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BAKALÁŘSKÁ PRÁCE

Ondřej Vodňanský *2007/2008*

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Determinants of the Czech Real Estate Market

Vypracoval: *Ondrej Vodnansky*
Vedoucí: *PhDr. Michal Hlavacek, PhD*.
Akademický rok: *2007/2008*

Prohlášení:

Prohlašuji, že jsem bakalářskou práci vypracoval samostatně a použil pouze uvedené prameny a literaturu.

V Praze dne

Ondřej Vodňanský

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ABSTRACT

Czech real estate market in its current form is relatively young and this paper focuses on its specificities. After presenting some general concepts and empirical findings from the researched literature, we proceed to the qualitative factors of the real estate environment in the Czech context. The core of the paper, however, lies in the quantitative assessment. Firstly, we were able to create a parsimonious but reliable econometric model that explains regional property price differences by labour market variables. Then, we used state-of-the-art methods of time series analysis to address the development of property prices and construction starts in time. Whereas in the latter case, our results were satisfying, in the former one, they were mixed.

JEL Classification: R21, R23, R31

Keywords: Real estate markets and prices, property markets and prices, housing supply

ABSTRAKT

Český realitní trh ve své současné podobě je relativně mladý a tato práce se zaměřuje na jeho charakteristické vlastnosti. Poté, co předložíme několik obecných konceptů a empirických výsledků z rešerše literatury, přejdeme ke kvalitativním faktorům nemovitostního prostředí v Českém kontextu. Nicméně jádro práce je kvantitativní analýza. Nejdříve se nám povedlo vytvořit jednoduchý, ale spolehlivý model, který vysvětluje regionální rozdíly v cenách nemovitostí pomocí proměnných trhu práce. Poté jsme použili moderní metody analýzy časových řad, abychom posoudili vývoj cen nemovitostí a zahájených bytů v čase. Zatímco ve druhém případě naše výsledky byly uspokojivé, v tom prvním byly spíše smíšené.

JEL Classification: R21, R23, R31

Klíčová slova: Trhy a ceny nemovitostí, reality, nabídka bydlení,

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1. INTRODUCTION

Real estate, a type of asset with a long history, has been a topic of research for many foreign authors, but in much lesser extent for Czech academicians. Partly, this might be due to the fact that in the Czech Republic, the time when asset markets have emerged is still not very long ago. It is perhaps even more true in the case of real estate market in particular. After all, both supply and demand have gained some momentum only at the turn of the millennium. There were various causes – e.g. mortgages have become available for mass consumers. This intensive positive shock to demand has spurred an unprecedented growth in supply with massive construction taking place. Furthermore, foreign institutional investors have been more and more active on the Czech property market in recent years. Therefore, the state of immaturity of the Czech market for real estate is of course changing as the overall Czech economy converges to the developed western countries.

However, the reasons for a researcher to occupy with real estate markets go well beyond the above mentioned recent developments. The markets for properties are obviously a major economic factor and also have strong social and political implications. Real estate is unique in its durability – once built; a property exists and serves its users for a period of several lifespans. This is one of the reasons that a piece of real estate can be used both as a consumption good and as an investment asset. Properties usually comprise a major part of wealth of individual households and the total worth of a nation's real estate might exceed the GDP multiple times. Real estate influences and is influenced by local and global financial markets. Moreover, specifically residential housing is connected with the functioning of the labour markets. Finally, fluctuations of the property markets can very well spillover into the overall economic cycle - a fact that is clearly observable from the current state of the global economy perhaps more than ever before.

This paper will try to address only some of the issues from the previous paragraph and will focus on the specificities of the Czech Republic with regards to real estate. Certain theoretical concepts and empirical findings will be outlined before we proceed to the context of the Czech real estate environment. The main areas covered will be the causes and effects of regional and temporal variations of prices and also determinants of supply of housing - namely new construction starts.

The thesis could be divided into two main parts and proceeds in the following order. Chapter 2 provides a general introduction into the wider issue and at the same time, serves as a survey of literature – both of theoretical and empirical. Chapter 3 sums up the models, which served as a reference for this paper. Chapter 4 closes the introductory and general part by briefly describing the real estate market in the Czech Republic and its developments.

Chapters 5 to 7 constitute the core of this paper. We wanted to examine the underlying relationships that exist on the Czech real estate market with some complexity and also quantitative rigour. Therefore, each of the chapters addresses a different aspect of the market with a different econometric model. In chapter 5, we will elaborate on regional differences in real estate prices using fundamental variables – mainly ones that are related to labour market. These variables, namely Unemployment and Wages, show high relevance for real estate prices in the regions of the Czech Republic and thus, at the end of the chapter, we present quite a reliable model. The method employed is the basic OLS, applied on cross-sectional data at one point in time.

In the following two chapters, we turn our attention to an inter-temporal, rather than a regional, comparison. There, we examine the development of property prices and construction starts of new apartments in time. To assess these developments, we carry out a rigorous time series analysis using state-of-the-art econometric methods – partly Cointegration, which has proven inconclusive, and mainly the Error Correction Models. Before arriving to these, several specification changes, complete recalculations and dataset adjustments had to be carried out. However, we present only the final form of the model.

In the case of the new construction starts, we believe to have found a model that depicts the relationship with respectable reliability. From that, we conclude that the supply of new housing (represented by the explained variable of construction starts) is driven by fundamental factors, rather than structural changes. However, the same is not true of the real estate prices. The model explaining fluctuations of the residential real estate prices in time came out with overall acceptable goodness of fit and significant parameters. However, the parameter estimates themselves are definitely not straightforward to interpret. There is either a restructuring still in progress, some complicated lagged relationships exist between the variables, or the regression is just spurious. This issue will require more research.

Finally, chapter 8 concludes the obtained results. Throughout the second part of the thesis, technical terms are used in the parts where the model specifications are defined. However, we will try to present the conclusions in such a way, that there is no need for extensive knowledge of econometric theory.

2. GENERAL OVERVIEW

2.1. Introduction to Real Estate Economics

From the point of view of economic theory, an important aspect of real estate is its dual nature. It can be viewed both as a commodity, as well as an investment asset (DiPasquale, Wheaton, 1996). We can easily notice that both dimensions influence each other and hence, it is not possible to draw a clear line between them and assess them separately. A case which demonstrates the need for a more complex view might be for example a policy of rental regulation (which views a property as a commodity serving to satisfy housing needs) that will obviously have an impact on the profitability of investment into real estate and therefore, its prices. To demonstrate the link from the other side as well, let us imagine a case where investors shift their preferences to real estate from other types of assets due to the fall of returns from these assets. We would expect the outcome to be an increase in prices of the residential housing, by itself, is a consumption good.

Another attribute of real estate is the word "real"; it is a real asset (e.g. Hoesli, 1993). Unlike a financial asset, ownership of a property grants the right to enjoy the durable and mainly material good. Real estate and the markets where it is transacted have some very specific traits that separate it from most other goods (Hilbers, Lei, Zacho, 2001).

- *Heterogeneity* – no two properties are the same and consequently, easily comparable. Very different are also the buyers and their preferences which is a cause of the next trait.

- *Number of transactions* – there is a relatively small amount of deals taking place in the market and the same time, the information on their outcomes or any other details are very rarely available. This of course makes the process of optimum price creation all the more difficult.

- *Transaction costs* – are very high, mainly in absolute terms. A participation of a third party, such as real estate agents or other intermediaries, or at least a lawyer, is common. Needless to say, such a participant requires a fee to be paid. But even if no third party is involved, the transaction costs remain high

due to the taxation of property transfer, unless the deal takes place among family members. Even if we were to abstract from taxation, at any rate, a transaction costs of real estate is quite distinctive because of the time requirements. These are extremely high compared to any other good. Firstly, there is the time implicitly required by the transaction – be it the time of the buyer needed to find a suitable property or the time that both parties spend by communication and negotiation over the deal. However, one must primarily take into account the deadline until which the clerks of the land register have to finish the transfer between the two participants of the deal. In the case of Prague, the maximum period was until recently as long as six months; now it is approximately one third of the time[1].

- *Rigidity of supply* – supply of land and buildings is highly inelastic. Case, Glaeser and Parker (2000, p.129) point out that property owners often refuse to sell a property at a lower than original price through lengthy periods: "Sellers almost always have a firm reservation price or simply resist selling property during recessions. " Besides, it is not possible to execute a "short sale" with a property (in financial markets that means to sell a security one does not yet own – to borrow it – with the intention of buying it back at a lower price) as it is possible with financial assets, which would cool down an overly optimistic, "bull", market. Therefore, it is no surprise that in practice, supply of real estate is often demonstrates strong downwards price-rigidity.

- *Imperfect information* – in a way common for almost any market outside of pure theory, however, the scope and importance of this issue in the particular case of real estate markets make it their defining and inherent factors. It is discussed in the following subsection.

2.2. Data and Information Availability

It is to be remarked that the above mentioned attributes do not influence only the way in which the market searches for the optimum price, which we will discuss later, but also the collection of appropriate data and the availability of information. This might also be one of the factors that amplify the scope of cycles on

[1] Author's personal experience from working as a real estate agent

the real estate markets. Because of lack of information, real estate markets diverge more easily from their long term, fundamentally based values, and consequently, also take longer time to adjust back (Collyns, Senhadji, 2002).

It is notably the small number of transactions, together with non-existent central settlement market (typical for other asset classes), that makes observing property prices with sufficient accuracy impossible. There are not only very few transactions, it is also difficult to find their results which are rarely disclosed.

One solution that is sometimes used is to monitor prices of properties for sale in classified advertisements in newspapers and on the internet. It is immediately clear that this approach might lead to inaccurate results. A real estate deal is usually an outcome of bilateral negotiations and the original asking price might differ largely from the final price. The latter obviously is not published in any classified advertisement.

All this presents a serious obstacle in creating a general statistical indicator, such as an average or an index, and implies that a lot caution be taken when interpreting such an indicator. A remarkable number of papers on real estate not only face the issue of insufficient data but are even devoted to the problematic completely (see e.g. Case, Wachter, 2003). In chapter 4, which discusses the real estate market in the Czech Republic, this issue shall be addressed with respect to the local particularities.

2.3. The Price – Making Process

The above mentioned matter of lack of quality information is tenuously connected with the question of the price – making process. Lack of information with the potential to distort the mechanism of optimum price search is of two types. The first one – very limited availability, if not complete unavailability, of the true transaction prices – was discussed in the previous subsection. The second one is related to forecasts about future demand which influences developers when they are planning construction. To shed light on the specificities of this problem, let us assume an example. Imagine there is a period of steadily rising property prices which stimulates a construction company to start a development of a new project. However, it might easily happen that the price growth reaches its climax before the project is finished (or several competing projects are finished simultaneously). This will lead to

an excess supply of real estate and a fall in prices. This phenomenon[2] is usually referred to as *construction lag*.

A unique optimum market price is impossible to find for several reasons. The real estate market is fragmented into local submarkets without central clearing institution. Transaction prices are therefore negotiated ad hoc which is another key aspect of the price – making process. Yet another role is played by the banking sector which influences the availability of financing.

2.4. Property and credit markets

An aspect of property prices that is often mentioned in literature is their link with the banking sector credit. More specifically, it is the reciprocal and two-way nature of the relationship, which caught the attention of researchers. A rise in the prices of real estate for whatever reason has two effects with respect to the banking industry. Firstly, it lowers loan-to-value ratios (LTVs) of mortgaged properties and thus has a considerable impact on private sector wealth (Hofman, 2001). LTVs being lower, homeowners can consequently increase their demand for credit by collateralizing the increase the price of their property. On the other hand however, banks themselves often use real estate as collateral - "higher prices also lift the value of banks' own property holdings and hence their capital, which encourages them to relax their lending standards (Case, Wachter, 2003, p.2)." Apart from the effect of overall increased lending, another notable consequence is the increase in the exposure of the banking sector to the real estate sector. The risk it yields is of great concern to both researchers and central bankers[3].

We have shown that the fluctuations on the credit markets with regard to real estate can manifest themselves both through the channel of demand and supply. This two-way relationship is more complicated by having another two-way, or reciprocal, aspect. As increased prices of real estate might lead to increased lending, the opposite causality is true, as well. More accessible financing through credit obviously pushes up demand for real estate and consequently, its prices, which in turn

[2] Being a typical trait of the real estate market and one of the main factors of supply rigidity, it is addressed, for example, in Case, Wachter, 2003, Collyns, Senhadji, 2002, or Hilbers, Lei, Zacho, 2001.
[3] Hilbers, Lei, Zacho (2001) and Collyns, Senhadji (2002) examine explicitly the link between real estate prices and crises in the financial sector. The former takes a more global view, although the examples from Europe seem to prevail. The latter focuses on the Asian banking crisis in the 1990s. Matalík, Skolková, Syrovátka (2003) discuss the need of the Czech National Bank to monitor real estate prices.

increases the value of collateral of individuals and banks. Ultimately, we arrive at the problem of separating the cause and effect, because the two influence, amplify and accelerate each other, mutually. The trouble comes once there is a negative change in either of the two – a prolonged vicious cycle is the result.

Besides the intuitive reasoning, the relationship has been also analyzed quantitatively. Hofman (2001) uses a cointegrating VAR model in order to assess long term relationships among property prices, credit, GDP and interest rates. The results prove the expected signs of the mutual relationships (including a positive relationship between property prices and credit volumes). Hilbers, Lei, Zacho (2001) use probit/logit model to measure whether the probability of a banking sector distress is increased when there has been a fall in prices of real estate. Their conclusions confirm the hypothesis that the real estate prices indeed have such an effect.

2.5. Real Estate Cycles

The existence of cycles of property prices has been already hinted at in the preceding paragraphs. In fact, the facts and relationships outlined in those paragraphs are the primary causes of such cycles. The construction lags are one of the major causes. They tend to create an autonomous cycle of prices rising above and then falling back below the so called "replacement costs" – costs necessary to identically reproduce (or replace) a particular property. Collyns and Senhadji (2002, p.5) sum up: "long construction lags prevent a quick supply response and therefore prices may keep rising for a protracted period, and, a price bubble may develop." We have mentioned that unreliable forecasts of future demand for real estate contribute to this difficulty.

These cycles, sustained endogenously by real estate market factors, such as supply and demand, are then reinforced even more by the influence of the banking sector. A typical real estate cycle, caused by the construction lag as described in the previous paragraph, is then amplified by increased lending when property prices are increasing or decreased lending, when they start to fall. A banking sector can start the cycle by itself if there is a positive shock in supply of credit (e.g. due to financial liberalization). The particularities of the mechanism linking property prices and supply of credit have been discussed in the subchapter above.

Šaroch (2002) mentions explicitly the positive effect of appreciation of residential housing prices on consumer wealth and moreover, stresses the economic

volatility caused by the so called "balance sheet channel". This channel is, in fact, the same we talked about in the previous subchapter – the channel that links increases in asset prices and consecutive increases in demand (and in supply, as well) for credit.

It is clear that once the property price cycle turns, it can easily translate into the overall business cycle. Case, Glaeser, Parker (2000, p.134) speak about the effects of commercial property markets saying that "Clearly, commercial real estate has played an important role in accelerating the recent upswings and downswings of both regional and national economies." Needless to say that, as we have witnessed recently, prices of real estate can have major impact even on the global scale.

2.6. Labour market

The author of this paper believes that the complexity of transactions, their social dimension and other particularities, namely the mentioned downward rigidity of prices, make the real estate market in many ways similar to the labour market. Just as the unemployment indicates unused supply on the labour market, a real estate market parallel would be the so called „vacancy rate"– which measures the proportion of vacant space (office, residential) offered on the market. Let us add that in the case of the vacancy rate we can, as with the unemployment, monitor a certain stable natural rate (Sunega, 2002), or distinguish the type – frictional, structural, cyclical... The difference lies perhaps in the approach of the policy of the government – it tries to regulate the demand-side and ease the supply-side in the case of the labour market, and vice-versa in the case of real estate.

Later in the paper, we demonstrate empirically through simple econometric methods that labour market determinants have major influence on prices of real estate across regions in the Czech Republic. Here, in this part, let us firstly assess some qualitative aspects of the relationship. For example, there has been an extensive research showing, that unemployment is directly influenced by type of tenure – rental or ownership (Lux, Sunega et al., 2006)[4]. Higher proportion of homeownership leads in general to higher unemployment, compared to rental tenure. The summary of the results from this research across countries is presented in table 2.1. The coefficient there is the parameter of homeownership rate, with unemployment being a dependent variable. Another interesting, qualitative issue the authors point out is concerned with

[4] Also contains an excellent summary of the results from this research across various countries worldwide.

how change of economic activity of women (from various reasons) might impact households' demand for housing. The question is, however, whether the same applies to the Czech Republic. The data on regional homeownership rates are not readily available, but a hypothesis, that regions with high wages and low unemployment have also high proportions of private homeownership, might not be too far from reality. Regulated rents might also lead to opposite results – inhabitants of such dwelling will tend to keep them, as it is very beneficial.

TABLE 2.1

Summary of the research about the influence of homeownership rate on unemployment

Author of the study	Year	Countries included	Coefficient*
Oswald	1996	OECD, USA	0,2
Nickell	1998	OECD	0,13
Pehkonen	1999	Finland	0,1
Green and Hendershott	2001	USA	1,8

** - coefficient of homeownership rate with regard to unemployment.*
Source: Lux, Sunega et al., 2003

In the empirical analysis, by using labour market factors to explain regional differences in property prices, we implicitly conform to two concepts. First one is the assumption that migration might be an important factor in the property prices variation and the second is the following citation. "The idea that differences in the levels of real wages across regions are the main cause of migration is a basic, oldest and most elementary to the theory of migration (Lux, Sunega et al., 2006, p.10)."

We can use neoclassical economic theory as a basis for the evaluation of the link between the prices of housing and the labour market. Let us assume an increase in demand for labour (caused, for example, by a positive exogenous shock to demand for output of firms in the particular region). Neoclassical economy views labour markets as flexible and as a consequence, the real wages and opportunity costs of leisure will quickly rise to equilibrate the market. For the same reasons, employment and / or participation rate will increase, as well. We can expect that such a specifically local demand shock will present an incentive for immigration (or commuting, at least) of labour force from other regions. Finally, the latter two effects imply an increase in the

number of available workers (an outward shift of the labour supply curve) and consequently a fall of wages to their original equilibrium.[5]

Now, we will take the analysis a step further by taking into account the real life rigidities as well as the existence of the real estate market where households demand and developers together with homeowners supply housing services. The fact that supply of housing is rigid in the short term was already mentioned – that leads to market adjustment process only through changes in prices. An interpretation of the situation above from the point of view housing markets would be an increase in demand for housing due to the inflow of new migrants. Except in the long term, this would lead to higher prices of real estate in the region in question.

We will use the general concepts behind the reasoning from the above paragraphs in our analysis of regional differences of real estate prices in chapter 5.

2.7. Real Estate and Economic Policy

Housing is often a target of various economic policies – be they regulatory, fiscal or monetary. Specific regulation works e.g. trough setting of maximum rent or by legislation concerning the banking sector, and more specifically the mortgage loans. As we will mention later in chapter 4, privatization of the Czech banks and introduction of mortgage had an unprecedented effect on the real estate market in the Czech Republic. An example of an active fiscal policy could be governmental programs to stimulate activity in the sector[6]. Moreover, other measures, that could be classified as part of the fiscal policy, such as taxation, its type and rate, have a strong influence, as well. Complexity of the issue of taxation goes beyond the scope and objective of this thesis. Let us mention at least, that apart from being a redistribution tool and a budgetary source, taxation also serves as a measure against speculative behaviour in real estate markets.

Finally, what is the relationship between the property market and the monetary policy which, unlike some obviously arbitrary measures of the government, strives to be above all objective? The asset market, and with it the market for real estate, is important from the point of view of financial stability: "...Now, the real

[5] Note that in reality, the situation is often different due to various market imperfections. In the specific case of the Czech Republic, two main factors that might step in are foreign direct investments and rent regulation.
[6] The administrative approach to real estate markets might be a type of a stabilization policy. In the 90s, the Hong Kong government increased the supply of land, which is state-owned. This has proven to lessen the impact of the depression on the economy and on the banking sector specifically. See Hilbers, Lei, Zacho, 2001.

estate sector is viewed as a significant contributor to the financial position of financial institutions in terms of mortgage loans as well as asset holdings. (BIS, 2005, p.16).” Central bankers need to monitor asset price developments before making decisions about future monetary policy but the influence works the other way around, as well. Typical examples of how monetary policy affects prices of assets including real estate are the interest rates or money supply.

3. REFERENTIAL MODELS

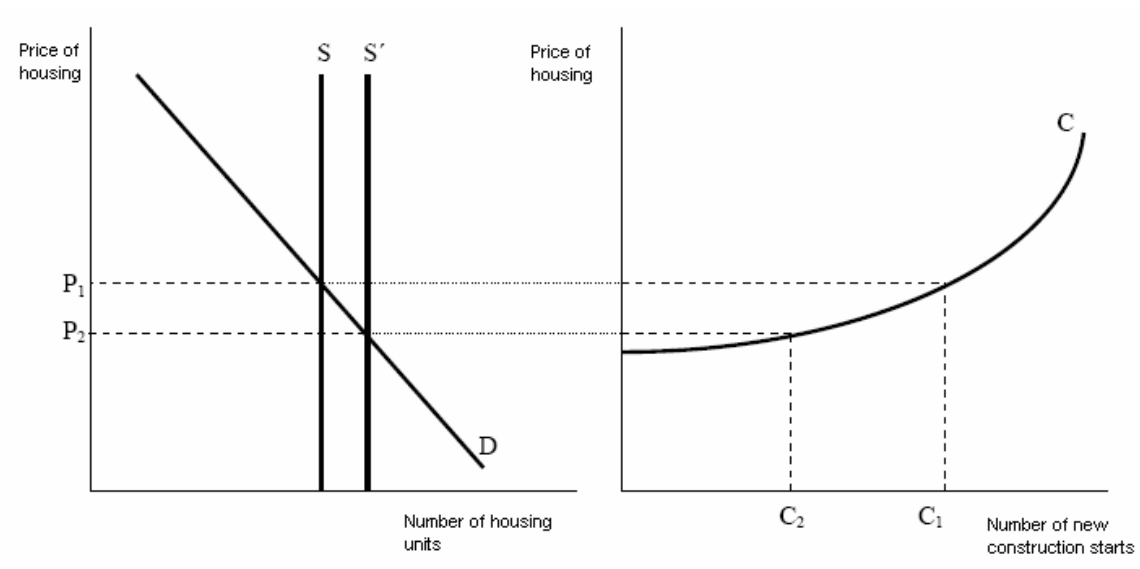
3.1. Work by George Fallis

Fallis's (1985) input has been invaluable to the part of the thesis, where we assess amounts of started constructions of new apartments – mainly his econometric research. For example, some insight can be obtained from the model[7] which is depicted on figure 3.1, although it is very simple. Its basic assumption about the market is that it is completely homogenous, regardless of quality or location. The analysis takes place on the aggregate level.

The graph on the left shows the market for housing in one short-term period, in which supply (S) is perfectly inelastic. Amount of new construction, which will be completed by the end of the period, is determined on the right graph by the intersection of the current price level of housing and the curve C. This curve can be interpreted as a developers' supply curve of new dwellings. Supply of the next period (S') is a result of new construction which took place in the first period, less depreciations. The process repeats itself until new construction is exactly offset by depreciation and an equilibrium is achieved.

FIGURE 3.1

Stock-flow model of housing market



Source: Adapted from Mankiw (2002)

[7] Fallis uses this model, but it is not originally his own invention. It is now a standard textbook model and before it has been used for example by Poterba.

The curve C incorporates the three factors of production (labour, land, capital) – their costs of use, share on overall production, their elasticities of mutual substitution and price. We can presume that construction has diminishing returns to scale, hence the curve's convex shape.

This point of view in a simple way demonstrates the relationship between short-term and long-term and moreover, already mentions the state of long-run equilibrium. However, it also makes some major simplifications. Apart from the assumptions, it is unclear how the long-run equilibrium is achieved – when exactly will depreciations equal new construction? This issue is addressed for example by DiPasquale and Wheaton (1996) in their model, which we also briefly discuss in this chapter.

Fallis used a more specific approach to assess new construction starts empirically, although he must have used some insights gained from his simple graphical analysis. The equation estimated for the case of Canada achieved R^2 of 0.94.

$$HS_t = 14.85 - 21.65*Q1_t + 7.22*Q2_t + 6.39*Q3_t + 8.88\ WW_t + 104.58\ (PH/CLC)_t$$
$$- 10.75\ RM_{t-1} + 6.07\ (RM - RB)_{t-1} + 1.87\ (CMHC/PH_{57})_t + 6.07\ (CMHC/PH_{57})_{t-1}$$

The variables employed were the following: construction starts of new housing (HS), quarterly dummies (Q1, Q2, Q3), government programs of support to new residential construction (WW), interest rates from mortgage loans (RM), yields from long-term obligations (RB), with their spread being a proxy for mortgage loan availability[8], total volume of mortgages issued by state-run Canada Mortgage and Housing Corporation (CMHC) and price of a housing average unit (PH), with the value of 1957 serving a as a deflator.

3.2. Stock-flow model of DiPasquale and Wheaton

In their impressive textbook exposition, DiPasquale and Wheaton (1996) present, among other things, a static model of real estate market, several econometric specifications and mainly a complex stock-flow model which shows dynamic development of real estate market factors in time. This model has been useful as an example for models in this paper and that is why its overview is offered below.

[8] Sunega (2002, p.9, translation by the author of this paper): „The higher is the spread (...), the more willing will the investors be to deposit their capital into funds that are used to finance mortgage loans..."

To begin, the model supposes that the demand is determined solely by market factors, whereas the supply for housing is mainly dependent on its past values. The demand for ownership of housing units, D_t, is a function of the number of households H_t, and an expression incorporating the annual costs of property ownership U_t.

$$D_t = H_t \cdot (\alpha_0 - \alpha_1 U_t)$$

The annual expenditures of owning a dwelling are then proportional to the current after-tax mortgage rate, M_t, less the expected appreciation of real estate prices, I_t. The difference is adjusted for inflation by the current price level of housing, P_t. Therefore, we obtain:

$$U_t = P_t \cdot (M_t - I_t)$$

As was already stated, demand is determined at each at every moment by the market factors. We can therefore assume that these factors will equilibrate supply and demand. If supply equals demand ($D_t = S_t$), we can modify the demand equation and then express it in terms of price:

$$P_t = \frac{\alpha_0 - S_t / H_t}{\alpha_1 (M_t - I_t)}$$

From this equation we can immediately see how different variables will influence prices of housing. Current prices will rise with increasing number of households and forecasts of future prices, and fall when stock of housing or tax adjusted mortgage rates increases.

The equation of supply is derived from the Solow growth model. Current stock of residential real estate is the stock from the previous period plus net new construction in the last period, which has two parts – the new construction itself, Ct, and depreciation. The depreciation is assumed to be proportional to the volume of housing stock; the proportion is marked as a parameter δ.

$$S_t = S_{t-1} + C_{t-1} - \delta S_{t-1}$$

The link with the model by Solow also works with the so called “steady state”. Here as well, the stock of housing increases only when new construction exceeds total depreciations. This happens until the two are equal, then $S_t = S_{t-1}$ and we say that the supply is in steady-state.

The model is taken further to incorporate the gradual process of convergence to the steady state. The long-run equilibrium supply is mainly determined by price and the construction adjusts to that value gradually. We will not delve any deeper into the details of that adjustment. The final forms of equilibrium supply and price are not difficult to derive mathematically; however, the intermediary algebraic formulas are quite complicated.

4. REAL ESTATE PRACTICE IN THE CZECH REPUBLIC

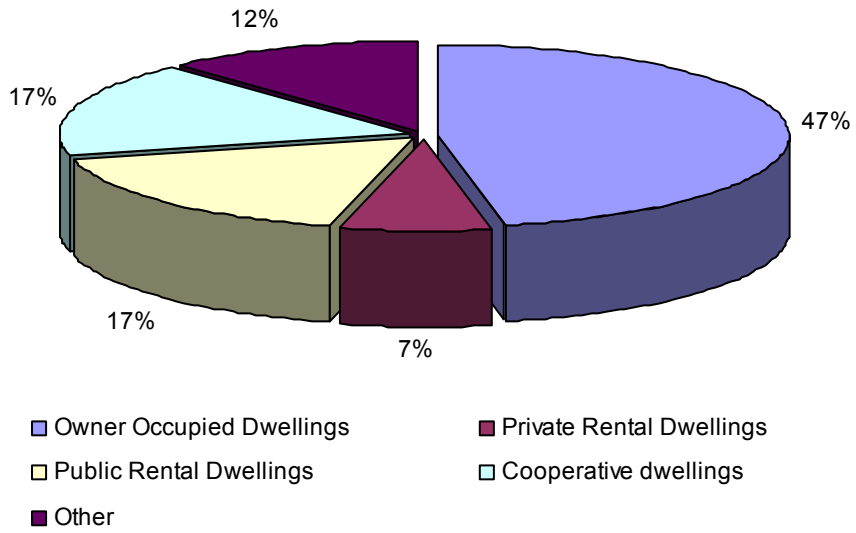
4.1. Establishment and socio-legal environment of the property market

The transition from a centrally planned economy to a market system obviously involved the foundation of a brand new market for real estate. A market that would remedy various problems like the following: "During the communist party rule, various forms of the right of use, often irrespective of ownership were introduced" (TradeLinks, 1994, p.10). Therefore, where price movements abroad were related to the economy's performance, in the Czech Republic during transition, price development was connected with major structural adjustments, such as changes in ownership (or tenure) structure (Matalík, Skolková, Syrovátka, 2003).

In principle four main types of tenure have emerged. Apart from standard ownership and rental, there is the widely spread cooperative form and the controversial public regulated rent. Breakdown of proportions of different sectors of tenure is shown on the figure 4.1.

FIGURE 4.1

Tenure sectors in the Czech Republic



Source: 2001 Census, Czech Statistical Office

We see from the figure that the most common title to real estate is full ownership ('vlastnické právo'), "which is similar to 'freehold' title in anglosaxon countries and entitles the owner to a full range of perpetual rights to use and enjoy real property" (King Sturge, 2007, p.10). It is also possible to use real estate based on (i) an easement ('věcné břemeno') or (ii) a lease ('nájemní právo'), which can be either a long-term lease or a lease for an indefinite period of time (King Sturge, 2007).The cooperative type is somewhat similar to private ownership in most practical aspects. The factor that degrades it the most with respect to private ownership is the fact that it cannot be mortgaged. In consequence, such apartments are usually cheaper. A specific type of tenure is the public rental, usually referred to as regulated rent[9].

All structures and land plots should be, in principle, registered in the so-called Cadastral Register ('Katastr nemovitostí'). Its foundation in 1993 has been another key event in the emergence of the Czech property market. The register doesn't serve only for tax control, but also for statistical and technical purposes. This register shows the owner of the property in question and also indicates the extent to which the land is encumbered by mortgages and other servitudes.

4.2. Qualitative factors

Later in the paper, quantitative approach will be employed in order to assess the determinants of the real estate market. However, as was mentioned above, it is clear the Czech market, existing in its free form for less than two decades, is prone to some hardly-quantifiable influences. This "youth" might in consequence render any potential quantitative analysis less reliable. Such analysis might lead to spurious conclusions, because variations in prices might be due to structural adjustments, rather than standard economic relationships. In the theoretical and general introduction in chapter 2, we mentioned the existence of real estate cycles, which are abroad a common fact. However, due to real convergence and other reasons, prices of Czech real estate keep rising almost constantly from the beginning of the 1990s. We might therefore argue that the property market will prove to have reached its maturity only once there is a downswing in prices. When carrying out the mentioned analysis we will be thus able to implicitly test a hypothesis whether some underlying economic links

[9]This type causes a lot of controversy. However, it is far from being a czech specialty. For example New York City is a famous rent-controlled metropolitan area. See e.g.:
<http://www.tenant.net/Oversight/50yrRentReg/history.html >

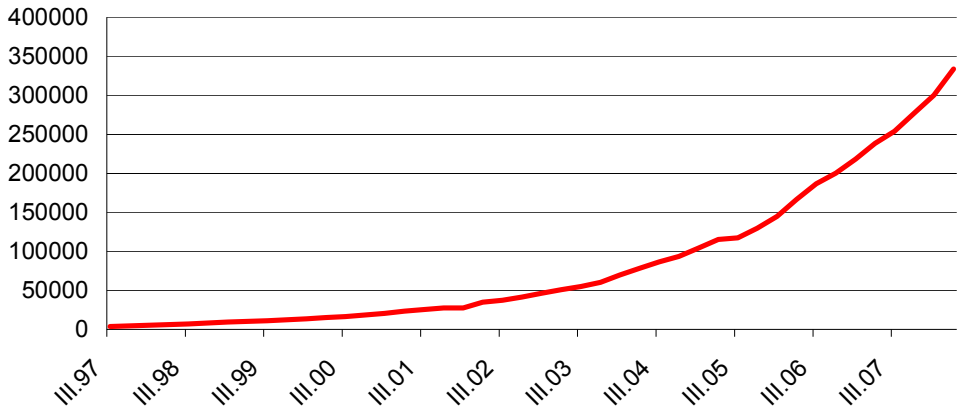
were already established or not. In this particular subchapter however, our focus will be on the qualitative, structural elements.

One of the most important contributors to the factual establishment of a market system for real estate and its takeoff has been the closely connected banking and namely credit industry. In fact, widespread availability of mortgage loans is a very recent phenomenon in the Czech Republic. Only after the completion of bank privatisation in the early 2000's did competition among banks start the development of a modern mortgage market. This coincided with a curbing of inflation and related interest rates, which dropped to around 4%. Although gradually on the rise, money market interest rates are still fairly low in the pan-european comparison and the mortgage market has been surging until recently. Although it might have reached its peak, there is a consensus among experts that it will continue to grow.

As can be clearly seen from the graph on the figure 4.2 below, the total volume of mortgage loans more than quadrupled in the last four years. The average volume of an individual loan is also on the increase, from about CZK 1 million in 2003, to CZK 1.5 million in 2007 (source: www.fincentrum.cz). Although the bulk of demand is concentrated in Prague, demand in the regions is catching on quickly. Obviously, the emergence of "institution" of mortgage lending has had strong impact on property prices.

FIGURE 4.2

Total Volume of Mortgage loans (in mil. CZK)



Source: Czech National Bank

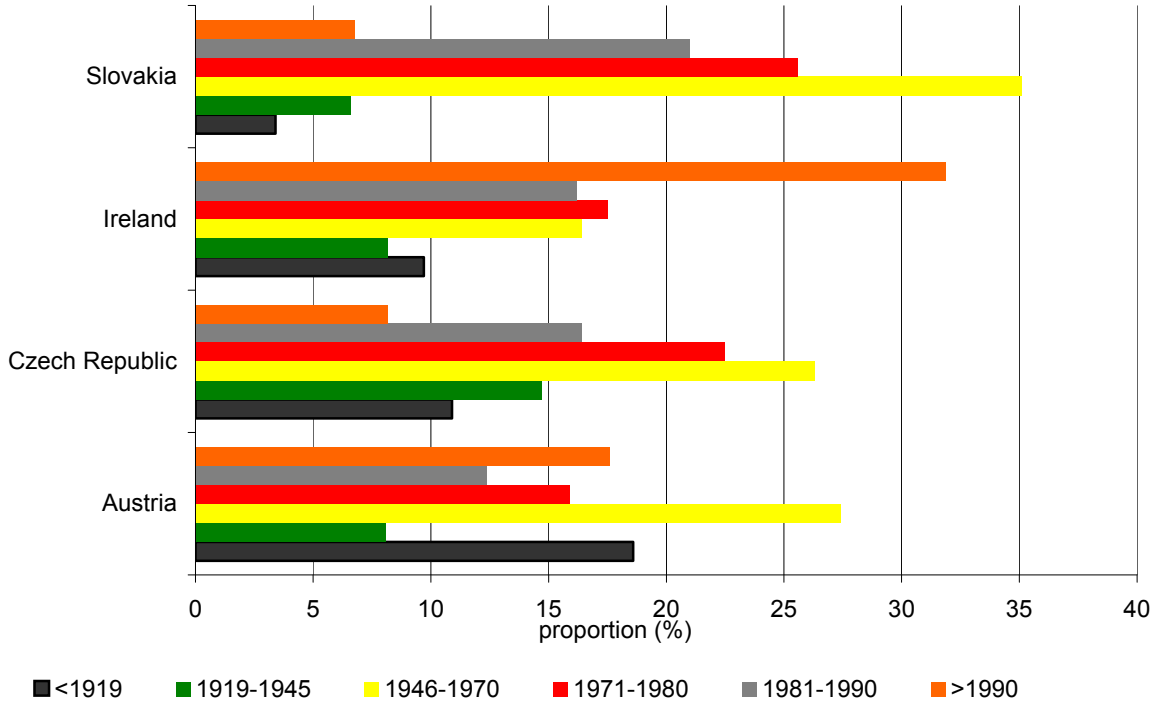
Two next important aspect of the Czech property market, which are still manifesting, are connected with the post-communist housing stock. Firstly, in 1992,

communist construction programmes, that produced an annual growth of the housing stock at over 40,000 completed dwellings, were finished. After that, output dropped significantly to reach an all-time low in 1995, when only 12,662 dwellings were completed. Since 1995, the numbers are up again. Recent years have seen a further increase in housing construction, fuelled by strongly improved mortgage market conditions and low interest rates. In 2007, 41,650 dwellings were completed, which is the highest number since the beginning of the series in 1993, as published by the Czech statistical office.

Furthermore, apart from the absolute volume of housing, there is also a problem with its age and, at the same time, its quality. As the graph below shows, most construction in the Czech Republic has been erected from 1946 to 1971, closely followed by the era until 1980. This does not a priori mean a disadvantage. Unfortunately, a large part of this output is comprised of the large "panel" blocks of flats, state of which is deteriorating rapidly. This is also this factor that incites developers to an unprecedented activity. Needless to say, improving demand factors, including purchasing power and financing affordability, together with insufficient supply pushes prices up.

FIGURE 4.3

Age of housing stock in selected countries



Source: Housing statistics in the European Union, 2006

Lastly, there is a very simple influence. In fact, since the beginning of the 1990s, the real estate market in the Czech Republic had to go through a lot of "catching – up" and adjustment, but not only in structural and institutional terms. There had to be some convergence also from the mere point of view of price levels, which were very low, compared to the Western Europe. Šaroch (2004, p.4) states that "It is typical for a converging economy that prices (and volumes) of transacted assets are determined not only by cyclical fluctuations and growth rate, but also by real convergence."

4.3. Data Issues

The Czech Republic is no exception in that the data collection is a difficult task. In fact there has been no official indicator of real estate prices until 1998, when the Act no 151/1997 Coll., on Asset Evaluation, came into effect (Matalík, Skolková, Syrovátka, 2003). This act obligates financial and land register authorities to pass information about prices of property transactions to the Ministry of Justice and the Czech Statistical Office.

Source data come mainly from compulsory price declarations. Therefore, they present a reliable source of information in the way that the prices are real amounts that were actually paid. On the other hand, we can suspect that in a certain portion of declarations, there is a tax optimization taking place. As a counter-argument, Matalík, Skolková, Syrovátka (2003, p.190) claim that "... in a relative comparison of prices over time and generally also in the real estate's location this objection has no weight since it can be posited that any such distortion remains, on average, constant."

Apart from this official source, there are also some representatives of the private sector who compete to achieve a similar goal. They use various methods – including estimates on the basis of economic theory[10] or monitoring asking prices of advertised properties for sale. One issue with these professional services is that they are, of course, paid. Another obstacle might be their availability - for example, they are not offered as paid service online, but they are published only in a specialized

[10] The economist Pavel Kohout uses quantitative theory of money to construct his index of real estate prices. For more information, see www.p-index.cz.

journal in the form of current values only (no time series) and not available in an electronic form.

For the regression models used in this paper, we shall use the time series of the index of property prices, provided by the Czech Statistical Office. It seems reasonable. Obviously, it is a source that is readily available, but also comes from an official authority guaranteed by the state, which should ensure certain consistency and precision, and moreover, has a long enough duration. These advantages outweigh the disadvantages, such as a long delay of the data or the tax optimization issue, which we have mentioned in the paragraph above.

5. ANALYSIS OF REGIONAL FACTORS

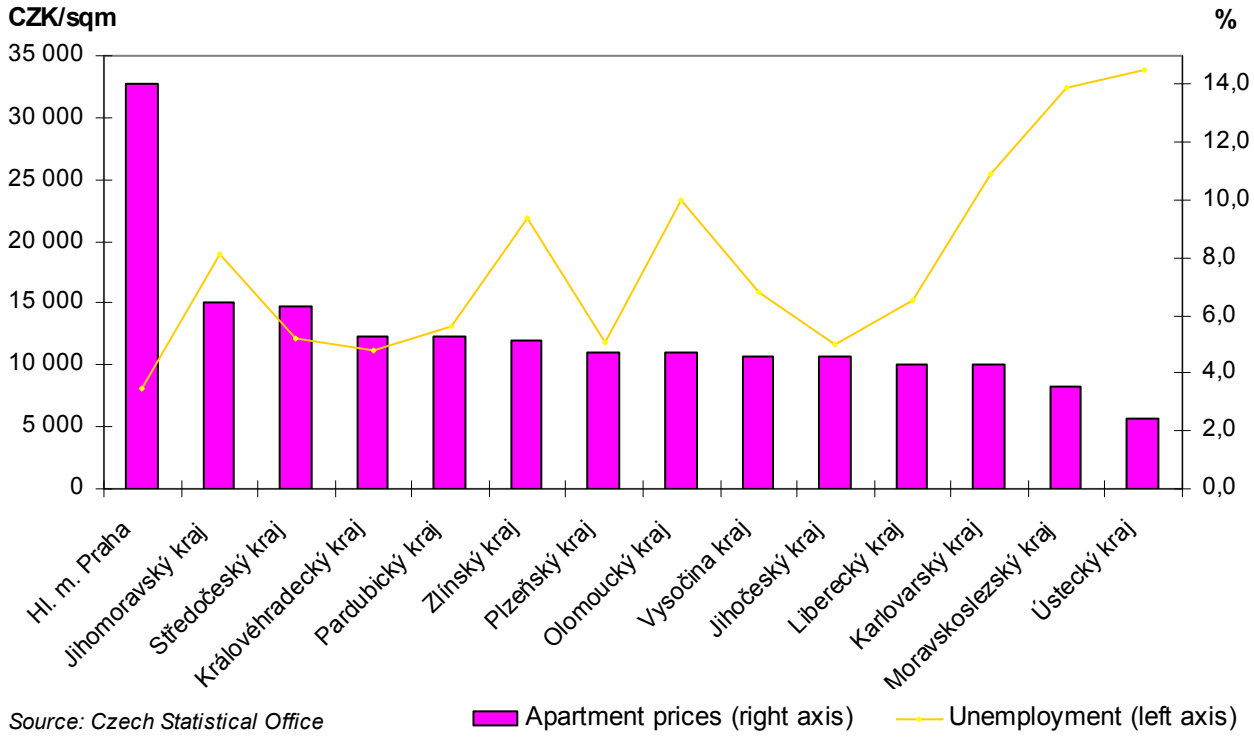
5.1. Unemployment

Economic relationships on the regional level are already on the border between macroeconomics and microeconomics; however their consequences can substantially influence the development of the aggregate economy. That is why we will at least briefly investigate implications of these local influences on real estate prices. Throughout the whole chapter, we use end-of-year data of Czech regions ("kraje", NUTS-3 units) for the year 2005.

Relevance of unemployment for real estate prices lies more in the regional comparison. On the aggregate level, we can hardly assume a logical direct dependence. Even the statistical one is non-existent – coefficient of correlation between the two variables during 1998 – 2005 is 0.043. Let us look at the figure 5.1 where we can see regional breakdown of apartment prices and unemployment.

FIGURE 5.1

Unemployment and average apartment prices per square meter in 2005



Source: Czech Statistical Office

Although we could probably claim that there is an obvious relationship from the first look, let us rather use "hard" statistical methods and test it. Nevertheless, a default hypothesis that real estate prices are negatively influenced by demand for labour seems to be intuitively correct – we would expect that there would be a connection. After all, price of a property is, for the most part, determined by local factors (DiPasquale and Wheaton, 1996), and that does include the labour market in the neighbourhood. Moreover, we have demonstrated some relationships in the general overview in chapter 2.

For the purpose of our analysis, we shall initially inspect the statistical correlation between the two variables and then, we will present a very simple regression model. The particular data sample to be tested is unemployment and apartment prices per square meter in the individual regions from 2003 to 2005. We can see the results of the calculation of the correlation coefficients in the table 5.1. (ρ stands for correlation coefficient).

TABLE 5.1

Correlation of average apartment prices and Unemployment among regions

Year	2003	2004	2005
ρ (whole CR)	-0,4482	-0,5783	-0,5689
ρ (without Prague)	-0,5248	-0,7114	-0,6714

Let us firstly examine the first line. A correlation with a negative sign is indeed present, even if perhaps slightly weaker than we would expect. However, just from a brief look at the regional graph, we can see that Prague is an outlier point with apartment prices more than two times bigger than the second most expensive region. If we remove the Prague observation from the sample, we should obtain higher correlation coefficients. The second line of the table confirms this conjecture.

Another strange thing is the sudden increase of correlation after the year 2003. What might be the reason? A possible explanation could be that the mobility for better employment prospects became easier with the mortgage loan boom in those years. The fact is also explicitly mentioned in Financial Stability Report of the Czech

National Bank for 2005. Czech Statistical Office (2007) documents increased migration in the period in question, as well[11].

For further analysis let us use a simple linear regression model:

$$P_i = \beta_0 + \beta_1 U_i + \varepsilon_i$$

P stands for the average price per square meter of an apartment, *U* is unemployment and ε is random error. Results of the estimation match the model's simplicity: the model explains the behavior of real estate prices with 32% reliability, β coefficients are significant both separately and jointly; however, the value of the F-test for joint significance is relatively low (5,7; p-value = 3,4%).

Now, let us incorporate the information discovered during the correlation computations to improve the model. We won't remove the Prague observation from the sample. Instead we will introduce a binary variable *PRAGUE*, which equals 1 for the observation from the Prague region, and 0 for any other observation. Therefore, we obtain the following equation:

$$P_i = \beta_0 + \beta_1 U_i + \beta_2 PRAHA_i + \varepsilon_i$$

Improvement of the model is sharp – Prague region is really very specific in this context. R2 equals 0,92, the model thus explains 92% of variations of real estate prices. The F-test statistic is several fold higher, as well. After estimation, we receive the following form (the numbers in parentheses are p-values):

$$\underset{}{P_i} = \underset{(.000)}{15098.5} - \underset{(0.012)}{492.45}\, U_i + \underset{(0.000)}{19373.1}\, PRAHA_i$$

The results are excellent; however, we had to resort to use of a dummy variable. We will therefore try to explain the regional differences in property prices by factors other than a simple dummy. This time, let's continue with a socio-demographic factor.

[11] The publication also provides a specific discussion of the more long-term general tendencies.

5.2. Immigration

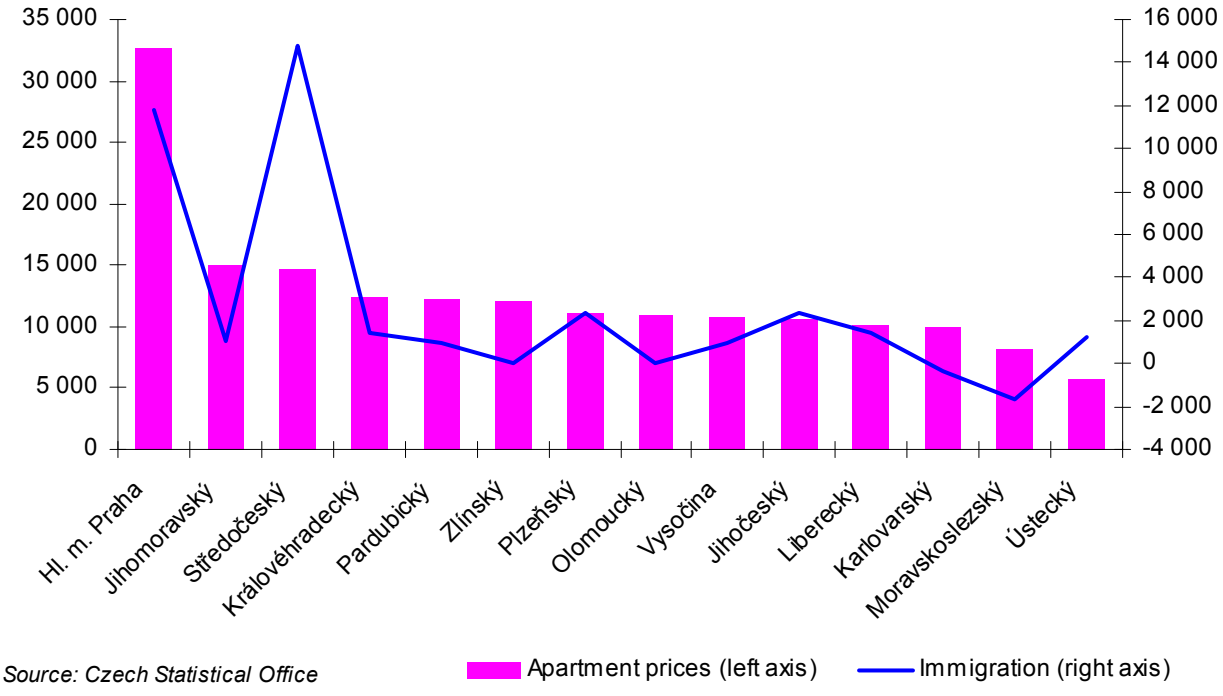
Real estate prices are no doubt highly influenced by socio-demographic factors. Some of them, or their effect on the prices, might be hard to quantify. Since this is mainly a quantitative economic analysis, we will try to address the effect of only one such factor, which is at the same time not that difficult to measure - immigration.

One reason we have chosen only this variable was already hinted at - we want to keep our analysis simple. In that respect, we wanted to choose a variable that would have an obvious, clear effect on the prices of real estate and represent well the overall socio - demographic situation. Moreover, Lux, Sunega, Mikeszova, Večerník and Matyáš (2006) point out findings of empirical studies, showing that migration from professional reasons is less frequent than a migration caused by motives related to the life cycle theory (Lux Sunega, et al., 2006, p. 10). We should therefore focus more on the general nature of migration in hope to grasp also its other determinants.

In the case of immigration, we monitor the numbers of new immigrants into the particular region. If positive, such an inflow of population should, ceteris paribus, raise the demand for housing services and thus lead to higher real estate prices. Some tendencies might be seen on the graph of the two variables.

FIGURE 5.2

Average apartment prices and net number of migrants in regional comparison (2005)



Source: Czech Statistical Office

Let us compute the correlation coefficients to better evaluate that relationship. In 2005, correlation between the two monitored variables is 0.67, which is quite a strong relationship. In this case, the "Středočeský kraj" (Central Bohemia region) seems to be the outlier point. Were we to remove the Středočeský kraj from the sample of observations, we would acquire a much higher coefficient with the value of 0.91.

Our goal in this paper is a macroeconomic analysis, so we shall not explore the reasons of that particularity in detail. Nonetheless, we can state our suppositions about the situation. We believe that the cause behind is the excessive inflow of people who work in Prague but prefer to live outside, be it for financial or other reasons, and thus they move to the Central Bohemian region which surrounds Prague. Some of them are Prague citizens who prefer suburbs to central areas while others might simply be newcomers from all of the country who cannot yet afford a living in the capital. Moreover, there have been studies proving, that the tendency of "suburbanization", moving of metropolitan inhabitants outside of bigger cities, has been increasing in recent years (Czech Statistical Office, 2007). Another reason for this disproportion might be the fact the prices reported in the graph are apartment prices, whereas the new migrants to the Central Bohemian region tend to move to houses, instead.

We will now return to our earlier model from the unemployment subchapter, remove the dummy variable and instead, use the numbers of new immigrants per region. When estimated in the usual way, the model shows mediocre significance of coefficients and mainly, signs of heteroskedasticity are detected (p-value of White test = 0.017). We proceed accordingly by estimating the model with White's heteroskedasticity-robust standard errors. This is the estimated equation (the numbers in parentheses are p-values), where I is the net migration into the observed region:

$$\underset{}{P_i} = \underset{(0.002)}{14956} - \underset{(0.396)}{525.6}\, U_i + \underset{(0.174)}{0.69}\, I_i$$

The goodness of fit, as measured by the R^2, is approx. 0.5. That is good compared to our original estimation with only *U* as an explanatory variable, but the model suffers from low significance of the parameters. Consequently, interpreting the parameters is problematic. We conjecture that the overall mediocre, if not worse, reliability of this

last model is due to collinearity of the two variables. Immigration itself might be in fact influenced by regional unemployment which of course distorts the results. To explain the regional differences in real estate prices, we will now return to labor market determinants once again to see if we can complement our earlier calculations.

5.3. Wages

There are several reasons for including wages in the model. The first of them is connected with economic theory and has been suggested in the chapter 2, namely section 2.6. That is, labour market fluctuations can have direct impact on the real estate markets. We would expect regions with higher wages to have more expensive housing. Besides, wages are sometimes put in relation with property prices through the price/income ration, where price of an average dwelling is divided by average yearly income. It serves as a predictor of a real estate bubble.

Apart from these general reasons, there are also related econometric issues. It might be practical to use wages in our estimations not just because immigration has proven to have dubious explanatory power. It is chiefly because we hope to cope with our dummy problem - wages should at least partially explain the particularity of Prague with respect to property prices. We should therefore obtain a more natural model without having to resort to dummies. As Kennedy (2003, p.254) puts the issue of observation specific dummies: "...these dummies could play a major role in generating a high R^2, hiding the fact that the independent variables have little explanatory power."

However, there is an issue to be addressed if we are to incorporate another labour market-related variable. First off, we must inspect whether the Wages and Unemployment are not too correlated which could consequently cause multicollinearity problem in the estimation. In 2005, their correlation coefficient is -0.37 which we find to be sufficiently low. That means their relationship is not very close and hence, each one of them should explain a different part of the variation of regional prices.

We will add wages to the other two variables. The table 5.2 shows the results of the estimation and related tests in detail:

TABLE 5.2

Regression results

variable	coefficient	t - statistic	p - value
const.	-29755.3	-3.51	0.006
U_i	-575.38	-2.43	0.036
W_i	2.65	5.46	0.000
I_i	-.2031	-.85	0.417
test		**statistic**	**p-value**
R^2		0.877	-
adjusted R^2		0.841	-
F-test		23.91	0.00
Jarque - Bera		0.92	0.632
White Het.		13.69	0.134

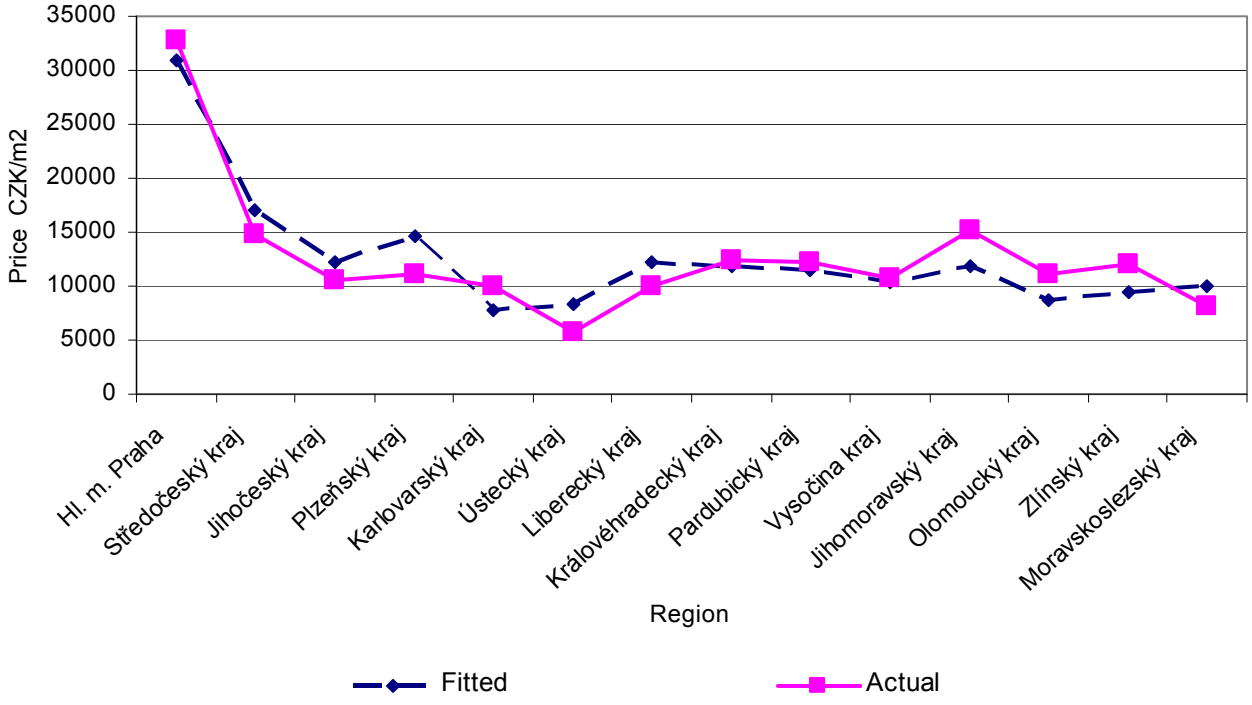
The model seems solid in terms of potential to explain the regional property prices with adjusted R^2 equal to 0.841. Together, the variables are significant. This time heteroskedasticity isn't present, but the number of net immigrants is insignificant, whereas the other two variables contribute highly to the explanatory potential of the model. We suppose that it is because wages and unemployment implicitly bear with themselves some information about migration already, since each of them influences it in some way. This therefore makes the immigration variable redundant. Removing it from the equation yields, after estimation, the following form (the numbers in parentheses are p-values):

$$P_i = \underset{}{-\ 25917.6} \underset{(0.004)}{-\ 491.202\ U_i} \underset{(0.041)}{+\ 2.37\ W_i} \qquad (0.000)$$

We now put the prices in individual regions estimated by this regression in comparison with the real prices. See the results on the graph, figure 5.3.

FIGURE 5.3

Final regression results



5.4. Interpretation of the Results

In this chapter, we tried to address the regional differences in prices of real estate, mainly from the point of view of labour markets. As a representative of the socio-demographic aspects, we also tried to include immigration into the research. However, it has show very little relevance to the variation of real estate prices in different regions. Although we did keep our analysis quite simple, this seems a bit strange. We believe this might be because the two labour-market variables we have used, wages and unemployment, are in fact, factors of migration, themselves. Because of that, the explanatory potential of immigration was somewhat distorted.

Methods and data employed seem to fit quite well the values of regional property prices, showing that prices in region are from a large part determined by the level of wages and rate of unemployment. The comparison of actual prices and those estimated by the model could be in fact used to predict future price movements. If prices are driven so much by fundamentals, we can therefore conjecture that certain regions are either over- or underpriced and the prices should adjust accordingly. For example, the most overpriced region seems to be the South Moravia (*Jihomoravsky*

region, capital: Brno), whereas we would expect the prices to rise the most in Pilsen (*Plzensky*) region.

With the focus of this work lying mainly on the aggregate level of the economy, we have limited the chapter's depth to a basic overview. The domain at hand is a much more complex one and deserves a specific approach and research which is beyond the scope of this chapter and the paper, as well[12]. An interesting direction for further research could be, for example, a model working not just with aggregate numbers, but rather trying to capture the simultaneous flow of migrants among regions with the help of various other variables.

[12] The issue has been addressed in Lux, Sunega et al. (2006) with the focus on the Czech Republic. The authors provide a good survey of international sources in the first part of their work.

6. TIME SERIES ANALYSIS OF PROPERTY PRICES

6.1. Introduction

If one is to examine factors of real estate markets, such an endeavour is hard to imagine without including the development of real estate prices throughout time. With the help of techniques of time series analysis, we will try to grasp both the short and long run relationships of the key real estate variables among themselves, as well as with respect to general macroeconomic indicators. The models outlined below were partly made on an "ad hoc" basis. Still, although intuitive economic reasoning has been used extensively, much insight has been obtained from studying theoretical models, mainly the stock – flow model proposed by DiPasquale and Wheaton (1996), which we have summed up in chapter 3. Moreover, the quantitative analysis required rigorous econometric methods. Their overview will be given in Appendix.

6.2. Prices of real estate – model specification

Prices of residential housing, although being very important for the issue at hand, have also proven to be quite difficult to model and make conclusions about. Basic methods such as OLS wouldn't work. There were two main problems with this elementary method. Apart from autocorrelated residuals, more importantly, the results we arrive at might be entirely spurious. Prices of housing as an explained variable, not surprisingly, follow a trend. Similarly, several of the explanatory variables used in this early stage of research were trended and consequently, non-stationary. The used variables may seem significant and relevant. However, it might easily be the trend these variables follow that "explains" the variation of the dependent variable, instead of an underlying economic relationship, as would be desirable. Estimating an autoregressive process would be possible, but we wanted to explore the relationships among different fundamental variables which the latter wouldn't allow.

Hence, more advanced econometric methods had to be employed. Links of real estate markets and fundamental economic indicators during longer timeframe were originally considered as one of the key topics for this thesis. For this reason, when other methods failed, Cointegration, a method usually used to identify long term relationships, seemed as a viable alternative. We will use specifically the Engel-

Granger two-stage procedure, as outlined in Thomas (1997)[13], in order to cover also the short-term dimension. The core of the method is as follows: in the first stage we estimate the cointegration equation by basic OLS, which serves to identify long run relationships between the variables, and store the residuals as a proxy for the real disequilibrium error. These are then added into an Error Correction Model (ECM) form in the second stage. This is perfectly in line with the nature of the ECMs, which are based on the assumption that there exists an equilibrium long term relationship between a set of variables and any departures from the equilibrium are merely temporary disequilibrium errors. The inclusion of the residuals from the long run cointegration equation will then serve to equilibrate the ECM.

Let us pass then to the first stage, by firstly listing the variables used, and providing their basic statistical details below. The observation frequency and timeframe is determined by the availability of the data on property prices. The observations are quarterly from 1998 to half of 2007:

- Real Property prices (P) – measured by an index of average apartment prices as a dependent variable. We have taken the time series provided by the Czech Statistical Office which is in nominal terms and transformed it into real terms by CPI.

- Gross domestic product (*Y*) – in real terms, as an indicator of household income and therefore, a demand factor. GDP should also cover potential cyclical movement of the economy. As we already mentioned, real estate industry behaves procyclically. This variable's coefficient should obviously have a positive effect on property prices.

- Total volume of morgage loans (*M*) – again deflated to real terms by CPI. Here we make a reference to the empirical observations about the interconnected cycles of real estate and credit markets, mentioned in chapter 2. We would thus expect a positive relationship between the two.

- EU Accession (*DEU*) – a dummy variable that equals 1 over the period 1 year prior to the EU accession in Q2 2004, and 0 otherwise. We have incorporated it to test a hypothesis whether the prices of real estate indeed did reflect the

[13] The overview of the method will be provided in the appendix.

pre-EU accession fears of rising prices of housing. If so, the estimated coefficient should be positive.

See below the statistical details of the employed variables. These are their real values, in model however, they used in their natural logarithm form.

TABLE 6.1

Descriptive statistics

variable	avg.	median	standard error	min.	max.
P	113,51	123,13	20,03	80,04	143,21
Y	598465,14	580528,00	54708,32	498865,00	757202,00
M	107682,14	74472,84	73900,93	16795,59	326871,32
DEU	0,11	0	0,19	0	1

In the first stage, we have estimated the following simple OLS equation:

$$P_t = 10{,}91 - 0{,}69\ Y_t + 0{,}26\ M_{t-1} + 0{,}14\ DEU_t$$

Since all the variables are non-stationary, it does not make sense to report any diagnostic or other statistics, such as t-ratios. Non-stationarity of the variables causes the errors to follow other than standard distributions. At least, the estimation should have fairly high R^2 to prevent small sample bias, which it has. The adjusted statistic equals *0,87*. Cointegration is ensured if the residuals from this regression are stationary. We can reject the hypothesis of non-stationarity with only 66% confidence (in this case, H_0 = non-stationarity p-value is *0,34*). This seems as a very high tolerance, yet we will continue this way for chiefly two reasons. Firstly, the stationarity of the residuals is tested by an Augmented Dickey-Fuller test, which is known to somewhat lack power – it may make some data as not stationary even if they, in fact, are stationary. Secondly, Thomas (1997, p.444) suggests that, if the residuals themselves prove to have a non-zero negative coefficient in the subsequent ECM estimation, it means that they indeed press the relationship between the selected variables in an ECM to an assumed equilibrium. We can then consider the variables to be cointegrated. This complicated procedure will be clearer from the model specification.

The general form of the ECM is as follows (all variables, except DEU in logs):

$$\Delta \ln P_t = \sum_{i=0}^{3} \alpha_i \Delta \ln Y_{t-i} + \sum_{i=0}^{3} \beta_i \Delta \ln M_{t-i} \sum_{i=1}^{3} \gamma_i \Delta \ln P_{t-i} + \delta \cdot DEU_t - \lambda e_t + \varepsilon_t$$

Recall that the e_t are the (true) disequilibrium errors and we will replace them with the residuals $\hat{e}_t$ from the cointegration regression to estimate the according parameter λ. If this parameter is significant, it will confirm that there is a long-run relationship between *P, Y* and *M* - that they are cointegrated.

The model required serious testing down, and many variables were dropped. The final form is the following:

$$\Delta \ln P_t = -0{,}12\ \Delta \ln Y_{t-1} + 0{,}17\ \Delta \ln Y_{t-2} + 0{,}51\ \Delta \ln P_{t-1} + 0{,}43\ \Delta \ln P_{t-4} - 0{,}046\ DEU_t + 0{,}082\ \hat{e}_t + \varepsilon_t$$

The coefficient on cointegration residuals emerged statistically different from zero but alas; we immediately see that its sign is positive, which would imply widening disequilibrium. We thus cannot assume cointegration between property prices, real output and total volume of mortgage loans. Taking an inspiration in Thomas (1997, p.452), we will try a different specification, using an ECM right from the outset by itself in its default form:

$$\Delta \ln P_t = k + \sum_{i=0}^{3} \alpha_i \Delta \ln P_{t-i} + \sum_{i=0}^{3} \beta_i \Delta \ln M_{t-i} \sum_{i=1}^{3} \gamma_i \Delta \ln Y_{t-i} + a \ln P_{t-1} + b \ln M_{t-1} + c \ln Y_{t-1} + \varepsilon_t$$

Again, in line with the "general-to-specific" nature of the ECM, the specification had to be simplified due to insignificance of many of the coefficients. This is equation in the form the shows its error–correcting function: the parameter in front of the parentheses has a negative sign and is significant, meaning that should the relationship get off-balance, it will be at least partially corrected in the next period.

$$\Delta \ln P_t = 0{,}644\ \Delta \ln P_{t-1} - 0{,}118\ \Delta \ln M_{t-1} - 0{,}102\ \Delta \ln M_{t-2} - 0{,}069\ \Delta \ln M_{t-3} - 0{,}719\ \Delta \ln Y_t - 0{,}378\ \Delta \ln Y_{t-3} - 0{,}227\ (\ln P_{t-1} - 42{,}64 - 0{,}577\ \ln M_{t-1} + 3{,}326\ \ln Y_{t-1})$$

The results, including statistics of major diagnostic tests, are stated in the table below. We can see that all the coefficients are strongly significant and

furthermore, the model has a fairly high goodness of fit taking into account the fact the dependent variable is a series of quarterly changes.

TABLE 6.2

Regression results

variable	coefficient	t - statistic	p - value
const.	9,682	4,218	0,000
$\Delta ln\ P_{t-1}$	0,644	5,337	0,000
$\Delta ln\ M_{t-1}$	-0,118	-3,768	0,001
$\Delta ln\ M_{t-2}$	-0,102	-3,867	0,001
$\Delta ln\ M_{t-3}$	-0,069	-3,06	0,005
$\Delta ln\ Y_t$	-0,719	-5,104	0,000
$\Delta ln\ Y_{t-3}$	-0,378	-3,791	0,001
$ln\ P_{t-1}$	0,227	-4,499	0,000
$ln\ M_{t-1}$	0,131	4,402	0,000
$ln\ Y_{t-1}$	-0,755	-4,127	0,000
test		**statistic**	**p-value**
R2		0,75	-
adjusted R2		0,65	-
F-test		7,91	2,45e-005
Jarque - Bera		0,57	0,75
White Het.		17,7	0,48
LM test for autocorrel. up to 4^{th} *order*		2,59	0,079

6.3. Interpretation of the Results

Through the use of rigorous and quite advanced econometric procedures, we have obtained a fitting model with statistically highly significant coefficients on the variables employed. Alas, its economic interpretation is complicated, if not impossible. Although the growth of mortgage market has proven to have a significant effect at least in the long-run, GDP seems to have a negative impact on the development of property prices both in the short and the long-term. What might be the explanation?

Attempting to interpret such results might lead easily to misleading conclusions. It is hard to imagine, that growth of output could lead to a fall of prices of

housing. There might be, however an econometric explanation, which is related with the nature of the data. It is possible that the two series have gone through several quarters of opposite developments during the observed timeframe. There were multiple cases where one fell while the other one grew, which might have lead the model to assume a negative relationship between the two. Similarly, the case at hand might be an existence of some complex lagged relationships. Such relationships could then have manifested themselves by these unexpected results.

Furthermore, there is a possible explanation of this problem in line with what has been stated in the earlier part of the paper, specifically in chapter 4. There, we have talked about the maturity of the market, and about testing the hypothesis that real estate market in the Czech Republic is being driven mainly by fundamental economic factors. The result of our model being what they are, that is not having a sensible economic explanation; we would be inclined to reject that hypothesis. That means that in terms of prices, the real estate market has yet to finish the process of structural adjustment - it is under influence of other than fundamental variables or at least, those influences are still quite strong. We will see if the same is true in terms of new construction taking place in the next chapter.

7. TIME SERIES ANALYSIS OF NEW CONSTRUCTION STARTS

7.1. Introduction

Whereas the previous model tried to describe mostly the elements of the demand side, we will now turn our attention to the factors influencing the supply. A perspective from the other side should help make a more complex idea about the functioning of the Czech real estate market on the aggregate level. We will both re-use several of the variables from the previous model, as well as introduce some new ones. Needless to say, as we are inspecting the determinants of supply, the interpretations of the reused variables will differ from the preceding chapter. Specifically, we will try to explain the amount of construction starts of new apartments.

The amount of started construction per period might be interpreted as a change of supply of housing (more precisely, future change of supply). In order to outline an appropriate specification, an insight might be gained from the obvious relationship between property prices and new construction, which should, according to the theory (e.g. Hilbers, Lei, Zacho, 2001), increase if a sale price of a property rises above (falls below) the „replacement cost“. Active construction should then continue (stop) until the price falls (rises) back to the level of these costs. This is connected with the concept of real estate cycles that was discussed in the second chapter.

When designing this model, we were partly inspired by the one that Fallis has created for the Canadian real estate market with solid results, and which we have discussed in chapter 3. Another insight, regarding the absolute employment as a proxy for the number of households, has been pulled out from the work of DiPasquale and Wheaton. Their equation of supply, however, is not usable due to lack of data (either on the depreciations of housing stock, or the stock itself). Nonetheless, in the future, this issue might be a viable topic for further research. We will elaborate more on this possibility in the conclusion.

7.2. New Construction Starts - Model Specification

This time we will proceed directly with the ECM specification as cointegration analysis was completely inconclusive. The period covered and observation frequency is the same as in the previous chapter. The dependent variable

shall be the number of newly started apartment constructions in the quarter. By using a flow series, rather than a stock, we should eliminate autocorrelation. Still, the series of construction starts is non-stationary and so we shall use its first difference instead. The interpretation should not become all too difficult. As exogenous variables, we use the following:

- Real Property prices *(P*) – measured by an index of average apartment prices. We have taken the time series provided by the Czech Statistical Office which is in nominal terms and transformed it into real terms with CPI. As we mentioned above, they should present a primary incentive for developers, and thus, we would expect a positive effect on the new construction.

- Difference between 1-year and 2-week PRIBORs (*YCS*), which can be interpreted as a yield curve slope. When pre-testing various models before, this difference has shown high significance, much higher than standard PRIBOR series. Inferences about its sign can be actually made both ways. One interpretation takes the perspective of the investor – larger long-term rates could induce them to lend more money, which could be then used to finance long term development projects. The other perspective is that of a buyer – the smaller the slope, the lower is the premium on long term loans and thus, the larger the demand for residential properties.

- Average wages of construction workers (*RCW*) in constant 1998 prices – in case of a proven dependence, we would expect a negative effect. The significance will depend on the proportion of workers' wages on overall developers' costs.

- Total Employment (*E*) – as a proxy for the number of households. As such it represents demographic factors of demand and a negative sign of its parameter is expected.

- Quarterly dummies (*D1, D2, D3*) – to cover the generally well known seasonal aspect of the construction industry.

The overview of variables in the above order (starting with the dependent variable), with their marks and basic statistical attributes, can be seen in table 7.1.

TABLE 7.1

Descriptive statistics

variable	avg.	median	standard error	min.	max.
starts	9036,24	9042,00	1168,94	5788,00	12280,00
P	113,51	123,13	20,03	80,04	143,21
rcw	660128,57	652857,00	81878,96	507358,00	831756,00
empl	4765,90	4750,70	45,71	4675,88	4913,90
YCS	0,2	0,28	0,28	-1,23	0,68
D1	0,24	0	0,37	0	1
D2	0,27	0	0,39	0	1
D3	0,24	0	0,37	0	1

This is the final form to be estimated:

$$\Delta \ln CS_t = k + \sum_{i=1}^{3} \alpha_i \Delta \ln CS_{t-i} + \sum_{i=0}^{3} \beta_i \Delta \ln P_{t-i} + \sum_{i=0}^{3} \gamma_i \Delta \ln CW_{t-i} + \sum_{i=0}^{3} \delta_i \Delta \ln E_{t-i} + \sum_{i=0}^{3} \tau_i \Delta \ln YCS_{t-i} + \sum_{i=1}^{3} \theta_i D_{it} + a \ln CS_{t-1} + b \ln P_{t-1} + c \ln CW_{t-1} + d \ln E_{t-1} + e \ln YCS_{t-1} + \varepsilon_t$$

Note that the natural logaritm of YCS is in fact a difference of logaritms of the corresponding PRIBORs, this is just a simplifying designation. After dropping all variables with their p-values over 0,1 as insignificant, the resulting equation, rewritten in the error-correction form, was:

$$\Delta \ln CS_t = 0{,}28 \Delta \ln CS_{t-1} - 2{,}86 \Delta \ln P_{t-2} - 1{,}45 (\ln CS_{t-1} + 32{,}33 - 0{,}49 \ln P_{t-1} - 4{,}62 \ln E_{t-1} + 0{,}155 D_{1t})$$

In the table below, we can see summary of the regression. All of the variables are strongly significant and the goodness of fit, as measured by R^2, is highly respectable since we were modelling a series of differences. The results of all auxiliary diagnostic tests are satisfactory. We can now proceed to the interpretation.

TABLE 7.2

Regression results

variable	coefficient	t - statistic	p - value
const,	-46,85	-2,706	0,012
$\Delta \ln CS_{t-1}$	0,279	1,82	0,08
$\Delta \ln P_{t-2}$	-2,865	-3,493	0,002
$\ln CS_{t-1}$	-1,445	-5,987	0,000
$\ln P_{t-1}$	0,708	5,051	0,000
$\ln E_{t-1}$	6,706	3,093	0,005
D_{1t}	-0,225	-5,562	0,000
test		**statistic**	**p-value**
R2		0,8	-
adjusted R2		0,75	-
F-test		18,12	0,000
Jarque - Bera		0,65	0,72
White Het,		30,27	0,256
LM test for autocorrel, up to 4th order		2,03	0,13

7.3. Interpretation of the Results

If we take the differences as short-run and the non-differenced variables as long-run factors, we will see that although the short-run elasticities are somewhat hard to interpret, the resulting long run elasticities are completely in line with our expectations without any ambiguity. The short-run elasticity of new construction with respect to its own past values (the parameter on $\Delta \ln(CS_{t-1})$) could be regarded as a sort of inertia. The short-run elasticity of construction with respect to prices does not have any clear interpretation. On the other hand, we see, that in the long run relationship (the term in parantheses can be interpreted as a disequilibrium departure from such relationship), construction starts are positively correlated with both prices of housing, and with the proxy for number of households.

The parameters in the default form of the ECM equation (with the parentheses multiplied out), make sense, as well. The interpretation of the two explanatory variables remains the same; however, we see that the coefficient on the part construction starts is negative. Intuitively, this would be imply that, ceteris paribus, should the amount of new construction in the past period be extraordinarily

high, developers in the current period will slow down the pace of starting new projects. Here is a list with a formal and detailed assessment of each parameter's effect on the explained variable:

- Property price index – we assumed a positive effect which was confirmed in the long run. The model predicts that if the index of real estate prices rose by 10%, ceteris paribus, 5% more flats would be started. The short-run interpretation is a bit trickier – it is the disadvantage of using non-stationary, differenced variables. All other things held constant, the quarterly change of new construction would fall by 30%, if prices of real estate increased by 10% half a year ago. We see this interpretation is somewhat ambiguous.

- Employment – confirmed its anticipated effect as well, yet only in the long-run. According to the model, in the longer term, should the total number of employed increase by 10%, the new construction starts would increase by almost 50%. In the short run, the elasticity of construction starts with respect to employment is equal to zero.

- Construction workers' wages – did not prove to have influence the amount of new construction in a significant way. This is perhaps because their real growth has been in the recent years slower than the housing prices appreciation, so developers were somewhat indifferent to this part of their costs.

- First quarter – ceteris paribus, first quarter of the year means 15% less of started constructions of new apartments in the long run.

Moreover, it would be helpful to see how the estimated values compare to the real ones. Below, you can see firstly the differences of logs from the model itself and then, with the derived absolute values of construction starts. As can be seen from the both graphs, although the former shows it particularly, the model succeeded very well in covering the various tops and bottoms of the time series (at least partly caused by seasonality), including the most extreme ones. That is a good sign and yet another assurance of the model's reliability.

FIGURE 7.1

Graph of actual and fitted values of Δln CS_t

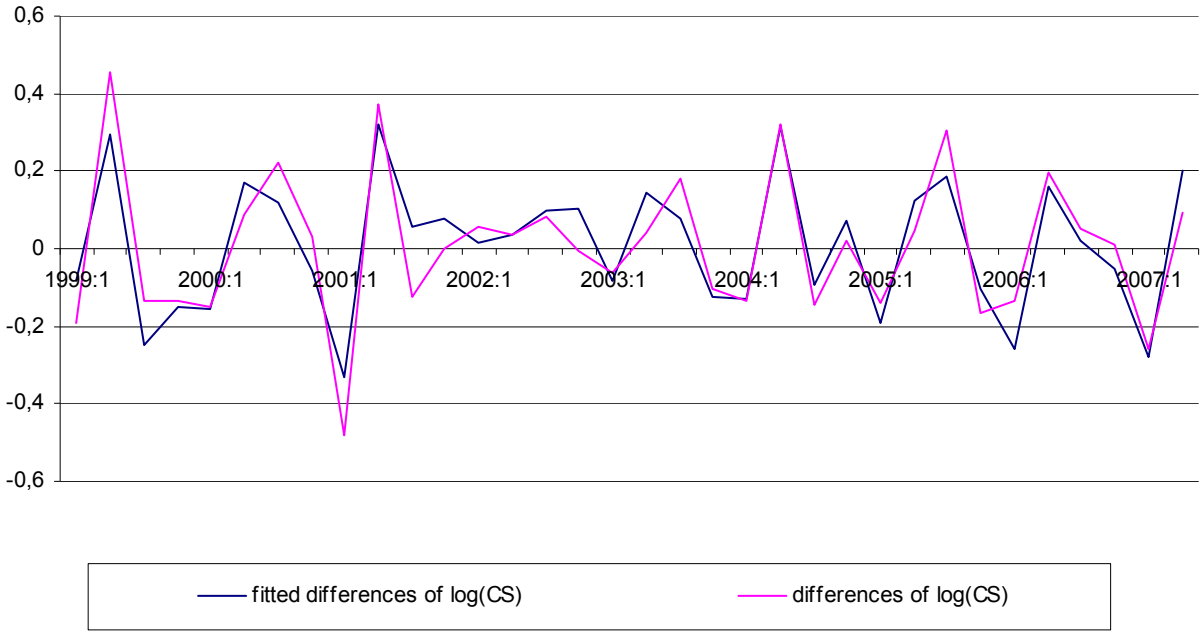


FIGURE 7.2

Graph of actual and fitted values of CS_t

Although up-to-date data on both property prices and construction starts are not yet available, we can make some preliminary and rough suppositions about the development following the end of the sample period. As the growth of prices has been reported to have accelerated last year, we presume that the number of new construction starts has risen as well. On the other hand, regarding the future developments, our conclusions are different. Increasing inflation and rising interest rate will make financing of homeownership less appealing and thus will erode demand. Supply, represented partly by developers, might on the other hand sober up and decrease the number of new projects. There are multiple reasons for this happening. Firstly, it might simply be due to the fall of demand mentioned in this paragraph. Other reason can be explained by the model developed. Rate of price increase will decline and as prices are a major long-run factor of new construction, the latter will decline as well. Yet another reason could be an empirical example of the issue of construction lags. There are many competing schemes in development and projected for completion at similar dates, some of them just a few hundred meters far from each other. Because of the fact the apartments are usually sold and paid in advance, the prices of these projects will probably not fall but instead, next "wave" of development will be less intensive.

The determinants we have chosen – macro-level indicators and a seasonal dummy – can be considered as more or less fundamental factors. The variables that have proven to have the most consistent influence on the new construction are the prices of real estate and the first quarter of the year. Therefore, this implies that almost a decade after the velvet revolution, the supply of residential housing, or more precisely, its change, is determined by basic fundamentals.

8. CONCLUSIONS

This paper tried to address at least some of the local aspects of the real estate market. We have listed several qualitative or structural influences but the core of the paper lied in the use of econometric methods. By evaluating the impact of economic and social variables on the real estate market, we have implicitly assumed its maturity. The estimation might be thus understood as way to test for the hypothesis of completed structural adjustment of the market to the capitalist system. The results of this test varied.

We have found an ad-hoc model that captures quite well the variation in real estate prices across regions by using wages and unemployment as explanatory variables. These labour market factors have proven to have a highly significant effect on the regional housing prices. We would be inclined to claim that regionally, prices are determined by fundamental factors.

However, the same was not true in the case of time series analysis of prices. By using the error-correcting method, we have obtained a significant and well-fitting model with dubious parameter estimates that can be hardly interpreted in a reasonable way. The explanation might be that in this case, transformation of the market is still in progress.

Lastly, we have devised a model of quarterly construction starts of new apartments, again in time. This series has shown to be determined with respectable reliability by housing prices, total number of employed as a proxy for number of households, and a seasonal dummy for the first quarter. Given the statistical significance of the parameter estimates and goodness of fit of the overall model, the conclusion is to accept the model. Consequently, the series appears to be fundamentally driven.

Are there any practical policy implications to draw from the results of the thesis? The outcome of the cross-regional estimation could definitely serve for specific locally-based policies, so that politicians have better understanding of the topic when considering, e.g. an investment incentive to boost the labour market in a particular region. The issue of the development of the property market in time is more complicated. Moreover, it is also true that country-wide policies with respect to housing are much less common in the Czech Republic – the market is provided with ample freedom to arrange itself. Given this complexity, we would advise a careful

observation of the market to ensure its stability. An explicit example would be the case of the financial sector which, as we have mentioned in chapter 2 is intertwined with the housing market. The influence of the booming mortgage market has certainly manifested itself. Finally, we would definitely agree with the central bank representatives (Matalík, Skolková, Syrovátka, 2003) that there is a strong need for reliable and mainly up-to-date data. The data currently available are probably reliable but come with a too long delay. This should be addressed in the future in order to ensure both reliable research results and qualified policy decisions.

There are many possibilities for future research connected with this issue. We have an idea for three main directions. One has been suggested at the end of chapter 5. It could link real estate with demographic and social determinants to, for example, explore the mutual impact of housing markets and immigration. Another option could take a more technical "route". The data on current absolute housing stock or the rate of depreciation were not available to us. If they were, we would be able to better analyse the development of supply, for example, similarly to DiPasquale's and Wheaton's models. However, on could also try to estimate the depreciation parameter. The last approach we have in mind is to focus on the investment aspect of real estate and evaluate its attributes in comparison with financial assets such as stocks or bonds.

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10. APPENDICES

10.1. Error Correction Models

Error Correction Models are one of the methods to cope with non-stationarity of economic data. At the same time, they function according to now widely spread and accepted "general-to-specific" movement in modern econometrics.

To begin, let us assume an equilibrium or long-run relationship between two variables, y and x, with β_0, β_1 being parameters:

$$y_t = \beta_0 + \beta_1 x_t ,$$

which, by definition, holds only if the system is in equilibrium. Obviously, we do allow for the existence of a non-zero disequilibrium error which is equal to:

$$y_t - \beta_0 - \beta_1 x_t .$$

Observed short-run relationship between y and x might include lagged values of both the dependent and the independent variable(s). For the sake of simplicity, let the form be:

$$y_t = b_0 + b_1 x_t + b_2 x_{t-1} + \mu y_{t-1} + \varepsilon_t, \quad 0 < \mu < 1.$$

Note that such a specification implies that it takes time for y to adjust to changes in x. A higher lag with a non-zero b-parameter would suggest longer adjustment period. Now, for the final form, we will rearrange. Firstly, subtracting y_{t-1} from both sides and than adding and subtracting $b_1 x_{t-1}$ from the right hand side yields:

$$\Delta y_t = b_0 + b_1 \Delta x_t + (b_1+b_2) x_{t-2} - \lambda y_{t-1} + \varepsilon_t , \text{ where } \lambda = 1 - \mu.$$

Finally, we reparametrize by putting $\beta_1 = (b_1+b_2)/\lambda$ and $\beta_0 = b_0/\lambda$ to obtain:

$$\Delta y_t = b_1 \Delta x_t - \lambda (y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + \varepsilon_t.$$

This also shows why the method is called error-correcting – we see that the disequilibrium error will be corrected by the parameter λ, which lies between zero and unity. Note that the model is well identified in the senses that after multiplying out the parentheses and estimation, all the parameters' estimates are easily calculated. Moreover, the random error is not autocorrelated, as would be the case of an equation obtained by simply differencing two subsequent periods.

Finally, let us show the form for a more complicated case with 3 independent variables and 2nd order lag. The basic, long term (or equilibrium) relationship is the following:

$$y_t = \beta_0 + \beta_1 x_t + \beta_2 z_t + \beta_3 r_t$$

Let the short-term version with a lag of order 2 be:

$$y_t = b_0 + \sum_{i=1}^{3} b_i x_{t-i+1} + \sum_{i=1}^{3} c_i z_{t-i+1} + \sum_{i=1}^{3} d_i r_{t-i+1} + \sum_{i=1}^{3} \mu_i y_{t-i} + \varepsilon_t$$

We make the following operations: subtract y_{t-1} from both sides, add and subtract $(b_1+b_2+b_3)\cdot x_{t-1}$, $(c_1+c_2+c_3)\cdot z_{t-1}$ and $(d_1+d_2+d_3)\cdot r_{t-1}$ from the right-hand side, add and subtract $\mu_2 \cdot y_{t-1}$ and $\mu_3 \cdot y_{t-2}$ from the right-hand side. Finally, we reparametrize $\lambda=(1-\mu_1)$, $\beta_1 = (b_1+b_2+b_3)/\lambda$, $\beta_2 = (c_1+c_2+c_3)/\lambda$, $\beta_3 = (d_1+d_2+d_3)/\lambda$ and $\beta_0 = b_0/\lambda$ to finally obtain:

$$\Delta y_t = b_1 \Delta x_t - b_3 \Delta x_{t-1} + c_1 \Delta z_t - c_3 \Delta z_{t-1} + d_1 \Delta r_t - d_3 \Delta r_{t-1} - \mu_2 \cdot \Delta y_{t-1} + \mu_2 \cdot y_{t-1} - \mu_3 \cdot \Delta y_{t-2} + \\ + \mu_3 \cdot y_{t-2} - \lambda \cdot (y_t - \beta_0 - \beta_1 x_t - \beta_2 z_t - \beta_3 r_t) + \varepsilon_t$$

This way, we see that in the short term, Δy is dependent on changes of the explanatory variables in the current and previous periods, its own past changes and lagged values and finally, the departure from the equilibrium relationship in the previous period.

10.2. Cointegration

Here, the procedure of testing for cointegration among variables will be outlined. However, deeper technical background will not be provided. Readers interested in the details of the method, please refer to Thomas (1997, p.424 – 456), and the literature mentioned therein. Originally devised by Engle and Granger in 1987, the method postulates that if two I(1)[14] variables are assumed to be in a long-term relationship, there might be departures from this long run equilibrium, but the disequilibrium error will only fluctuate around zero without going too far away. This is something we would intuitively expect. Mathematically, this means that there exists a unique linear combination of the two variables that will be stationary, or I(0) (therefore, having the basic attribute of zero mean and constant variance), and also unique[15]. If we include a constant, this is the equation of the linear combination:

$$v_t = \delta_0 y_t - \delta_1 - \delta_2 x_t .$$

There is no reason we couldn't normalize the coefficient of one of the variables to unity, thus simplifying the linear combination to a form that can be immediately interpreted as the disequilibrium error.

$$u_t = y_t - \beta_0 - \beta_1 x_t .$$

In summary, two time series are said to be *cointegrated* if they are I(1) and the series of the errors, as shown above, is I(0). The testing for cointegration by the original Engle - Granger method is as follows:

1) We test for stationarity of the two variables with the use of an Augmented Dickey-Fuller test (ADF). They should be non-stationary. On the other hand, their first differences must be stationary.

2) We run a simple OLS regression, constant included, of the type:

[14] Integrated of order 1, that is that they are stationary after first differencing.
[15] Proof of the uniqueness of the combination is given in Thomas (1997) on pages 425 and 426.

$$y_t = \beta_0 + \beta_1 x_t ,$$

and store the residuals. Details why this is possible despite the non-stationarity of the two series are again given in Thomas (1997).

3) Finally, we use an ADF test to test the hypothesis of the stationarity of the stored residuals. However, therein lies a complication, because the OLS regression naturally pulls the error to be zero. For that reason, the critical values of the ADF test must be adjusted. Some, originally elaborated by McKinnon in 1991, are provided on the page 427 of Thomas (1997).

There is a special feature that links the ECM and Cointegration method. It can be proven that if two variables are cointegrated, their short–run relationship can be expressed in an error correction form, using the disequilibrium error from the cointegration estimation. Its general form might be the following:

$$\Delta y_t = lagged(\Delta y_t , \Delta x_t) - \lambda u_{t-1} + \varepsilon_t , \; 0 < \lambda < 1,$$

where u_t is the mentioned disequilibrium error. The the first term on the right-hand side means that the lag length might vary and is not determined *a priori*.

This form, called the Granger representation theorem, implies, in fact, another method which is generally referred to as the Engle–Granger two-stage procedure. In the first stage, a cointegration method is carried out in a standard way, mentioned above. Then, in the second stage, the residuals are used in the ECM. Note that since the error comes from the cointegration regression, there is no place for the element $(y_{t-1} - \beta_0 - \beta_1 x_{t-1})$ as in a standard ECM stated in the previous appendix.

Finally, let us mention two specialities. In the subchapter 6.2, when carrying out the two-stage method, we actually resorted to tolerate bad ADF test results for the cointegration residuals. We might conjecture that the cointegration hypothesis for the employed variables holds if the residuals, a proxy for the true disequilibrium error, prove to be significant in the second stage of the procedure. However, the problem is that the technical attributes are shifted in an unknown way, since the variables can be no longer supposed stationary and therefore, the t-test on the residuals cannot be

employed. Thomas (1997, p.444) recognizes: “unfortunately, little is yet known about the power of these tests...”

Another particularity comes in the general, multivariate case of the cointegration method. Note that since the variables are non-stationary, the t ratios or F-statistics cannot be used for significance testing and other, much less direct methods, such as intuition guided by economic theory, must be used in order to choose among multiple specifications. All the points mentioned in this appendix hold for the multivariate case as well, except the uniqueness of the linear combination. There might be only one relationship, in which case we talk about a cointegration vector, and the two-stage method is plausible. However, there might also be relationship between the subsets (e.g. pairs) of the variables simultaneously. In this case, the Engle-Granger procedure does no longer hold. We will not continue with the technical or other details of this specific issue as it is a very advanced econometric topic and at the same time, the cointegration as a whole did not work for the data used in the thesis and thus this complex topic is irrelevant. Yet we felt at least a basic introduction to the issue was necessary to provide adequate overview of the method.

10.3. Econometric SW output

MODEL 1(CH.5):

```
Model 1: OLS estimates using the 14 observations 1-14
Dependent variable: P

     VARIABLE       COEFFICIENT        STDERROR      T STAT   P-VALUE

  const            -25917,6           7086,38         -3,657   0,00377 ***
  U                  -491,202          212,422        -2,312   0,04113 **
  W                     2,36780          0,350084       6,764   0,00003 ***

  Mean of dependent variable = 12637,6
  Standard deviation of dep. var. = 6255,92
  Sum of squared residuals = 6,67101e+007
  Standard error of residuals = 2462,63
  Unadjusted R-squared = 0,868881
  Adjusted R-squared = 0,845041
  F-statistic (2, 11) = 36,4467 (p-value = 1,4e-005)
  Log-likelihood = -127,503
  Akaike information criterion (AIC) = 261,006
  Schwarz Bayesian criterion (BIC) = 262,923
  Hannan-Quinn criterion (HQC) = 260,828
```

MODEL 2 (CH.6):

```
Model 13: OLS estimates using the 34 observations 1999:1-2007:2
Dependent variable: d_l_rHP

     VARIABLE       COEFFICIENT        STDERROR      T STAT   P-VALUE

  const               9,68296          2,29546       4,218   0,00030 ***
  d_l_rHP_1           0,644041         0,120679      5,337   0,00002 ***
  d_l_M_1            -0,118335         0,0314033    -3,768   0,00094 ***
  d_l_M_2            -0,101879         0,0260546    -3,910   0,00066 ***
  d_l_M_3            -0,0690292        0,0225570    -3,060   0,00538 ***
  d_l_yr_3           -0,378415         0,0998261    -3,791   0,00089 ***
  l_rHP_1            -0,227316         0,0505308    -4,499   0,00015 ***
  l_M_1               0,131386         0,0298479     4,402   0,00019 ***
  l_yr_1             -0,755491         0,183082     -4,127   0,00038 ***
  d_l_yr             -0,719025         0,140876     -5,104   0,00003 ***

  Mean of dependent variable = 0,0144771
  Standard deviation of dep. var. = 0,0279453
  Sum of squared residuals = 0,00649958
  Standard error of residuals = 0,0164565
  Unadjusted R-squared = 0,747796
  Adjusted R-squared = 0,653219
  F-statistic (9, 24) = 7,90677 (p-value = 2,45e-005)
  Durbin-Watson statistic = 2,69925
  First-order autocorrelation coeff. = -0,35878
  Durbin's h stat. -2,85977
  (Using variable 45 for h stat, with T' = 33)
  Log-likelihood = 97,3165
  Akaike information criterion (AIC) = -174,633
  Schwarz Bayesian criterion (BIC) = -159,369
  Hannan-Quinn criterion (HQC) = -169,428
```

MODEL 3 (CH.7):

```
Model 15: OLS estimates using the 34 observations 1999:1-2007:2
Dependent variable: d_l_starts

      VARIABLE       COEFFICIENT        STDERROR      T STAT   P-VALUE

  const               -46,8512          17,3118       -2,706   0,01165 **
  d_l_rHP_2            -2,86451          0,820150      -3,493   0,00166 ***
  l_starts_1           -1,44894          0,242006      -5,987  <0,00001 ***
  l_rHP_1               0,708063         0,140192       5,051   0,00003 ***
  l_empl_1              6,70585          2,16839        3,093   0,00457 ***
  D1                   -0,225021         0,0404575     -5,562  <0,00001 ***
  d_l_starts_1          0,278941         0,153293       1,820   0,07992 *

  Mean of dependent variable = 0,00755934
  Standard deviation of dep. var. = 0,192522
  Sum of squared residuals = 0,243381
  Standard error of residuals = 0,0949427
  Unadjusted R-squared = 0,80102
  Adjusted R-squared = 0,756802
  F-statistic (6, 27) = 18,1153 (p-value < 0,00001)
  Durbin-Watson statistic = 2,32418
  First-order autocorrelation coeff. = -0,21833
  Durbin's h stat. -2,64681
  (Using variable 61 for h stat, with T' = 33)
  Log-likelihood = 35,7274
  Akaike information criterion (AIC) = -57,4547
  Schwarz Bayesian criterion (BIC) = -46,7702
  Hannan-Quinn criterion (HQC) = -53,811
```

FORMULÁŘ TEZE BP

UNIVERSITAS CAROLINA PRAGENSIS
založena 1348

Univerzita Karlova v Praze
Fakulta sociálních věd
Institut ekonomických studií

Opletalova 26
110 00 Praha 1
TEL: 222 112 330,305
TEL/FAX:
E-mail:
ies@mbox.fsv.cuni.cz
http://ies.fsv.cuni.cz

Akademický rok 2007/2008

TEZE BAKALÁŘSKÉ PRÁCE

Student:	Ondřej Vodňanský
Obor:	Ekonomie
Konzultant:	PhDr. Michal Hlaváček, PhD.

Garant studijního programu Vám dle zákona č. 111/1998 Sb. o vysokých školách a Studijního a zkušebního řádu UK v Praze určuje následující bakalářskou práci

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Determinanty trhů nemovitostí v ČR

Charakteristika tématu, současný stav poznání, případné zvláštní metody zpracování tématu:

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3. ANALÝZA REGIONÁLNÍCH ROZDÍLŮ
4. VÝVOJ V ČASE - CENY
5. VÝVOJ V ČASE - VÝSTAVBA
6. SHRNUTÍ

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