Estimating a stock-flow model for the Swiss housing market*

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Abstract

This paper analyses the development of housing market imbalances, housing prices and residential investment in Switzerland within a stock-flow framework. Empirical results indicate that the desired level of residential capital stock can diverge from the existing residential capital stock for several years due to the short-run rigidity of the residential capital stock. Imbalances have to therefore be cleared in the short-run by price adjustment. And indeed, it can empirically be shown that changes in prices are significantly and strongly dependent on the level of stock imbalances. Furthermore, housing prices prove to be an important determinant of residential investment which in turn drives the adjustment process of the residential capital stock towards its desired level.

JEL classification: C13, C32, E22

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1 Introduction

The dynamics of durable goods, such as housing, are typically estimated with a stock-flow model. In a stock-flow model for the housing market, the housing stock and the flow of residential investment are linked together through two channels.

Firstly, the residential capital stock is the accumulation of residential investment over time. The rate of expansion of the stock depends on the rate of expansion of gross residential investment and the rate of depreciation which is often assumed to be constant over time. The residential capital stock develops smoothly and does not react quickly to shocks. The sluggish adjustment process is due to the fact that the rate of depreciation of residential capital stock is low. Therefore also the ratio of the flow to the stock is low. In Switzerland, net residential investment accounts only for about 2% of the housing stock making quick variations in the level of the residential capital stock practically impossible. The sluggish adjustment of the stock can be additionally delayed owing to the fact that also the flow of residential investment reacts relatively slowly to shocks. This is because of the lengthy "time to build"[1] and also because residential investment is lumpy and investment decisions often costly to reverse.

Secondly, the residential capital stock and the flow of residential investment are linked together through housing prices. Housing prices which are determined by the supply and demand on the market of existing housing stock have a strong influence on the flow of new residential investment.

[1] "Time to build" includes, besides the actual construction period also the time needed for architectural planning as well as the time needed to acquire a dwelling approval. According to analysis done by Peters and Wapf (2007), the total "time to build" in Switzerland is on average 18 months.

Empirical results suggest that the stock-flow framework is supported by the Swiss data. The estimated level of desired stock diverges for sustained periods from the existing stock. Consequently, the market has to be cleared by price adjustments and empirical results show that the estimated imbalances of the stock are significant in explaining changes in housing prices. Furthermore, we find that residential investment is strongly influenced by housing prices as well as by construction costs and the mortgage rate.

This paper is based on housing market research done abroad, in particular the work of DiPasquale and Wheaton (1994) as well as McCarthy and Peach (2002):

DiPasquale and Wheaton analyse the US housing market within a stock-flow framework. They find strong evidence that it takes several years for the housing market to clear and extend therefore the traditional stock-flow model by allowing prices to converge to equilibrium over several periods. They propose an equation for a market clearing price determined by demand variables and the actual stock. DiPasquale and Wheaton estimate a separate equation for residential investment in which construction is dependent on housing prices, the level of the existing stock and an array of cost shifters.

McCarthy and Peach implement the DiPasquale and Wheaton stock-flow model in an error-correction framework. Using US data, they estimate an equilibrium price of housing which is determined by the existing housing stock and demand shifting variables. This is a hypothetical, unobserved market clearing price that would clear the existing residential stock in the absence of market imperfections. The residuals of this equation are used to estimate short-run variations in housing prices. They estimate an equilibrium price that would be consistent with the long-run equilibrium level of residential investment. Differences between this equilibrium price and the actual price are then used to estimate residential investment.

Alternative empirical models which describe the housing market from a stock-flow perspective have been provided by Topel and Rosen (1988), Riddle (2004) and Demers (2005).

This paper is structured as follows. Section 2 describes a stock-flow model for the housing market. Section 3 shows estimate results and section 4 concludes. A data description is provided in the appendix.

2 A model of the housing market

In this section we present an empirical approach to model housing prices and residential investment dynamics in the framework of a stock-flow model. The residential capital stock and residential investment are linked together through the following capital accumulation identity:

$$S_t = I_t + (1 - d)S_{t-1} \tag{1}$$

Equation (1) states that the residential capital stock in period t, S_t, is the sum of residential investment made in period t, I_t, and the level of the residential capital stock in t-1 net of depreciation, $(1-d)S_{t-1}$. In our model, S_t stands for the supply of existing housing stock.

In the long-run, the supply of existing housing stock should equate demand (lower case letters denote variables in logarithms):

$$s_t = \alpha_1 - \alpha_2 p_t + \alpha_3' U_t + \varepsilon_t^s \tag{2}$$

The long-run demand, $\alpha_1 - \alpha_2 p_t + \alpha_3' U_t$, is determined by housing prices and its position depends on a set of demand shifting variables, summarised in vector U_t. These could be population, income or wealth. ε_t^s tracks the short-run deviation between the supply of existing housing stock and its desired level, i.e. the level of housing market imbalance.

As the residential capital stock can only adjust slowly to shocks, a rapid clearing of the market for existing housing stock can only be achieved if the price elasticity of demand, described by α_2, is high and if prices react strongly and simultaneously to a demand shock (i.e. the actual housing price equals the market clearing price). If this is not the case, the housing market can take several periods to clear - as shown in several studies done for the US market[2].

When ε_t^s is negative the desired level of housing stock is higher than the existing supply. The housing market is in a situation of excess-demand and real housing prices will tend to rise. When ε_t^s is positive the housing market is characterised by an excess-supply and housing prices will normally fall. Housing prices respond to housing market imbalances as follows:

$$\Delta p_t = \phi_1 + \phi_2 \varepsilon_{t-1}^s + \phi_3' W_t + \mu_t \tag{3}$$

Equation (3) allows housing prices to react to ε_t^s over several periods: ϕ_2 indicates the speed of price adjustment and is expected be negative. Additionally, changes in housing prices are expected to be a function of various factors, summarised in vector W_t.

Housing prices which are set on the market for existing stock affect the flow of residential investment. This is a key feature of the stock-flow approach. Higher housing prices give incentive to build new houses and boost residential investment. The long-run residential investment equation can be expressed as:

$$i_t = \beta_1 + \beta_2 p_t + \beta_3' Z_t + \varepsilon_t^i \tag{4}$$

Besides, residential investment depends on a vector of cost shifting vari-

[2]See DiPasquale and Wheaton (1994), McCarthy and Peach (2002), Riddel (2004).

ables, Z_t, which are typically variables such as construction costs or capital costs. ε_t^i tracks the level of over or under investment which cannot be explained by the variables in equation (4). The dynamics of residential investment expressed in first differences are described by the following equation:

$$\Delta i_t = \gamma_1 + \gamma_2 \varepsilon_{t-1}^i + \gamma_3' V_t + \zeta_t \tag{5}$$

Equation (5), allows a fraction of ε_t^i to be corrected in the following period. The speed of adjustment is given by the coefficient γ_2 which is expected to lie between 0 and -1. The vector V_t comprises various factors which influence changes in residential investment.

3 Estimation results

All estimates shown in this paper are based on annual data from 1975 to 2007. Details on the data can be found in the appendix.

The estimated long-run level of residential capital stock

As proposed in equation (2), the long-run demand for residential housing stock is determined by housing prices and set of demand shifting variables. In our estimations, the variables included in vector U_t are the logarithms of real GDP, gdp_t, as a broad measure of income[3] and the logarithms of real wages index[4], w_t, as a measure of labour market conditions.

[3]We also tested the equation with consumption, as proxy for permanent income of households, and with employee income. The equation results were inferior.

[4]The wage index used is the OFS wage index which measures the development in real wages given an unchanged employment structure. This index does not measure wage developments due to changes in qualification neither does it include any bonus payments nor does it take into account the continuous rise in employment over the past 35 years.

The residential stock, real prices, real GDP and real wages are all I(1). The two-stage least squares parameter estimates of the long-run equation for the housing stock for 1975-2007 are written in equation (6). The dependent variable, the logarithms of the housing stock, is s_t. The logarithms of housing prices, p_t, is instrumented by its lag. Coefficient standard errors are given in parentheses:

$$\begin{array}{ccccccccccc} s_t & = & - & 7.95 & - & 0.16 p_t & + & 0.93 gdp_t & + & 1.91 w_t & + \varepsilon_t^s \\ & & & (0.5) & & (0.05) & & (0.13) & & (0.43) & \\ \end{array} \qquad (6)$$
$$\text{Adjusted } R^2 : 0.99$$

All coefficients have the expected sign and are statistically significant. According to the augmented Dickey-Fuller Unit Root Test, the null hypothesis of ε_t^i having a unit root is rejected at the 5% level[5]. The residuals of equation (6), i.e. the stock imbalance, are shown in Fig (2).

The results imply a long-run price elasticity of demand of 16%. McCarthy and Peach (2002) obtain an estimated long-run price elasticity of 24%[6]. There are manifold possible explanations for the higher long-run price elasticity of demand in the US compared to Switzerland. Generally speaking, laxer legal and institutional framework in the US may make a market more responsive to price changes. Relevant in this context are for example factors such as the accessibility to mortgages[7] (for example due to a lower down-

Its high significance implies that besides the size of overall income, proxied by GDP, households incorporate in their long-run housing decisions also the level of their basic wages, presuming that they stay at their present job.

[5]A Johansen Cointegration Test indicates that the residential stock, real housing prices, real GDP and real wages are cointegrated with one cointegrating vector.

[6]Grimes and Aitken (2006), who's dependent variable is the number of housing units per capita, find in their study for New Zealand a long-run price elasticity of 0.34.

[7]Rosenthal, Duca and Gabriel (1987) show with cross-sectional data that the price elasticity of demand falls markedly when one differentiates for households with strong

payment constraint) or the restrictiveness of the planning and regulatory environment[8].

The estimated income elasticity of housing demand for Switzerland is slightly below 1 and not significantly different to McCarthy and Peach's estimate for the US. The wage variable enters the equation to control for labour market factors which are not covered by GDP and which have an independent effect on the stock of residential capital. As a control variable not too much weight should be attributed to the interpretation of its coefficient which appears to be quite high[9].

Although population is generally thought to be a key determinant for the demand of housing stock, it turns out to be insignificant in our estimates for Switzerland[10]. This indicates that it is not the size of the population that is relevant but how much that population is actually earning, which is captured by GDP.

The user cost of ownership, a variable which is frequently included in housing equations, is a function of interest payments, taxes, depreciation and house price appreciation[11]. We have tested various user cost of capital formula, none of which prove to be significant in determining the long-run housing stock in Switzerland. This can be explained by the fact that in

credit constraints.

[8] Grimes and Aitken (2006) find that the price elasticity is lower in local authorities in which housing supply responsiveness is low compared with those in which supply responsiveness is high.

[9] The high coefficient could be assigned to the fact that real wages do not move linear to the residential capital stock. This may be because components (such as the rise in working population) which are included in the capital stock and GDP are omitted in this variable. The coefficient might be overestimated due to this non-linearity.

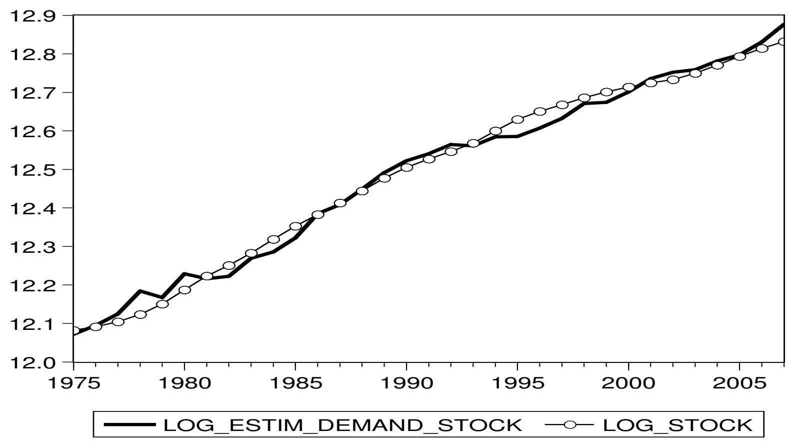
[10] We have tested the equation with various population age groups as well as their share to total population.

[11] For detailed information see Appendix, equation (12)

Switzerland the development of user costs are mainly driven by price developments, which are already included in the equation.

As the long-run demand for housing is influenced by real housing prices, real GDP and real wages which are all cyclical variables, it is not surprising that the estimated demand level fluctuates more than the very smooth housing stock, as shown in Fig.1. The estimated demand rises above the actual supply at the end of boom periods indicating an excess-demand and falls below actual supply at the end of periods of reduced economic growth. This finding is consistent with theory and also in line with empirical results for the US housing market[12].

Figure 1: Residential capital stock and estimates of the long-run demand 1975-2007



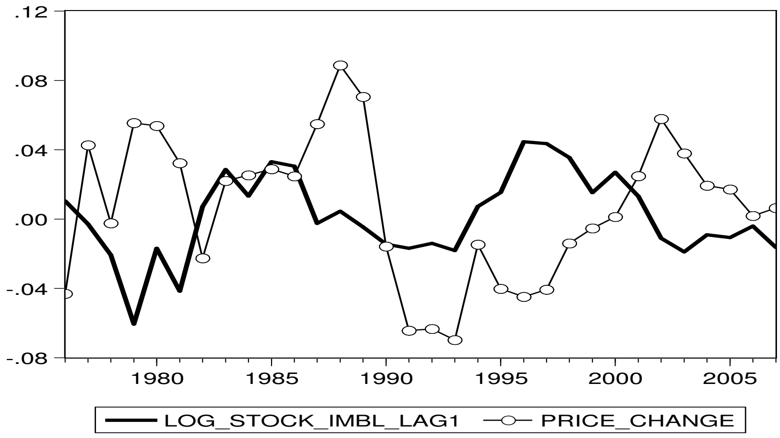
Price adjustment

The residuals of equation (6), ε_t^s, track the divergence between the existing housing stock and the long-run demand level of the stock, i.e. the imbalance on the housing market. When the demand level of the stock rises above the

[12] McCarthy and Peach (2002)

actual level of the stock prices are expected to rise, and vice-versa. This is relationship is shown in Fig 2.

Figure 2: Change in real housing prices and estimates of housing market imbalance 1976-2007



Besides the estimated housing market imbalances, ε_t^s, we include in our price adjustment equation changes in the nominal mortgage rate, Δn_t. Furthermore, to control for the period of overheating during the late eighties[13] we have also included a dummy with the value +1 in the years before 1989 and the value -1 in the years thereafter. Besides, also an autoregressive term enters the equation in order to capture persistence.

$$\begin{array}{cccccccc} \Delta p_t & = & 0.005 & -0.53\varepsilon_{t-1}^s & -1.55\Delta n_t & +0.28\Delta p_{t-1} & +0.04 dum_{89} & +z_t \\ & & (0.004) & (0.2) & (0.67) & (0.12) & (0.01) & \\ \end{array}$$
$$\text{Adjusted } R^2 : 0.7 \tag{7}$$

The estimate results show that imbalances of the stock have a significant

[13] Real housing prices in Switzerland increased at an average annual rate of 7.4% during 1985 and 1989 and dropping sharply in the following years.

and large impact on prices. Furthermore, changes in nominal mortgage rates have a strong negative influence on short-run price developments.

The use of the nominal rates, as opposed to the real rates, is not only justified by its higher explanatory power but also by the fact that that nominal interest rates are more closely related to financing constraints in the short-run[14].

The estimated long-run level of residential investment

Next we move to the residential investment equation. Besides the logarithms of housing prices[15], also the logarithms of the real construction deflator, cc_t, and real interest rates, r_t enter the investment equation, as cost shifting variables. The two-stage least squares parameter estimates of the long-run investment equation for 1975-2007 are reported below. The dependent variable is the logarithms of gross residential investment, i_t, and the instrument for p_t is p_{t-1}. Coefficient standard errors are given in parentheses:

$$\begin{array}{cccccccccc} i_t & = & 12.89 & + & 1.35 p_t & - & 2.12 cc_t & - & 3.8 r_t & + & \varepsilon_t^i \\ & & (1.35) & & (0.18) & & (0.27) & & (1.53) & & \\ & & & & \multicolumn{5}{c}{\text{Adjusted } R^2 : 0.78} & & \end{array} \quad (8)$$

[14]Borio and McGuire (2004) and Van den Noord (2006) show that financing constraints, such as changes in the proportion of income absorbed by mortgage payments, are linked tightly to the level of the nominal mortgage rates which therefore should be used for short-run equations. Our estimates of housing price adjustment show that also in Switzerland the explanatory power of nominal interest rates is higher than that of the real rates.

[15]In their two-sector Bayesian model Iacoviello and Neri (2006) attribute to housing prices the function of linking endogenously the demand for housing with residential investment. Their impulse response results show that a positive demand shock raises house prices and the returns to investing in the construction sector, thus causing residential investment to rise.

All coefficients have the expected sign and are statistically significant. According to the augmented Dickey-Fuller Unit Root Test, the null hypotheses of ε_t^i having a unit root is rejected at the 1% level[16]. The residuals of equation (8), i.e. the investment imbalance, are shown in Fig (4).

The empirical results in equation (8) indicate that in Switzerland housing prices have a strong positive influence on the long-run flow of new housing construction[17], while real mortgage rates and construction costs dampen investment.

Although mortgage rates already enter the price adjustment equation, the high sensitivity of housing investment to the real mortgage rates indicates that they have an independent cost-shifting effect on residential investment[18]. This is also consistent with the general view that monetary policy influences building investment through the interest rate transmission channel[19].

Fig. 3 depicts residential investment and the in-sample results of equation (8). The figure clearly shows that the quantity invested can diverge from its

[16] A Johansen Cointegration Test indicates that residential investment, real housing prices, real construction cost and real interest rates are cointegrated with one cointegrating vector.

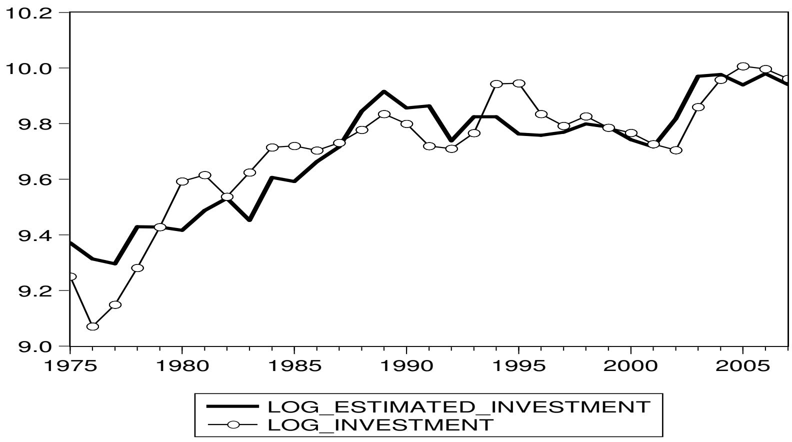
[17] The range of long-run price elasticity of supply in literature is wide. While, for the US, Topen and Rosen (1988) and DiPasquale and Wheaton (1994) estimate price elasticities ranging from 1.2 - 2.2, McCarthy and Peach (2002) and Demers (2005) find much lower values around 0.4.

[18] This topic is thoroughly discussed by Topel and Rosen (1988) who justify the inclusion of mortgage rates in their supply equation by using them as an additional cost shifter reflecting the cost of capital for builders (as opposed to a demand shifter). McCarthy and Peach (2002) as well as DiPasquale and Wheaton (1992) include in their long-run supply equations beside housing prices also land prices and the T-bill rate.

[19] Iacoviello and Neri (2006) demonstrate in their two-sector Bayesian model that of all components of aggregate demand residential investment reacts the strongest to a monetary policy shock.

long-run equilibrium level in certain years. On one hand this can come from the relative long laps of time between the decision to build and the actual construction start, owing to construction planning and lengthy administration (i.e. the procurement of a dwelling approval), or on the other hand to non-fundamental factors. For example, from beginning 1994 to mid 1995 a governmental residential construction stimulation program was implemented and led to a sharp rise in investment which[20], according to equation (8), does not seem to be "fundamentally" justified.

Figure 3: Residential investment and long-run estimates 1975-2007

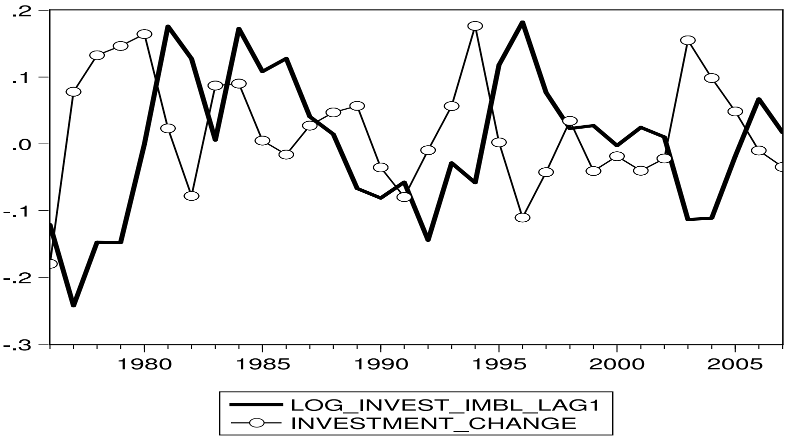


Investment dynamics

In Fig. 4 the dynamics of residential investment are depicted together with the lagged residuals of equation (8). Both series are negatively correlated with one another - indicating that over or under investment will be corrected (at least partially) in the following period.

[20] In 1994, in the midst of a severe economic recession, residential construction increased by 17.7% . This is the highest annual rise in residential construction since the 1971. For more details see Saurer (1996).

Figure 4: Change in real housing prices and estimates investment imbalance 1976-2007



Besides the residuals of the long-run investment equation, ε_t^i, also change in mortgage rates influence the investment adjustment process. Like in the price adjustment equation, mortgage rates are denoted in nominal terms, n_t. Given that a housing unit in Switzerland takes over a year to be constructed, many projects that have been started in the course of a year are probably still under construction during the following year. It therefore makes sense to include a lag of the growth in investment.

$$\begin{array}{ccccccccccc} \Delta i_t & = & 0.01 & - & 0.33\varepsilon_{t-1}^i & - & 6.21\Delta n_{t-1} & + & 0.4\Delta i_{t-1} & + & \nu_t \\ & & (0.01) & & (0.09) & & (1.56) & & (0.1) & & \end{array} \quad (9)$$
$$\text{Adjusted } R^2 : 0.63$$

The estimation results show that only about one third of the imbalances in long-run investment will be corrected in the following year. This relatively sluggish adjustment process could be explained by the relative long laps of time needed before construction can even be started: Peters and Wapf (2007) estimate that the time needed to procure a dwelling approval takes on average about 6 months in Switzerland.

4 Conclusion

This paper analyses the determinants of the residential capital stock, residential investment and housing prices in Switzerland in a stock-flow framework. A disequilibrium approach was applied allowing prices and investment to adjust to shocks in several periods.

A long-run demand level residential capital stock is estimated using real housing prices, real GDP and real wages. Empirical results indicate that the desired level of residential capital stock can diverge from the existing residential capital stock for several years. This is not surprising given the fact that the flow of net residential investment only accounts for about 2% of the stock and that consequently the housing stock cannot adjust rapidly to shocks. Imbalances therefore have to be cleared in the short-run by price adjustments, and indeed, changes in prices are significantly and strongly dependent on the level of residential stock imbalances.

Housing prices, which are set on the market for the existing residential stock, are an important determinant for the evolution of residential investment - together with the two cost shifting variables construction costs and the mortgage rate. Results show that one third of the divergences of actual investment from the estimated long-run level will be corrected in the following year. This is a reasonable result, given the slow planning process in residential construction.

The empirical results of the model are well in line with theory although the figures used are highly aggregated. Over the past 33 years, some regions in Switzerland (cities and their agglomerations) have become continually more attractive, while others have lost economic importance. Strong migration flows from less attractive regions in Switzerland and from foreign countries towards the cities have had an important impact on the regional housing markets. Additional regional analysis could help to understand these features better and it would be interesting to see if the developments of regional markets confirm our findings of the aggregated market. This, however, is left for future research.

References

Borio, C., and P. McGuire (2004): "Twin peaks in equity and housing prices?," *BIS Quarterly Review*, 7, 79–96.

Demers, F. (2005): "Modelling and Forecasting Housing Investment: The Case of Canada," *Bank of Canada Working Papers*, 41.

DiPasquale, D., and W. Wheaton (1994): "Housing Market Dynamics and the Future of Housing Prices," *Journal of Urban Economics*, 35, 1–27.

Goldsmith, R. (1981): "A Tentative Secular National Balance Sheet for Switzerland," *Schweizerische Zeitschrift fur Volkswirtschaft und Statistik*, 117(2), 175–187.

Grimes, A., and A. Aitken (2006): "Housing Supply and Price Adjustment," *Motu Economic and Public Policy Research Working Paper*, 01.

HEV (1997): "Mietzins und Mietzinsanpassung," *Hauseigentümerverband Zürich*.

Iacoviello, M., and S. Neri (2006): "The Role of Housing Collateral in an Estimated Two-Sector Model of the US Economy," *Boston College Working Papers in Economics*.

McCarthy, J., and R. Peach (2002): "Monetary Policy Transmission to Residential Investment," *FRBNY Economic Policy Review*, 8(1).

Oulton, N., and S. Srinivasan (2003): "Capital Stocks, Capital Services, and Depreciation: An Integrated Framework," *Bank of England Working Paper*, 192.

Peters, M., and B. Wapf (2007): "Befragung von Schweizer Baugesuchstellern," *Die Volkswirtschaft*, 5.

Riddel, M. (2004): "Housing-market disequilibrium: an examination of housing-market price and stock dynamics 1967–1998," *Journal of Housing Economics*, 13(2), 120–135.

Rosenthal, S., J. Duca, and S. Gabriel (1987): "Credit Rationing and the Demand for Owner-occupied Housing," *Journal of Housing Economics.*

Rudolf, B., and M. Zurlinden (2008): "Measuring capital stocks and capital services in Switzerland," *Swiss National Bank Working Paper*, (11).

Saurer, P. (1996): "Der Investitionsbonus 1993-1995, Schlussbericht'," *Mitteilungsblatt fur Konjunkturfragen*, 3, 3–16.

Topel, R., and S. Rosen (1988): "Housing Investment in the United States," *The Journal of Political Economy*, 96(4), 718–740.

van den Noord, P. (2006): "Are House Prices Nearing a Peak? a Probit Analysis for 17 OECD Countries," *OECD Economics Department Working Papers*, 488.

5 Appendix

The residential capital stock

The residential capital stock in any period is determined by the existing stock in the previous period, the rate of depreciation of the existing stock and the flow of new residential construction investment. For the calculation of the Swiss residential capital stock, we assume that the stock decays geometrically, a widespread assumption that considerably simplifies the estimation of the stock as it implies that the stock depreciates at a constant rate. Thus, the equation for the residential capital stock can be written as follows, where is the starting value of real residential capital stock in 1948[21] and is a constant depreciation rate of 4%[22].

$$S_t = S_0 + \sum_{\beta=0}^{N} (1-d))^{\beta} I_{t-\beta} \tag{10}$$

or

$$S_t = I_t + (1-d) S_{t-1} \tag{11}$$

All volume data are rebased at 2000 prices. The building deflator was used for this purpose. Thus, the residential capital stock measures the price one would have had to pay in 2000 to rebuild the entire stock of any specific year, taking into account the vintage (i.e. the age) of the housing units. The upper chart in Fig. 5 plots the real residential capital stock which was in 2007 worth over 370 billion CHF - approximately three fourths of the size

[21]We start our calculations for the stock in 1948. The starting value of the stock in 1948 is taken from work done by Goldsmith (1980). The nominal term has been rebased to 2000 prices. Note however that the initial level of the stock has little impact of the level of the stock in 1975 (the starting date of our model). This is because of the strong net residential investment that took place from 1948 to 1974.

[22]The assumption of a depreciation rate of 4% p.a. for residential buildings corresponds to those in Rudolf and Zurinden (2008).

of annual real GDP. Over the period 1975-2007, the real housing stock more than doubled, growing at a relatively constant rate (on average 2.4% p.a.). In the lower chart, the residential capital stock is compared with the number of housing units and population. Over the past 33 years, the number of housing units increased much less than the stock, on average only by 1.3% p.a. This means that the size and quality of the new dwellings has increased considerably. Population, on the other hand, only increased by 0.5% p.a. implying that the household size diminished from 2.5 persons to 2.0.

[Insert figure 5 here]

Residential investment

Due to the long lifespan of buildings - a depreciation rate of 4% corresponds to an average durability of residential buildings of 50 years - the stock is far larger that the investment flow. Indeed, the flow of net-investment only accounts for about 2% of the stock. The impact of new construction is therefore mitigated by the comparatively large stock of existing buildings. This is why the stock can in the short-term only in a minor way adjust to changes in macroeconomic conditions or demographic developments shocks and a key reason for the long periods of imbalance on the housing market. Fig. 6 plots the level of annual investment in residential construction (gross housing investment) and the annual increase of the residential capital stock (net housing investment). While gross residential investment has a slight upwards trend, net residential investment has remained on average flat. This shows that the level of investment in residential construction has risen only on the back of the rising depreciation which increases proportionally to the stock.

[Insert figure 6 here]

Labour market and income measures

In Fig. 7, the upper left chart shows the development of GDP and employment, measured as the number of employees and the number of hours worked. Although, due to productivity gains, employment has grown over time at a slower speed than GDP, the overall pattern is quite similar. In the upper left chart the unemployment rate is depict. Until the end of the eighties, this series has not much economic information and can therefore not be used for long-run analysis. The lower left chart shows various Swiss measures of income. Employee income and non-employee income (self-employed income, capital income, taxes and subsidies) and the total of both, GDP, are plotted together with private consumption. In the bottom right chart, GDP is plotted together with the OFS wage index, a measure of individual income give a constant employment. This wage index measures the development in basic wages given an unchanged employment structure. The information incorporated in the OFS wage index is quite different than that in GDP.

[Insert figure 7 here]

Housing prices

Sale prices are the sum of the discounted expected future rental yield[23]. It is therefore correct to use sale prices as the price measure which is set to clear the housing market as opposed to rental prices[24]. In Fig. 8 various housing market prices are plotted. The sale prices depicted are the weighted average of the price indexes of single-family houses and condominiums. The weights have been provided from Wüest&Partner. The nominal prices have been

[23]See, for example, Topel and Rosen (1988)

[24]In Switzerland there exists a large rental market. Actually, a majority of all housing units, about 65%, are not occupied by the owner but rented out.

deflated with the GDP deflator. In the upper chart real sale prices, supply (which are the prices offered on the market) and hedonic prices, are plotted. Hedonic prices do not include changes in prices due to changes in quality and are therefore not adequate to explain the developments in residential stock and investment. In the lower chart the real supply sale prices are plotted together with real supply rents. The start and end points of both series are more or less the same, but in the nineties rents reacted much stronger (and with a lag) to the tightness of the housing market.

[Insert figure 8 here]

User costs of ownership and mortgage interest rate

The user cost of ownership is typically calculated as a function of interest rates and house price appreciation. There exists several user cost of capital formula. Ignoring taxes and including the depreciation rate, a broad definition could be:

$$U_t = P_{t-1} \cdot (n_t + \delta - \pi_t) \tag{12}$$

Where P_{t-1} is the real housing price of the previous period, n_t is the nominal mortgage rate, δ is the rate of depreciation (which we assume to be constant at 4%) and π_t is the nominal annual housing price inflation. A constant was added to the series to ensure that there were no negative values of user costs.

In the upper chart of Figure 9, the user costs of capital are plotted with the mortgage rates and the change in housing prices. This chart shows that in Switzerland the user cost of capital are mainly determined by the change in housing prices. Using Swiss data, it would therefore be problematic to explain the change in prices with the user costs of capital.

In the lower chart, nominal and real mortgage rates are shown. While the real mortgage rate enters our long-run investment equation the changes in the nominal rate enter the price and investment adjustment equations.

[Insert figure 9 here]

Figure 5: Real residential capital stock, the number of housing units and population.

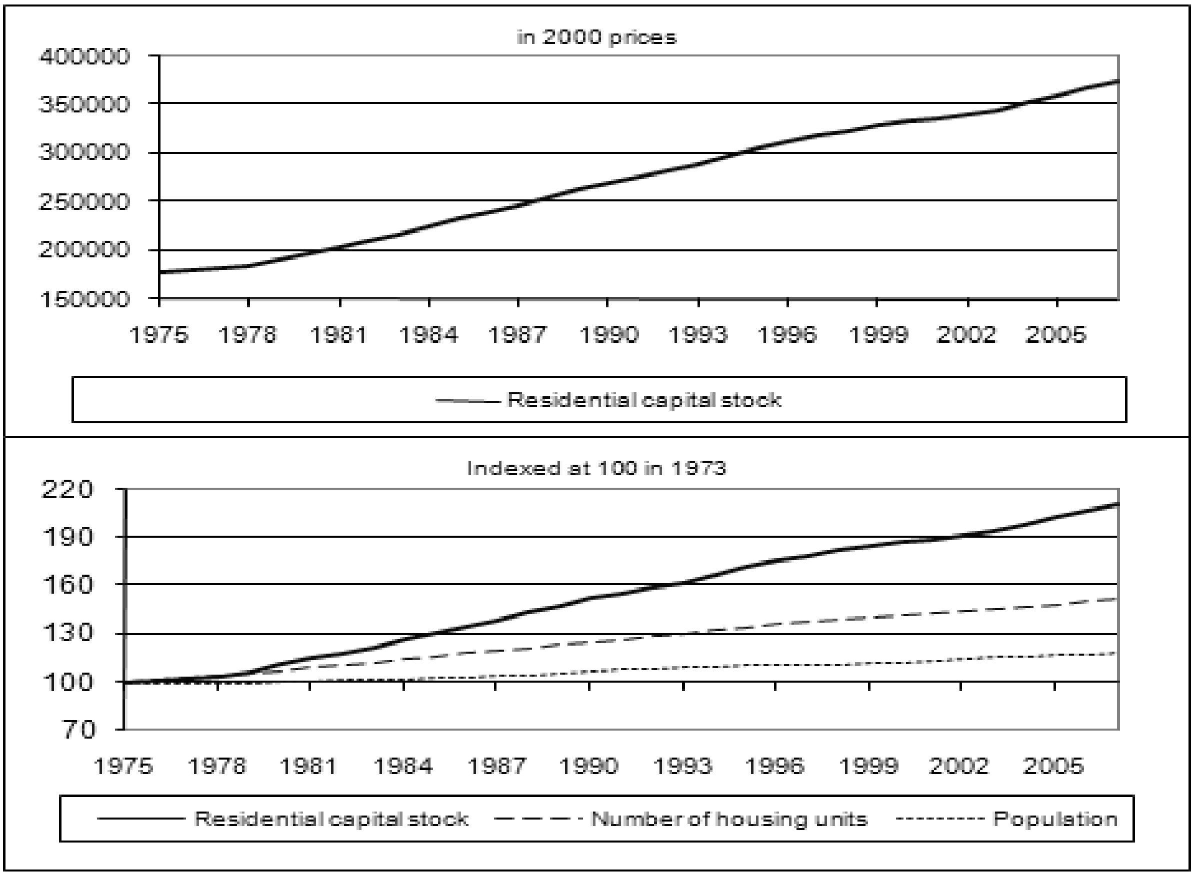


Figure 6: Residential investment, gross and net; in 2000 prices.

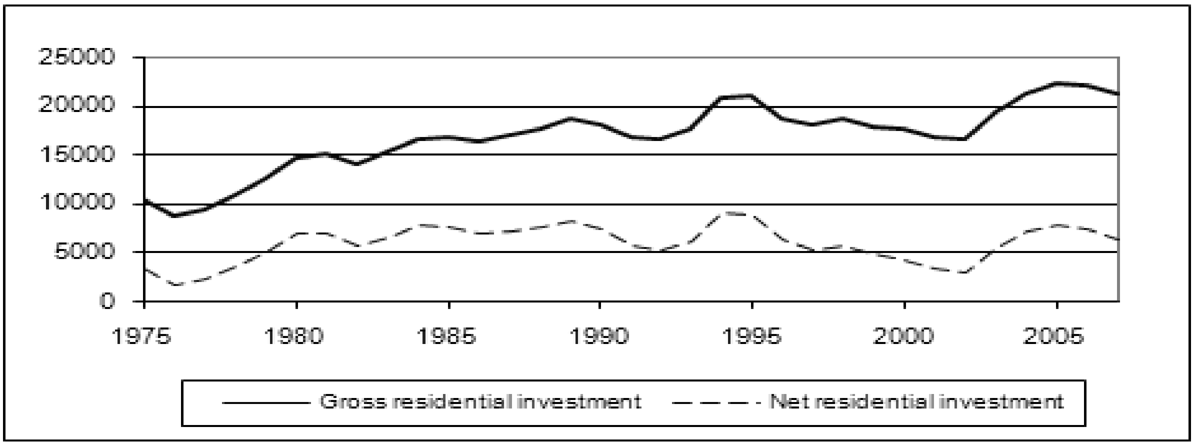


Figure 7: Labour market and income measures, in 2000 prices

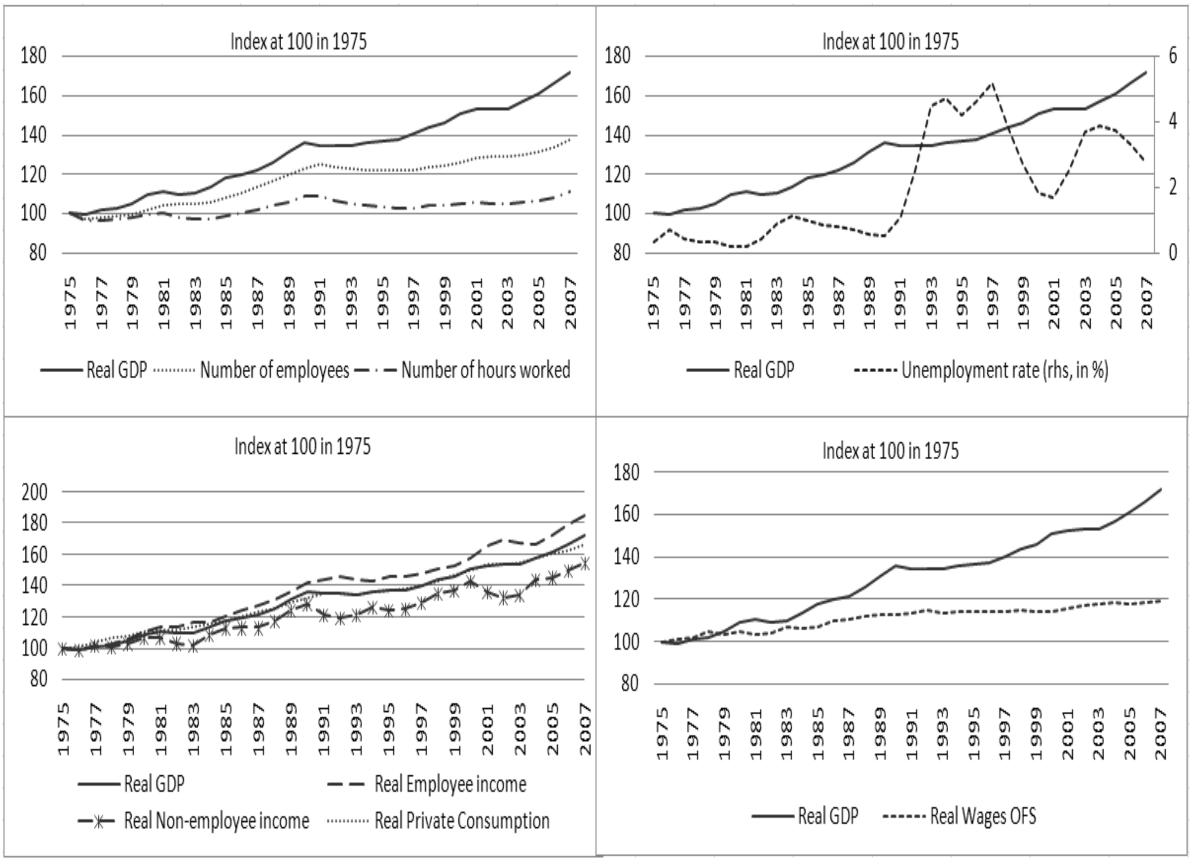


Figure 8: Real housing prices

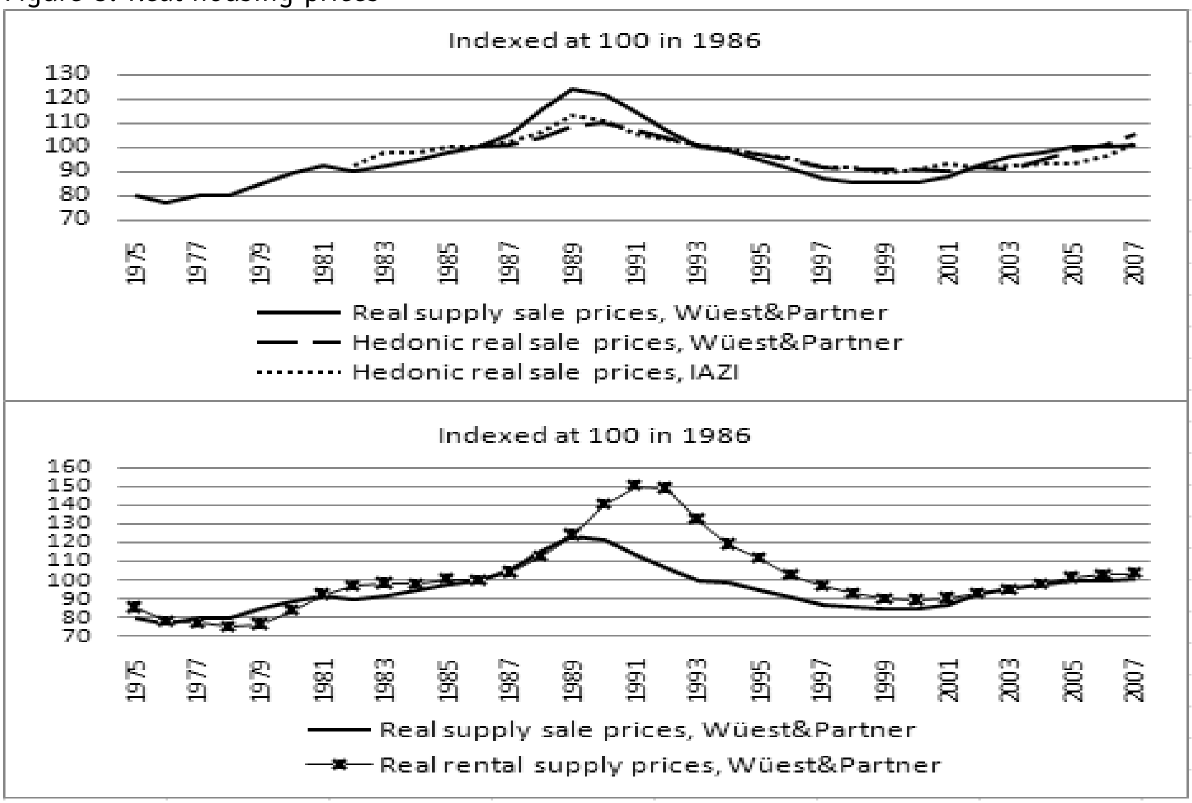


Figure 9: Real user costs of capital and mortgage rates