Working Paper I/2013

Agent-based modelling and the Swiss real estate market

Fabian Kostadinov, fk@avaco.ch
Thomas Ankenbrand, ta@avaco.ch

Abstract

The real estate market in Switzerland is attracting much attention at the moment. Fears about the formation of a bubble and a subsequent crash are increasing.

AVACO has developed an agent-based model of the Swiss real estate market. Agent-based modelling and simulation reproduces the complex patterns found in real-world markets. This is achieved by simulating the relatively simple behavioural structures of individual market participants (the so called *agents*) and combining them to a greater whole. Such an approach allows to develop dynamic, non-linear models, comprising multiple input factors like interest rates and rental prices. Typical participants found in real estate markets such as private residents, institutional investors (pension funds, insurance companies, etc.) and speculators (trend followers) are included in the model as classes of agents. Hence, our model combines explicit knowledge of behavioural patterns of the agents with implicit knowledge in the form of time series analysis. Based on this, the behaviour in bubble and crash situations can be simulated.

The AVACO model fits very well to the development of the Swiss real estate market since 1986. It can be used for forecasting in asset management and for scenario analysis in risk management. Scenario analyses conducted by AVACO indicate that the Swiss real estate market is in a rather weak condition. In the absence of positive market forces, the market has a tendency towards a negative correction, which becomes more poignant in the presence of negative market forces such as rising interest rates. In the simulated scenarios, increasing interest rates can lead to a sharp correction of the real estate indices.

Introduction

Agent-based modelling

Agent-based modelling (ABM) is a technique used to model and simulate a system's micro-level behaviour, aggregate it and then generate its macro-level behaviour as an emergent, complex pattern. It thus allows us to combine a bottom-up with a top-down perspective in a coherent approach. In agent-based models, real-world actors are represented as a population of heterogeneous, interacting (software) *agents*. Just like market participants interact with others in the pursuit of their individual goals, agents "live" in a virtual simulation environment where they interact with other agents to pursue their individual goals. In this way, distributed and interacting assemblies of agents can lead to an emergent and potentially complex behaviour of the system as a whole. This macro-level behaviour is thus the result of the aggregation of simple adaptive rules followed by individual agents. Such a modelling approach naturally integrates the rational and behavioural aspects of market participants. Agent-based models give insight into complex systems like markets that would be difficult to obtain with classical approaches.

ABM has been used to simulate various economic systems such as markets in general and financial markets in particular (LeBaron 2006). Historically, agent-based models of financial markets mainly served two complementary purposes: to get a better understanding of certain observed market patterns (Samanidou et al. 2007), and/or to derive trading signals and investment recommendations (Farmer 2001).

The Swiss real estate market

The real estate market in Switzerland is attracting much attention at the moment. Whereas over the past few years rising prices have led to high returns for investors and very little defaults for creditors, more recently concerns about the formation of a speculative bubble followed by a corresponding correction have increased. The real estate market in Switzerland is characterized by illiquidity and high transaction costs.

The consequences of a real estate crash are dramatic for everyone involved, and it takes years to recover. The established risk management practice is to focus on the acquisition phase of new real estate objects. Effective adjustments to an already existing portfolio are only possible in a relatively stable market environment. Otherwise they can come at a very high price with the added risk of unwanted counter effects, for instance lowering market prices by selling high volumes of real estate objects. For this reason, strategic planning over a time horizon of five to ten years is essential. Doing so again requires adequate forecasting and analysis tools that offer more than simple single measure forecasts, and instead can capture the complex, dynamic dependencies between the various constituent market factors. This is where simulation models can help. Agent-based modelling generates virtual worlds for what-if scenario analysis and stress testing.

Agent-based real estate market models

Several studies describe agent-based models of housing markets (Geanakoplos et al. 2012; Jordan et al. 2012; Gilbert et al. 2009). Most of these models were built with the intention to help explain observable patterns such as spatial and social segregation, or spatial and temporal distributions of housing prices. These models typically combine demographic factors such as age distribution or family size with economic factors such as wealth distribution, income or level of debt. Sometimes, also psychological factors are included, for example value structures or changing fashions. From all these factors, agent behaviour rules are deduced. Most of these models rely on a grid-like or map-based settlement representation with individual parcels and houses.
Hedonic modelling, which also focuses on single real estate objects, is yet another, more traditional approach on which many real estate market studies rely. These studies typically try to derive information from aggregated data on real estate objects in a certain region or during a certain time period.

Our approach is quite different and leads to new insights and applications.

AVACO Model

In AVACO's agent-based real estate market model traded goods are real estate market indices (Kostadinov 2013). Based on a set of fundamental and technical input parameters, agents take a decision to either buy or sell such an index. From the combination of all agents' buy and sell decisions, a market forecast is deduced, which can effectively be used for trading and/or risk management.

In the model, agents are grouped in three different classes representing real-world investors: Institutional investors, private residents or self users and trend followers or speculators. Depending on their class, agents invest in either the SWX IAZI Investment Real Estate Price Index (SI Investment PR; IAZI, 2013a), and/or SWX IAZI Private Real Estate Price Index (SI Private PR; IAZI, 2013b). To make trading decisions, they rely on a set of both technical and fundamental factors based on the movements of different time series[1]. Their decision includes whether to buy or sell the index or alternatively to take no action. Table 1 gives an overview on all agent classes, the index they trade and the time series they use as input decision factors.

Agent class	**Institutional Investors**	**Private residents/ self users**	**Trend followers/ speculators**
Characteris-tics	• Insurance companies, pension and real estate funds • A mid- to long-term investment perspective • Low leverage • Investment in property as an alternative to bonds or stocks • Perform technical and fundamental analysis	• Potential land- and house owners who buy real estate for their own, private use • A long-term perspective	• Trade real estate for speculative reasons • Always follow the markets' trends • Short-term investment perspective • Rely on technical analysis
Market/ traded index	• SI Investment PR	• SI Private PR	• SI Investment PR • SI Private PR
Decision inputs	• SI Investment PR • Swiss rental price index • Swiss Bond Index • MSCI World Index	• SI Private PR • Swiss rental price index • Swiss Bond Index	• SI Investment PR only or SI Private PR only

Table 1 Agent classes, traded indices and input decision factors

[1] Data sources: Swiss rental price index provided by Bundesamt für Statistik (2013), Swiss Bond Index published by Neue Zürcher Zeitung, MSCI World Index by MSCI (2013).

The simulation is 'round-based' with a round equalling a quarter. Each round/quarter, agents re-evaluate the current situation based on their sources of information and make a decision whether to buy or sell an asset. They then register their trade orders with a virtual market maker agent. Once all agents have placed their orders, the market maker clears the market. From all buy and sell orders of an index, a forecast is computed. This forecast constitutes the model's collective guess.

A wealth effect is also in place. Agents trading successfully for some time accumulate more wealth than others. As time goes by, they start trading higher volumes. As a consequence, their influence on the virtual market or forecast increases. This allows to model the drift component (changes) of the market resulting from innovation, regulation, etc..

Results

Model quality measures

We ran the model over a time period from Dec. 1986 – June 2013, resulting in 105 trading rounds. Table 2 gives an overview of the achieved results[2]:

	SI Investment PR	**SI Private PR**
Observed upward price changes	54	61
Observed downward price changes	51	44
Generated BUY signals	58	69
Generated SELL signals	47	36
Hits	79	79
Misses	26	26
Hit rate	0.75 (75%)	0.75 (75%)
Model efficiency	0.54 (54%)	0.54 (54%)

Table 2 Simulation results: model quality measures

Two different quality measures are used to assess the model's forecasting quality: the *hit rate* and the *model efficiency*. The hit rate indicates how many times an up or down price movement has been correctly predicted. It can take values from 1 (100% hits and 0% misses) to 0 (0% hits and 100% misses). For both observed indices, the SI Investment PR and the SI Private PR, the hit rate has a value of 0.75 (75%).
Although the hit rate gives an overall impression of the number of correctly predicted price movements, it does not say anything about the relative size of these movements and the resulting potential gains and losses. As is well known, a single big drawdown can nullify a whole series of precedent gains. The model efficiency can take values from 1 to -1. If its value is 1 [-1], all possible gains [losses] through correctly [wrongly] predicting up and down movements of the price are realized by trading according to the model's predictions. If it is 0, the gains equal the losses and the model is not better than a random predictor (flipping a coin). The current model efficiency is 0.54 (54%) for the SI Investment PR and 0.54 (54%) for the SI Private PR.

[2] By coincidence both the hit rate and the model efficiency happen to have the same values for both indices by the end of June 2013. This can of course not be generalized.

Scenario analysis: rising interest rates

Besides producing trend predictions for the next quarter, the model can be used for long term scenario analysis and stress testing. In the following example, the effects of a long-term rise in interest rates on the SI Investment PR and SI Private PR are analysed. The simulation is run up to the last quarter end (Q2 2013) relying on historical data, then the interest rates are continuously increased. From this point on, the output time series (SI Investment PR and SI Private PR) is generated by the model. Figure 1 shows the outcome of the simulation runs for both target indices and also the yield of the Swiss Bond Index as the varied input measure.

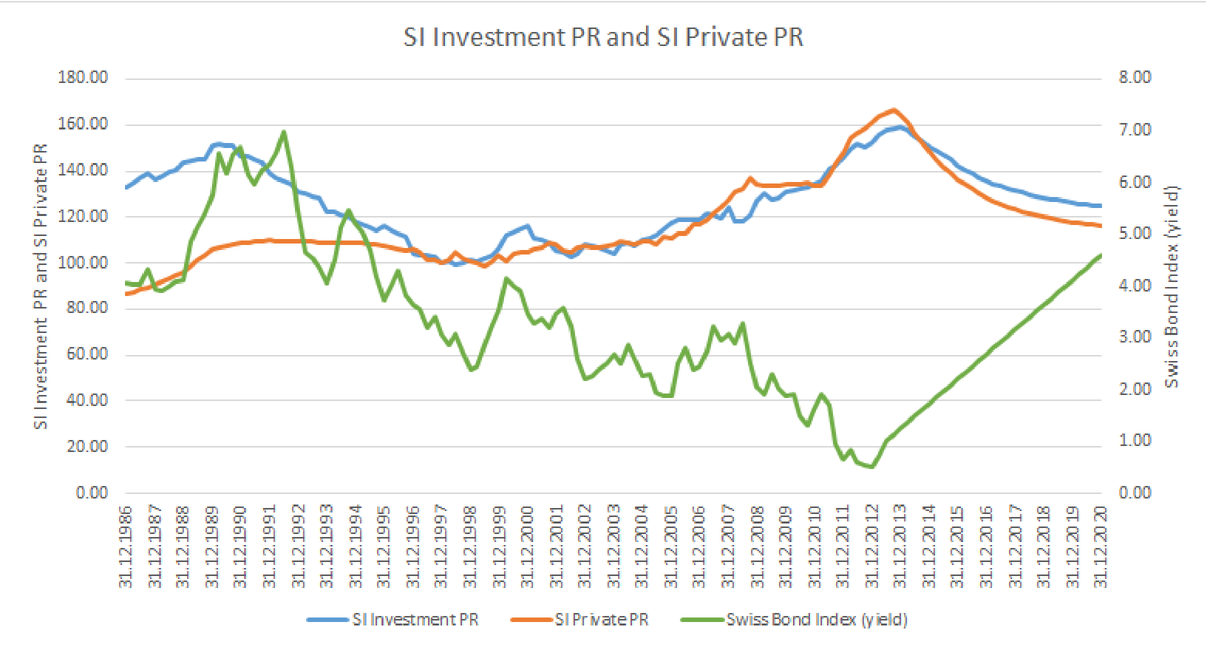

Figure 1 Scenario analysis results

For both indices, a long-term increase of the interest rates leads to a clearly observable and significant decrease of both indices.

In a situation lacking both positive as well as negative market forces, the simulated market is nevertheless inclined towards a negative correction. The reason is that the majority of agents/market participants have already invested in real estate, and their potential to adding further assets to their existing investment portfolio is limited due to monetary limitations. If however negative market impulses prevail, a significant negative correction is to be expected according to our simulation results.
Therefore, according to the model a further long-term rise in the Swiss real estate markets is to be expected only in a regime of prolonged, strong and positive market forces.

Conclusions

The AVACO model of the Swiss real estate market fits very well to the development of the market since 1986. The hit rate – 75% for the SI Investment PR and 75% for the SI Private PR – and model efficiency – 54% for the SI Investment PR and 54% for the SI Private PR – signify a high degree of reliability.

The scenario analyses indicate that the Swiss real estate market is in a rather weak condition. In the absence of positive market forces, the market has a tendency towards a negative correction, which becomes more poignant in the presence of negative market forces such as rising interest rates. In the simulated scenarios, increasing interest rates can lead to a strong negative correction of the real estate markets.

AVACO is a start-up company with an experienced staff and a proven track record in modelling of markets. Our target is to understand markets better in order to make sure that our customers can improve and optimize their risk/return exposure. Our models are used for risk management and asset management.

References

Bundesamt für Statistik (2013): Mietpreisindex. Schweizerisches Bundesamt für Statistik BFS. Data obtained from http://www.bfs.admin.ch/bfs/portal/de/index/themen/05/06/blank/key/index.html

Farmer J. D. (2001): Toward Agent-Based Models for Investment. In: Developments in Quantitative Investment Models, AIMR Conference Proceedings. pp. 61-70.

Geanakoplos J., Axtell R., Farmer J.D., Howitt P., Conlee B., Goldstein J., Hendrey M., Palmer N.M., Yang Ch.-Y. (2012): Getting at Systemic Risk via an Agent-Based Model of the Housing Market. American Economic Review, Vol. 102 (3). pp. 53-58.

Gilbert N., Hawksworth J. C., Swinney P. A. (2009): An Agent-Based Model of the English Housing Market. In: Proceeding of: Technosocial Predictive Analytics, Papers from the 2009 AAAI Spring Symposium. Stanford, California, USA.

IAZI (2013a): SWX IAZI Investment Real Estate Price Index. Data obtained from IAZI CIFI. http://www.iazicifi.ch/de/transaktionsindizes.php

IAZI (2013b): SWX IAZI Private Real Estate Price Index. Data obtained from IAZI CIFI. http://www.iazicifi.ch/de/transaktionsindizes.php

Jordan R, Birkin M., Evans A. (2012): Agent-Based Modelling of Residential Mobility, Housing Choice and Regeneration. In: Heppenstal, A.J., Crooks, A.T., See, L.M., Batty, M. (editors, 2012), Agent-Based Models of Geographical Systems. Dordrecht: Springer Science + Business Media. DOI 10.1007/978-90-481-8927-4_25

Kostadinov F. (2013): An agent-based model of a Swiss real estate market. Conference paper to be presented at the European Social Simulation Association (ESSA) conference Sept. 2013 in Warsaw.

LeBaron B. (2006): Agent-Based Computational Finance. In: Tesfatsion L, Judd K. L. (editors; 2006): Handbook of Computational Economics – Agent-Based Computational Economics. Vol. 2. North-Holland, Amsterdam. pp. 30-35

MSCI (2013): MSCI World Index (WI). Data obtained from MSCI. http://www.msci.com

Neue Zürcher Zeitung: Swiss Bond Index SBI. Published regularly by Neue Zürcher Zeitung NZZ.

Samanidou E., Zschischang E., Stauffer D., Lux T. (2007): Agent-based Models of Financial Markets. Reports on Progress in Physics, Vol. 70 (3). pp. 409-450.