) and 17.7% (first half of 2007), this rate slowed down to 9.1% in the second half of 2007. In the City of Zagreb a mild slowdown

18 Except in 2002, when real estate prices at the Adriatic coast grew by 5.5% annually.

of the annual growth rate of real estate prices started in the first half of 2007, while on the coast this rate declined in the second half of 2007. The annual real estate growth rate of newly approved housing loans in Croatia declined from 4.9% in 2006 to 1.7% u 2007, indicating falling demand for real estate and contributing to a slowdown in the growth of real estate prices. The number of building permits issued for the construction of dwellings went up between 20% and 30% in the last three years as compared to 2002, indicating that an increased supply of real estate in the market may be one of the factors contributing to the slowdown in the growth of real estate prices.

4 Additional Use of the Database Obtained from *Burza nekretnina*

As we mentioned earlier, in addition to the construction of the real estate price index, the goal of the analysis carried out in this section is to verify empirically certain hypotheses formulated as questions in the introduction to this paper.

4.1 How Has the Registered Rise in Real Estate Prices Affected the Average Floor Space of Purchased Real Estate?

A simple, descriptive analysis of the available database of real estate prices was implemented to provide a more detailed overview of the distribution of the floor space of real estate purchased in Croatia over the last ten years. Since the data on real estate in the City of Zagreb are quantitatively best represented in the database available, we limited our analysis to the data pertaining to this city. It is noteworthy that this segment is dominated by the sale of flats, with a share of 86%.

Table 8 shows minimums, maximums, averages, medians, standard deviations and the first and the third quartile of floor space of real estate sold in the City of Zagreb from 1997 to 2007. In addition to the basic statistics, we show the shares of dwellings sold in the City of Zagreb the floor area of which is below 50, 70 and 90 square meters. This is aimed at checking whether the information from the analysed database provides certain indications on possible systematic changes in the floor area of purchased dwellings caused by the inflation of real estate prices. Put more simply, we want to answer the question of whether the rise in real estate prices implies a reduction in the floor space of dwellings purchased.

Table 5 Minimums, Maximums, Averages, Medians, Standard Deviations and the First and the Third Quartile of Floor Area of Dwellings Sold in the City of Zagreb

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Minimum	16	14	17	14	20	20	20	18	21	21	19
Q1	50	48	51	51	53	51	55	50	50	53	48
Median	61	60	63	65	68	66	70	66	65	69	68
Medium	65	64	68	69	75	73	79	73	72	76	74
Q3	77	75	80	82	90	88	94	86	89	90	92
Maximum	168	285	467	230	330	350	300	285	235	438	248
Stand. dev.	24	26	28	27	33	32	36	35	32	37	34

Sources: *Burza nekretnina* and CNB calculations.

Table 6 Shares of Dwellings with Floor Area below 50, 70 and 90 Square Meters in the Total Number of Sold Dwellings in the City of Zagreb

Dwellings smaller than	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
50 m^2	24	27	23	22	22	23	16	25	25	21	27
70 m^2	64	67	61	57	53	55	49	54	56	51	52
90 m^2	87	88	83	83	74	76	73	76	76	76	72

Sources: *Burza nekretnina* and CNB calculations.

The results shown indicate that statistics measuring median values of the floor area of dwellings sold in the City of Zagreb are on a mild upward path. The moderate growth of third quartiles and medians suggests mild increase in the purchase of dwellings of larger floor area. Data also indicate that the share of real estate whose floor area is below 50 or 70 square meters has not substantially grown despite the observed growth in the prices of such real estate. Based on this, and assuming satisfying representativenes of the sample, there is no rationale for the claim that the growth of real estate prices in the City of Zagreb resulted in the purchase of smaller dwellings.[19]

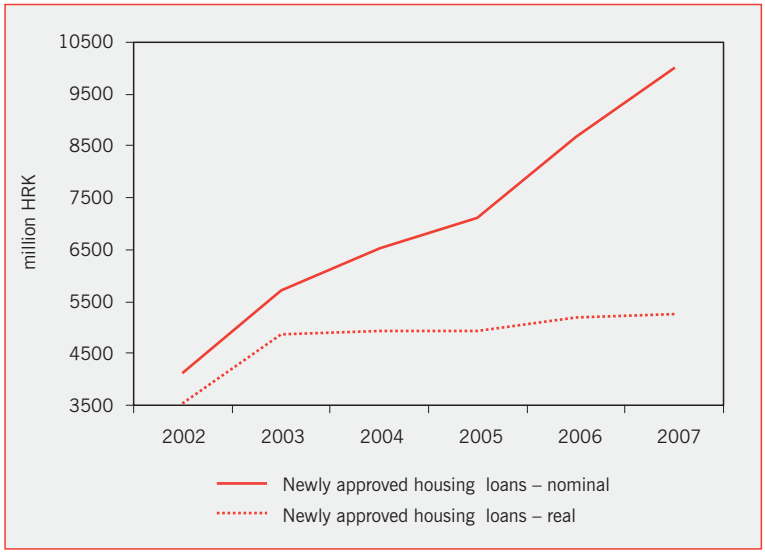
4.2 How Has the Rise in Real Estate Prices Affected Real Demand for Housing Loans?

For a better overview of real demand for housing loans, we give a graphic presentation of annual aggregates of newly approved housing loans deflated by the constructed hedonic real estate price index in Croatia (Figure 10). In addition, Table 10 presents the respective annual rates of change of the nominal series of newly approved housing loans and the series deflated by hedonic real estate price index and consumer price index.

The amounts of newly approved loans went up at high growth rates (nominally 142%) in the past five years. However, if the effects of the increase in real estate

19 We found formal support for this claim in the result of the χ^2-test, when we tested the null hypothesis on the equality of shares of sold dwellings below 50 square meters in the total number of sold dwellings in two subsamples: from 1997 to 2001 and from 2002 to 2006. The value of χ^2-statistics (with one degree of freedom) totals 3.04, which means a p-value of 0.08, so there is no rationale for rejecting the hypothesis on the equality of the said shares for all levels of significance below 0.08. Specifically, we do not reject the null hypothesis for the standard level of significance of 5%.

Figure 10 Newly Approved Housing Loans, Nominal and Real (deflated by the Hedonic Real Estate Price Index)



Source: CNB.

Table 7 Annual Rate of Change of Newly Approved Housing Loans (nominal and real)

Newly approved loans	2003	2004	2005	2006	2007
Nominal	38.0	14.6	9.0	21.8	15.2
Real					
Deflated by HREPI	37.6	1.6	0.2	4.9	1.7
Deflated by CPI	35.6	12.3	5.5	18.0	12.0

Source: CNB calculations.

prices were excluded, this growth would be much lower, totalling 49.4%, with 2003 accounting for the major portion of this growth. This indicates that, taking all other factors in account, the major contribution to the nominal growth of housing loans came from the high growth of real estate prices, meaning that real demand for housing loans grew only mildly. Table 7 reflects the need for a credible index for deflating nominal amounts of housing loans because when they do not exist nominal amounts are deflated by other available, but less appropriate, price indices, which may provide a completely different picture of the movements of real aggregates.

As shown in the previous subsection (4.1), real demand for housing loans has been affected by the strong inclination of buyers towards dwellings of moderately large floor area.[20] Consequently, the results obtained in relation to this and the previous sub-section lead us to the conclusion that real estate buyers in Croatia deal with high inflation of real estate prices by taking out larger housing loans and generating rising real demand for real estate.

20 One of the possible causes is the period for which banks lately approve housing loans, which has been extended to up to 30 years.

4.3 How Has the Difference between Asking and Achieved Prices of Real Estate been Distributed?

An advantage of the database of *Burza nekretnina* is that it captures both asking and achieved prices, which is not often the case. This is important to us for the purpose of checking the possible usefulness of real estate databases which capture only asking prices (such as, newspapers, commercial agents, web portals, etc.).

Figure 12 is a histogram of the differences between asking and achieved prices of a square metre of floor area of dwellings sold in the City of Zagreb in the past two years, where the black vertical line indicates the mean of the differences, which totals EUR 59.8. The standard deviation is EUR 71.1, so the difference between the asking and achieved price of a square meter of real estate in the City of Zagreb deviated from the mean value by EUR 71.2 on average. The value of the third quartile is EUR 84.3, which means that three quarters of all differences were lower than EUR 84.3. The reason for the occurrence of negative values, i.e. in some cases the achieved price exceeds the asking price, lies in the fact that the seller and the buyer may later agree that the purchase price includes the price of parking space, storage, etc. which is not appropriately registered in the database.

All this means that in the mid-term these differences are not substantial enough fully to discredit the indices of asking prices. However, it seems that such cases require thorough preparation of data in the sense of cleaning up the database of suspicious data that are believed to be able to cause price bias. Those are most often data pertaining to unrealistically high asking prices.

To support the last assertion, in Table 8 we present the annual rates of change of hedonic indices of real estate price [21] in the City of Zagreb computed by using the asking or achieved prices. The following table reflects that the differences in the rates of change of hedonic indices are not large.[22]

Table 8 Hedonic Index of Dwelling Prices in the City of Zagreb, annual rate of change

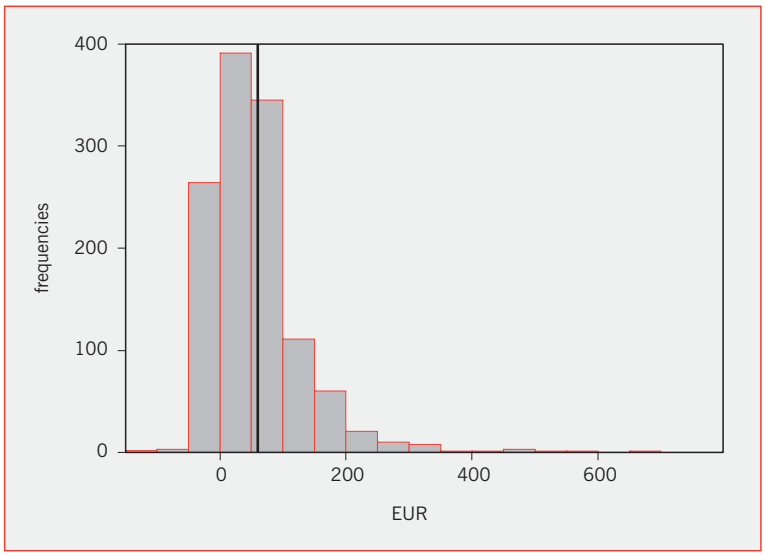
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2006		2007	
											1st half	2nd half	1st half	2nd half
Hedonic index of achieved prices	6.0	2.1	–2.9	–4.9	3.8	3.8	11.4	11.4	16.3	11.1	17.1	15.5	12.3	10.1
Hedonic index of asking prices	6.1	1.6	–2.8	–4.5	3.4	3.2	11.8	11.5	16.5	11.8	17.0	16.0	12.9	10.8

Note: The methodology of calculation of the hedonic real estate price index in Croatia requires that for each new calculation of the index (after the expiry of a semi-annual period) all parameters in individual equations of achieved real estate price be reestimated, which in turn requires the revision of the real estate price index for previous semi-annual periods or years. Each update thus changes the indices realised over the previous years. However, each time they are measured more precisely because they are calculated on the basis of more data.
Sources: *Burza nekretnina* and CNB calculations.

21 The analysis was carried out on flats to ensure the required homogeneity of observed real estate used to construct real estate price indices.

22 Only in two years (in 2003 and 2007) the difference between annual rates of change calculated on the basis of achieved or asking prices of dwellings exceeded 0.5 percentage points, while the trend was the same in both cases.

Figure 11 Histogram of the Differences between Asking and Achieved Prices of Square Meter of Floor Space of Real Estate Sold in the City of Zagreb in the Period from 2006 to 2007 (in euro)



Sources: *Burza nekretnina* and CNB calculations.

4.4 Can the Elements of Analysis Carried out in this Paper be Used for the Creation of an Expert System for the Computation of Prices of Real Estate of Known Characteristics?

All hedonic indices presented here are calculated using simple regression analysis, which means from the estimate of equation (1). This means that for a real estate of known characteristics, assumed in advance to be sufficient for approximation of real estate prices, we may, after estimating coefficients in equation (1), determine the expected price, which we treat as the estimate of the price of such real estate. Accordingly, we can immediately give a positive answer to the question asked. The areas of application of such a system are numerous, for example assessment of credit risk in the context of bank supervision, estimation of real estate value in the tax administration, commercial agents in real estate trading, purchase of real estate by citizens, etc.

Implementation of an expert system for determining real estate prices consists of several important steps and assumes the availability of a database of real estate prices which captures a sufficient number of characteristics required for the precise estimate of real estate prices. These steps include:

1 careful preparation of data in terms of eliminating errors in the database and records with unrealistically high or low values of a characteristic. This is important to achieve homogeneity;
2 determination of the best model in statistical terms;
3 estimation of implicit prices of characteristics, that is, estimation of regression parameters in case of an estimation of equation (1);
4 creation of a simple application that enables the use of the system by end users. Depending on the purpose, this may be an excel table, java application, etc.

Further in the paper we will demonstrate the use of such a system on the example of dwellings sold in the City of Zagreb in the last ten years. Our specification is to be used only for purpose of information, while in case of application more attention should be given to the first, second and third step, segmentation of the market whose prices are of interest, aggregation of characteristics, etc.

The estimates of model (1) parameters estimate the implicit prices of real estate characteristics in the City of Zagreb which are presented in the following table.

Table 9 Implicit Prices of Dwelling Characteristics in the City of Zagreb

Characteristic	Implicit price	Characteristic	Implicit price
Logarithm of floor area	0.91	Heating – central, floor lvl., gas	0.15
Sold in the 2nd half of 1997	0.03	Heating – central, boiler room, CTC heating boiler	0.10
Sold in the 1st half of 1998	0.07	Heating – central, boiler room, electric	0.06
Sold in the 2nd half of 1998	0.08	Heating – boiler room, fossil fuels	0.04
Sold in the 1st half of 1999	0.09	Heating – traditional, gas	0.05
Sold in the 2nd half of 1999	0.10	No heating, no chimney	–0.28
Sold in the 1st half of 2000	0.10	No heating, chimney exists	–0.12
Sold in the 2nd half of 2000	0.03	Heating – traditional, oil	0.10
Sold in the 1st half of 2001	0.04	Heating – traditional, fossil fuels	–0.04
Sold in the 2nd half of 2001	–0.01	Heating – air conditioning unit	0.10
Sold in the 1st half of 2002	0.07	Heating – central, district heating	0.10
Sold in the 2nd half of 2002	0.04	Heating – central, boiler room, gas	0.07
Sold in the 1st half of 2003	0.10	Heating – central, boiler room, oil	0.05
Sold in the 2nd half of 2003	0.09	Centar	0.28
Sold in the 1st half of 2004	0.18	Črnomerec	0.13
Sold in the 2nd half of 2004	0.22	Dubrava	–0.07
Sold in the 1st half of 2005	0.28	Maksimir	0.19
Sold in the 2nd half of 2005	0.33	Medveščak	0.28
Sold in the 1st half of 2006	0.44	Novi Zagreb	–0.07
Sold in the 2nd half of 2006	0.48	Sesvete	–0.19
Sold in the 1st half of 2007	0.55	Susedgrad	–0.03
Sold in the 2nd half of 2007	0.57	Trešnjevka	0.06
Balcony	0.02	Trnje	0.12
Number of rooms	0.02	Dwelling in a house	0.05
Newly constructed	0.13	Dwelling in a block	0.12
Attic/ground floor	–0.03	Multi-level dwelling in a block	0.09
Ground level/basement	–0.22	Lift	0.02
Garage	0.04	Loggia	0.02
Heating – central, floor lvl, electric	0.06	Gas	0.02
Heating – central, floor lvl, fossil fuels	0.22	Constant	6.90

Note: Value 0.91 (implicit price of the log of floor area) is interpreted as the partial elasticity of price compared to floor area. Value 0.02 for the characteristic pertaining to number of rooms is interpreted as the increase in (logarithm) real estate price due to the fact that the real estate has one more room. Other variables (except the constant) are indicator variables which reflect the change in real estate price caused by the fact that the real estate has precisely this characteristic. Implicit prices for types of heating are interpreted as the divergence from the type of heating *central, heating boiler, solar*. Implicit prices of the characteristic of the part of the city is interpreted as the divergence from the price of the part of the city called *Peščenica*, while prices for the type of real estate are interpreted as divergence from the type *multi-level dwelling in a house*. Analogously, prices for the year of sale are interpreted as divergence from the price in the basis period, 1st half of 1997.
Sources: *Burza nekretnina* and CNB calculations.

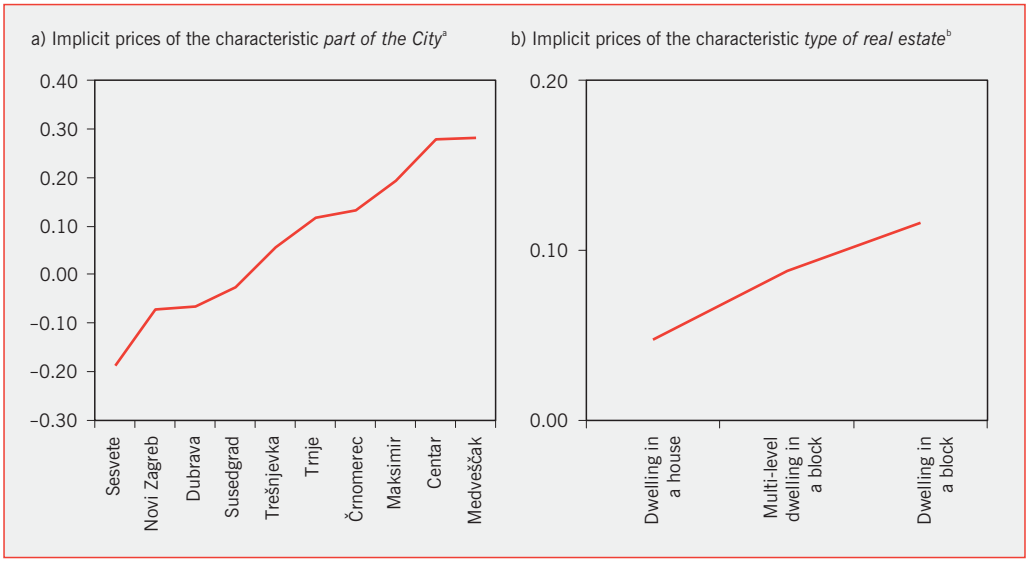
By including implicit prices of real estate in equation (1) and using the antilogarithm process, we obtain the expected price.

As an example, we will determine the expected price of a flat in a block in the City of Zagreb in the second half of 2007, with floor area of 60 m^2, three rooms,

balcony, located in the city centre, with central heating, telephone, garage (or parking space), in a building that is not newly constructed (older than five years), not in the basement or at ground level, on the ground floor or in the attic. The expected price of the respective real estate is estimated at EUR 140,449, or EUR 2,341 per square meter of floor area. Further, the system estimated that real estate of the same characteristics would have been worth EUR 85,048, or EUR 1,417 per square meter in the second half of 2002. So the system provides for price estimation for different periods, regardless of the fact that real estate of described characteristics does not even have to exist in the database.

In addition to the evaluation of real estate, using data from Table 9, we can directly compare implicit prices of certain characteristics, such as for example part of the city. These prices are interpreted as the change in the price of real estate caused by the fact that the respective real estate is situated at that precise location. Intuitively, we imagined that we had one and the same real property, which we moved around the City of Zagreb and observed the differences in prices. Similar analysis may be carried out for other real estate characteristics as well.

Figure 12 Implicit Prices of the Characteristics Part of the City and Type of Real Estate for Dwellings in the City of Zagreb



[a] Values interpreted as divergence from the price of the neighbourhood called Peščenica
[b] Values interpreted as divergence from the price of the type of real estate multi-level dwelling in a house
Sources: *Burza nekretnina* and CNB calculations.

5 Conclusion

In this paper we described the procedure of calculating the hedonic real estate price index which indicates a *pure* change in real estate prices of real estate sold between two periods, i.e. trimmed of the influence of changes in prices induced by the changes in qualitative and locational characteristics of real estate sold within a certain period as compared to the previous period. Detailed data on prices of

real estate sold and their characteristics, as the key prerequisite for the calculation of hedonic real estate price index, had been obtained from *Burza nekretnina*. The available database was divided into four relatively homogeneous markets (City of Zagreb, Adriatic coast, Other – urban and Other – rural). In this context it must be mentioned that 65.3% of data in the database pertain to Zagreb, of which 85.2% pertains flats, so that the hedonic index of flat prices in the City of Zagreb is considered the most reliable among the calculated indices. In the hedonic model, we expressed the price of real estate as the sum of implicit prices of its floor area and the group of characteristics, with the price also being influenced by the period in which the transaction was conducted. We assumed that implicit prices of real estate characteristics do not change over time, thus using fixed coefficients for the same characteristics in the entire sample and that the change in price is fully reflected in the coefficients for the time indicator variable.

According to the hedonic real estate price index (HREPI), real estate prices in Croatia went up by 89.9% in the last decade, with the most prominent growth of real estate prices of 61.6% being realised in the last four years (from 2004 to 2007). An overview of the growth of prices by *region* indicates that prices grew strongest on the coast. In 2006, real estate prices in Croatia grew strongly (by 16.2%) compared with the previous year, which was the largest recorded annual growth of real estate prices over the observed ten-year period. The annual rate of change of real estate prices in 2007 slowed down to 13.3%. It should also be noted, that after three consecutive half-year periods during which the annual growth rate of residential real estate prices in Croatia went up between 14.9% (first half of 2006) and 17.7% (first half of 2007), the annual growth rate of real estate prices slowed down to 9.1% in the second half of 2007. In the City of Zagreb a mild slow down in the annual growth rate of residential real estate prices started in the first half of 2007, while at the coast the growth rate started declining in the second half of 2007.

The analysis further in the paper showed that the considerable growth of real estate prices did not result in the purchase of smaller dwellings, as would have been intuitively expected. On the contrary, statistics measuring mean values of the floor area of dwellings sold in the City of Zagreb have been rising mildly. We can thus conclude that the major portion of the nominal growth of newly approved housing loans that has been seen over the past four years resulted from the high growth of real estate prices and only a smaller portion from the increased inclination of buyers to buy larger dwellings and the growth of real demand for housing loans. Further, we concluded that there were no major differences between hedonic real estate price indices calculated on the basis of achieved prices and hedonic real estate price indices calculated on the basis of asking prices, which makes it feasible to us other databases on the movements of real estate prices in Croatia containing only asking prices. In the end, we indicated the possibility of using the estimated regression model for the creation of an expert system for the estimation of prices of real estate of known characteristics.

References

Bežovan, G. (2004): *Housing Statistics – Housing Standard in Croatia*, The Journal of Social Policy, Year 11, No. 2, 267 – 279.

Botrić, V., and Ž. Kordej De Villa (2005): *Determinants of Regional Housing Market in Croatia*, Paper prepared for the 45th Congress of the European Regional Science Association.

Amsterdam, the Netherlands, 23 – 27 August 2005.

Bover, O., and P. Velilla (2002): *Hedonic House Prices Without Characterisis: The Case of New Multiunit Housing*, ECB Working Paper, No. 117, January.

Brachinger, H. W. (2002): *Statistical Theory of Hedonic Price Indices*, University of Fribourg, www.unifr.ch.

Central Bureau of Statistics, *Census 2001*, Statistical Yearbooks and First Releases (different numbers).

Gourieroux, C., and A. Laferrere (2006): *Managing Hedonic Housing Price Indexes: the French Experience*, paper presented at the workshop organised by the OECD and IMF: Real Estate Price Indexes, Paris, 6 – 7 November (www.oecd.org).

Linz, S., and T. Behrmann (2004): *Using Hedonic Pricing for the German House Price Index*, Federal Statistical Office of Germany.

Lovrinčević, Ž., D. Mikulić, and Z. Marić (2006): *Maastricht Criteria and the Inclusion of the Underground Economy - the Case of Croatia*, Privredna kretanja i ekonomska politika, No. 106.

Lye, J. N., and J. G. Hirschberg (2002): Tests of Inference for Dummy Variables in Regressions with Logarithmic Transformed Dependent Variables, Department of Economics – Working Papers, Series 852, The University of Melbourne.

Mihaljek, D. (2005): *Free movement of capital, the real estate market and tourism. A Blessing or a Curse for Croatia on its way to the European Union?* In: Ott, K. (ed.). Croatian Accession to the European Union. Vol. 3., Institut of Public Finance and Friedrich-Ebert-Stiftung, Zagreb, pp. 181 – 222.

Melser, D. (2005): *The Hedonic Regression Time-Dummy Method and the Monotonicity Axioms,* Journal of Business & Economic Statistics, Vol. 23, No. 4, October.

Moulton, B. R. (2001): *The Expanding Role of Hedonic Methods in the Official Statistics of the United States,* Washington, Bureau of Economic Analysis U. S. Department of Commerce, June.

Nair, B. P.: *Use of Hedonic Regression Methods for Quality Adjustment in Statistics NZ,* Statistics New Zeland.

Pavlin, B. (2006): *Dwelling Price Index in Slovenia – Pilot Study of Hedonic Approaches*, paper presented at the workshop organised by the OECD and the IMF: Real Estate Price Indexes, Paris, 6 and 7 November (www.oecd.org).

Rae, D., and P. van den Noord (2006): *Ireland's Housing Boom: What Has Driven It And Have Prices Overshot?*, OECD Economics Department Working Paper, No. 492.

Tepuš, M. (2004): An *Analysis of Housing Finance Models in the Republic of Croatia*, Croatian National Bank Surveys, No. 18.

Tepuš, M. (2006): An Analysis of the Operation of Building Societies in the Republic of Croatia: Results of the Second CNB Interview of Housing Savings Banks, Croatian National Bank Surveys; No. 23.

Tica, J. (2002): *The Transition of Croatian Apartment Market*, Politička kultura, Zagreb.

United Nations Commission for Europe (UNECE), *Annual Bulletin of Housing Statistics for Europe and North America 2004.*

The Act on Subsidised Residential Construction, Official Gazette 109/2001.

The Act on Housing Savings and State Incentive to Housing Savings, Official Gazette 109/1997.

Appendix A

Database for the Calculation of a Hedonic Real Estate Price Index in Croatia

The database used in this paper has been purchased by the Croatian National Bank from *Burza nekretnina*. *Burza nekretnina* is an association of real estate agencies that was established in 1996 and has been collecting data on houses and dwellings for sale, which the agencies advertise on its internet site. For all real estate, data is collected on the price (asking and achieved) date of sale and geographic/locational and qualitative characteristics (attributes). The geographic division used in this paper is based on the division into four *regions*: *the City of Zagreb, Adriatic coast, Other - urban* and *Other - rural*, with the group Adriatic coast including real estate up to 10 km inland.

Table A1 Number of Real Properties Sold

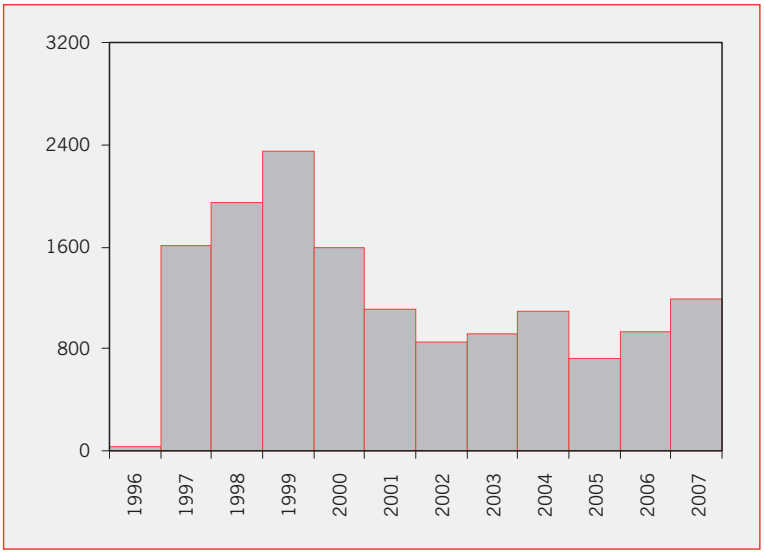
	Real estate sold	Share
The City of Zagreb	9368	65.3
Adriatic coast	3162	22.0
Other – urban	655	4.6
Other – rural	1164	8.1
Croatia	14349	100.0

Sources: *Burza nekretnina* and CNB calculations

Data in Table A1 indicate unequal geographic distribution of data contained in the database of *Burza nekretnina*. Of all the data on real estate sold, 65.3% pertains to the City of Zagreb. Since as much as 85.2% of this share relates to the sale of flats we devoted special attention to the analysis of the movement of prices in Zagreb, were we expected the estimate of flat price movements to be most reliable. The share of data on real estate on the Adriatic coast sold makes up 22.0%, while other areas account only for 12.7%, rural areas accounting for 8.1% and urban areas for 4.6%.

The data in Table A1 show that the database obtained from *Burza nekretnina* does not contain sufficient information (in terms of data quantity) to enable a higher level of disaggregation, which means that it does not allow the construction of county real estate price indices even at the annual frequency. The usefulness of such an index would also be questionable due to significant heterogeneity of real estate characteristics within different counties. For instance, several counties stretch across mountain areas inland and the coast line, where the structure of both supply and demand for real estate greatly differs. Such counties are hardly to be considered homogeneous markets, which is one of the key assumptions for the creation of a real estate price index. Further, the assertion that the database is inappropriate for creation of county real estate price indices is supported by the fact that eight counties account for shares of less than 1% and, with the exception of the City of Zagreb, only two counties make up shares of 5% (the Primorje-Gorski Kotar County and the Split-Dalmatia County).

Figure A1 Time Distribution of Real Estate Sold in Croatia



Sources: *Burza nekretnina* and CNB calculations.

As for time distribution, Figure A1 indicates that data are distributed more equally. Except for 1996, when only 40 real properties were sold, and was thus excluded from analysis, other years are relatively better represented, ranging from 719 registered real estate transactions in 2005 to 2343 registered real estate transactions in 1999.

Appendix B

Results of the Estimation of Regression Parameters

Tables B1 and B4 show the results of estimated regression parameters for four specifications used for calculating the hedonic indices for the following *regions*: City of Zagreb, the Adriatic coast, Other - rural and Other urban. In addition, Table B5 presents the results of the Wald test, which has been used to test the null hypothesis of whether the partial elasticity of the price of real estate compared to floor area equals one for each equation. If elasticity statistically equals one, for real estate in a certain *region* this means that real estate which is twice the size, and has the same characteristics, will cost twice as much. Finally, Table B6 presents the list of real estate characteristics and respective abbreviations.

Table B1 Estimated Parameters for Real Estate in the City of Zagreb
The City of Zagreb
Number of observations: 9368
White Heteroscedasticity-Consistent Standard Errors & Covariance

	Coefficient	Std. error	t-statistics
LOG FLOOR AREA	0.85	0.01	70.48
2nd half of 1997	0.04	0.01	2.46
1st half of 1998	0.08	0.01	5.79
2nd half of 1998	0.08	0.01	5.81
1st half of 1999	0.09	0.01	6.94
2nd half of 1999	0.10	0.01	7.13
1st half of 2000	0.11	0.01	8.06
2nd half of 2000	0.06	0.02	3.03
1st half of 2001	0.06	0.01	3.95
2nd half of 2001	0.00	0.02	0.08
1st half of 2002	0.10	0.02	5.91
2nd half of 2002	0.09	0.02	4.64
1st half of 2003	0.10	0.02	6.29
2nd half of 2003	0.10	0.01	6.60
1st half of 2004	0.19	0.02	10.82
2nd half of 2004	0.22	0.02	13.76
1st half of 2005	0.29	0.02	17.33
2nd half of 2005	0.32	0.02	18.54
1st half of 2006	0.44	0.02	28.40
2nd half of 2006	0.49	0.02	31.52
1st half of 2007	0.57	0.02	37.42
2nd half of 2007	0.58	0.01	39.58
PART OF THE CITY *CENTAR*	0.38	0.01	29.49
PART OF THE CITY *ČRNOMEREC*	0.19	0.01	15.86
PART OF THE CITY *DUBRAVA*	–0.04	0.01	–2.58
PART OF THE CITY *MAKSIMIR*	0.24	0.01	18.13
PART OF THE CITY *MEDVEŠČAK*	0.37	0.01	27.64
PART OF THE CITY *NOVI ZAGREB*	–0.01	0.01	–1.12
PART OF THE CITY *SESVETE*	–0.13	0.04	–3.50
PART OF THE CITY *SUSEDGRAD*	0.02	0.01	1.39
PART OF THE CITY *TREŠNJEVKA*	0.12	0.01	11.17
PART OF THE CITY *TRNJE*	0.17	0.01	14.33
VNKDVOJNA	–0.03	0.07	–0.43
VNKSAMOSTOJECA	–0.10	0.06	–1.60

VNKUNIZU	–0.03	0.07	–0.51
VNSUKUCI	–0.01	0.06	–0.12
VNSUZGRADI	0.07	0.06	1.08
VNSVETUZGRADI	0.06	0.06	0.91
DRUBOVI	–0.03	0.00	–7.20
DNOVOGRADNJA	0.11	0.01	20.18
DSUTPOD	–0.24	0.02	–9.97
NUMBER OF ROOMS	0.02	0.00	5.25
BALCONY	0.01	0.01	2.62
GARAGE	0.05	0.01	8.57
GCETEL	0.07	0.04	1.90
GCETKG	0.12	0.07	1.86
GCETPL	0.17	0.02	9.56
GCKOTCTC	0.15	0.03	4.79
GCKOTEL	–0.11	0.08	–1.26
GCKOTKG	0.07	0.04	2.05
GCKOTN	0.06	0.02	2.43
GCKOTP	0.17	0.02	6.76
GCTOP	0.16	0.02	9.34
GKLIMA	0.18	0.11	1.66
GKLKG	–0.06	0.02	–2.34
GKLN	–0.03	0.09	–0.29
GKLP	0.06	0.02	3.27
GNGD	–0.38	0.06	–5.86
GNGRND	–0.34	0.10	–3.41
LIFT	0.01	0.00	3.12
LOGGIA	0.02	0.00	4.37
GAS	0.05	0.01	5.19
C	7.10	0.08	92.59
R-squared	0.89		
Adjusted R-squared	0.88		
S.E. of regression	0.20		

Sources: *Burza nekretnina* and CNB calculations.

Table B2 Estimated Parameters for Real Estate along the Adriatic Coast
Adriatic coast
Number of observations: 3162
White Heteroscedasticity-Consistent Standard Errors & Covariance

	Coefficient	Std. error	t-statistics
LOG FLOOR AREA	0.69	0.02	41.41
2nd half of 1997	0.10	0.04	2.19
1st half of 1998	0.14	0.04	3.84
2nd half of 1998	0.08	0.05	1.58
1st half of 1999	0.07	0.04	1.71
2nd half of 1999	0.10	0.04	2.37
1st half of 2000	0.11	0.05	2.14
2nd half of 2000	–0.08	0.05	–1.62
1st half of 2001	0.29	0.03	8.34
2nd half of 2001	0.21	0.06	3.53
1st half of 2002	0.26	0.05	5.73
2nd half of 2002	0.35	0.06	5.95
1st half of 2003	0.29	0.04	6.94
2nd half of 2003	0.48	0.05	8.79
1st half of 2004	0.36	0.05	7.92
2nd half of 2004	0.58	0.04	14.78
1st half of 2005	0.58	0.05	11.95
2nd half of 2005	0.67	0.04	14.99
1st half of 2006	0.71	0.04	18.26
2nd half of 2006	0.82	0.04	20.28
1st half of 2007	0.93	0.04	25.20
2nd half of 2007	0.92	0.04	20.63
BALCONY	0.11	0.02	6.89
NUMBER OF ROOMS	0.04	0.00	7.70
DNOVOGRADNJA	0.12	0.02	6.83
DUBROVNIK-NERETVA COUNTY	0.16	0.03	4.80
GARAGE	0.14	0.02	7.13
GNGD	–0.23	0.04	–5.33
ZADAR COUNTY	–0.23	0.02	–10.44
LIKA-SENJ COUNTY	–0.27	0.02	–12.43
ŠIBENIK-KNIN COUNTY	–0.16	0.03	–5.77
C	7.68	0.07	107.00
R-squared	0.72		
Adjusted R-squared	0.72		
S.E. of regression	0.40		

Sources: *Burza nekretnina* and CNB calculations.

Table B3 Estimated Parameters for Real Estate in the region Other – rural
Other
Number of observations: 1164
White Heteroscedasticity-Consistent Standard Errors & Covariance

	Coefficient	Std. error	t-statistics
LOG FLOOR AREA	0.63	0.03	24.82
2nd half of 1997	–0.14	0.09	–1.66
1st half of 1998	0.04	0.08	0.47
2nd half of 1998	–0.07	0.11	–0.68
1st half of 1999	–0.01	0.08	–0.16
2nd half of 1999	0.09	0.08	1.11
1st half of 2000	0.09	0.10	0.85
2nd half of 2000	0.11	0.08	1.32
1st half of 2001	0.34	0.17	1.95
2nd half of 2001	0.44	0.17	2.65
1st half of 2002	0.13	0.13	1.01
2nd half of 2002	0.01	0.12	0.08
1st half of 2003	–0.06	0.11	–0.53
2nd half of 2003	0.09	0.15	0.58
1st half of 2004	0.26	0.10	2.69
2nd half of 2004	0.22	0.10	2.32
1st half of 2005	0.03	0.16	0.17
2nd half of 2005	0.03	0.10	0.29
1st half of 2006	0.09	0.09	0.99
2nd half of 2006	0.12	0.10	1.28
1st half of 2007	0.32	0.10	3.25
2nd half of 2007	0.21	0.11	1.84
ISTRA COUNTY	0.77	0.12	6.22
ZAGREB COUNTY	0.29	0.03	8.27
VNSUKUCI	–0.16	0.08	–2.13
DNOVOGRADNJA	0.25	0.04	5.76
GCETEL	0.43	0.19	2.28
GCETKG	0.50	0.12	4.03
GCETPL	0.49	0.06	8.47
GCKOTEL	0.36	0.27	1.35
GCKOTKG	0.33	0.06	5.36
GCKOTN	0.47	0.05	10.04
GCKOTP	0.23	0.09	2.49
GNGRND	–0.56	0.09	–6.09
LOGGIA	0.08	0.04	1.83
TELEPHONE	0.17	0.04	4.64
GAS	0.10	0.05	2.16
C	7.28	0.14	53.46
R-squared	0.69		
Adjusted R-squared	0.68		
S.E. of regression	0.43		

Sources: *Burza nekretnina* and CNB calculations.

Table B4 Estimated Parameters for Real Estate in the region Other – urban
Other - urban
Number of observations: 655
White Heteroscedasticity-Consistent Standard Errors & Covariance

	Coefficient	Std. error	t-statistics
LOG FLOOR AREA	0.66	0.03	20.63
2nd half of 1997	0.16	0.10	1.65
1st half of 1998	0.20	0.10	2.02
2nd half of 1998	0.17	0.10	1.68
1st half of 1999	0.05	0.10	0.51
2nd half of 1999	0.21	0.10	2.16
1st half of 2000	0.16	0.13	1.24
2nd half of 2000	0.17	0.10	1.77
1st half of 2001	0.48	0.11	4.51
2nd half of 2001	0.49	0.31	1.59
1st half of 2002	0.59	0.12	4.85
2nd half of 2002	0.21	0.11	1.81
1st half of 2003	0.13	0.12	1.12
2nd half of 2003	–0.12	0.11	–1.12
1st half of 2004	0.33	0.12	2.73
2nd half of 2004	0.37	0.14	2.64
1st half of 2005	0.31	0.19	1.61
2nd half of 2005	0.28	0.10	2.71
1st half of 2006	0.46	0.11	4.29
2nd half of 2006	0.57	0.12	4.72
1st half of 2007	0.62	0.10	5.97
2nd half of 2007	0.48	0.11	4.41
NUMBER OF ROOMS	0.05	0.01	4.08
DUBROVNIK-NERETVA COUNTY	1.48	0.06	23.10
ZAGREB COUNTY	0.46	0.04	12.45
VARAŽDIN COUNTY	0.37	0.06	5.92
ISTRA COUNTY	0.30	0.17	1.80
GAS	0.11	0.03	3.31
TELEPHONE	0.31	0.05	6.62
LOGGIA	0.10	0.03	3.12
DNOVOGRADNJA	0.11	0.05	2.38
C	6.94	0.17	40.63
R-squared	0.77		
Adjusted R-squared	0.76		
S.E. of regression	0.35		

Sources: *Burza nekretnina* and CNB calculations.

Table B5 Wald Test of the Unit Elasticity of Price Compared to Floor Area

	Wald statistics	p-value
The City of Zagreb	164.7	0.0000
Adriatic coast	356.9	0.0000
Other – rural	217.2	0.0000
Other – urban	112.2	0.0000

Sources: *Burza nekretnina* and CNB calculations.

Based on the results of the test, we do not accept the null hypothesis on unit elasticity of prices compared to floor area for any of the regions.

The following real estate characteristics (with relevant abbreviations) are used in equations:

Table B6 Real Estate Characteristics
Real estate characteristics – abbreviations

Real estate characteristic	Abbreviation/description
Newly constructed (not older than 5 years)	DNOVOGRADNJA
Attic/ground floor	DRUBOVI
Ground level/basement	DSUTPOD
Heating – central, floor lvl, electric	GCETEL
Heating – central, floor lvl, fossil fuels	GCETKG
Heating – central, floor lvl, gas	GCETPL
Heating – central, floor lvl, solar	GCETSOL
Heating – central, boiler room, CTC heating boiler	GCKOTCTC
Heating – central, boiler room, electric	GCKOTEL
Heating – central, boiler room, fossil fuels	GCKOTKG
Heating – central, boiler room, gas	GCKOTP
Heating – traditional, gas	GKLP
Heating – central, boiler room, oil	GCKOTN
No heating, no chimney	GNGRND
No heating, chimney exists	GNGD
Heating – traditional, oil	GKLN
Heating – traditional, fossil fuels	GKLKG
Heating – air conditioning unit	GKLIMA
Heating – central, district heating	GCTOP
Semi-detached house	VNKDVOJNA
Detached house	VNKSAMOSTOJECA
Terraced house	VNKUNIZU
Dwelling in a house	VNSUKUCI
Dwelling in a block	VNSUZGRADI
Multi-level dwelling in a house	VNSVETUKUCI
Multi-level dwelling in a block	VNSVETUZGRADI

Source: CNB.

The following Working Papers have been published:

No.	Date	Title	Author(s)
W–1	December 1999	Croatia in the Second Stage of Transition, 1994–1999	Velimir Šonje and Boris Vujčić
W–2	January 2000	Is Unofficial Economy a Source of Corruption?	Michael Faulend and Vedran Šošić
W–3	September 2000	Measuring the Similarities of Economic Developments in Central Europe: A Correlation between the Business Cycles of Germany, Hungary, the Czech Republic and Croatia	Velimir Šonje and Igeta Vrbanc
W–4	September 2000	Exchange Rate and Output in the Aftermath of the Great Depression and During the Transition Period in Central Europe	Velimir Šonje
W–5	September 2000	The Monthly Transaction Money Demand in Croatia	Ante Babić
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