



Banks and Real Estate Prices

Christian Hott

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Abstract

The willingness of banks to provide funding for real estate purchases depends on the creditworthiness of their borrowers. Beside other factors, the creditworthiness of borrowers depends on the development of real estate prices. Real estate prices, in turn, depend on the demand for homes which is influenced by the willingness of banks to provide funding for real estate purchases. In this paper I develop a theoretical model which describes and explains this circular relationship. Using this model, I show how different kinds of expectation formations can lead to fluctuations of real estate prices. Furthermore, I show that banks make above average profits in the upswing phase of the real estate cycle but suffer high losses when the market turns.

Keywords: Credit Cycle, Real Estate Prices, Bubbles.

JEL-Classifications: E51, G12, G21.

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1 Introduction

The recent crisis in the US sub-prime mortgage market has illustrated that problems in the housing market can have a pronounced impact on the banking sector. When real estate prices in the US started to grow substantially in the late 1990's the wealth of sub-prime borrowers increased also and, as an effect of the higher wealth, default rates decreased. This development made it more and more profitable to invest in sub-prime mortgages and banks and other financial institutions invested more and more money into the housing market. In doing so, they were fueling the bubble and created a positive feedback effect between real estate prices, default rates, and mortgages.

Growing real estate prices have a positive effect on the wealth of borrowers, however, on the other hand they also lead to a higher mortgage burden. In 2006 the real estate price increase slowed down and the wealth effect of increasing real estate prices became too small to compensate for the high mortgage burden. As a result default rates among sub-prime borrowers started to rise again. This led to losses for sub-prime lenders and lending standards were tightened. The tighter lending standards together with the high mortgage burden led to a situation where many borrowers were forced to sell their homes or became insolvent.

The described cyclical relationship between real estate prices, default rates, bank profits and mortgage lending is not a new development. Real estate crises have led to problems in the banking sector already in the past. In countries such as Japan (JAP), Norway (NOW), Switzerland (CH), the UK, and the US, for example, bank lending grew substantially in the mid/late 1980's. This development was accompanied by a strong increase in real estate prices. Around 1990 in each of these countries the housing bubble burst. In reaction to this, default rates among borrowers and loan losses at banks increased and some banks got into server problems.¹

Table 1 shows the correlation between annual growth rates of bank loans and annual growth rates of real estate prices for the above mentioned five countries. As we can see, this correlation is quite high, with an average of 70%, ranging between 55% in NOW and 85% in JAP. In addition, Table 1 shows the correlation between annual growth rates of real estate prices and the fraction of non-performing loans. This correlation is highly negative, with an average of -54%, a minimum of -68% (US), and a maximum of -48% (JAP).

¹BIS (2004) describes the development of the banking crises in all of these countries.

Figure 1 demonstrates the close relationship between mortgages, real estate prices and charge-off rates for the US market. In addition, the figure displays the development of the lending conditions of US banks according to the Senior Loan Officer Opinion Survey on Bank Lending Practices of the Federal Reserve.² As we can see, the fraction of the reporting banks that have tightened their mortgage lending policies over the previous three months is reflective of the changes in the charge-off rates on real estate loans (delta charge-off). The correlation between these two series is almost 90%. This indicates that the lending condition of banks might be influenced by the performance of their existing loan portfolio.

[Insert Table 1 about here.]

[Insert Figure 1 about here.]

The relationship between real estate cycles and bank exposures is examined in a number of studies. Gerlach and Peng (2005), for example, examine the relationship between property prices and bank lending in Hong Kong. Their results suggest that the development of property prices influences bank lending. Collyns and Senhadji (2002), on the other hand, look at Asian countries during the Asian Crisis and find evidence that lending influences property prices. Mora (2008) finds evidence that bank lending is a possible explanation for the Japanese real estate boom during the 1980's and following Hofmann (2004) the development of property prices helps to explain long-run movements of credit in a sample of 16 industrialized countries.

In general one can say that the relationship works in both ways, meaning that there is a positive feedback effect between real estate prices, mortgage loans and bank profits. Collyns and Senhadji (2002, p. 6) provide a motivation for this feedback effect:³

“Increases in the price of real estate may increase both the value of bank capital, to the extent that banks own real estate, and increase the value of real estate collateral, leading to a downward revision of the perceived risk of real estate lending. Consequently, an increase in real estate prices may

²See Federal Reserve Board (2009).

³These factors are also mentioned by Herring and Wachter (1999, p. 3). In addition they point out that the development of real estate prices might also influence the perceived risk in real estate lending.

increase the supply of credit to the real estate industry, which in turn, is likely to lead to further increases in the price of real estate. These feedback effects go into reverse when real estate prices start to decline.”

There are several models which formalize these basic effects. Kiyotaki and Moore (1997), for example, develop a model where a fixed stock of land is used for production. At the same time credit constrained firms use their land as collateral to borrow money. If we suppose that there is a temporary productivity shock, firms will earn less and, therefore, can invest less in the factor land. This reduces their output further and, since the supply of land is fixed, the value of their land is reduced. Because of the reduced value of their collateral, firms can borrow less, reducing their demand for land further and so on.

Iacoviello (2005) develops a model where households supply their labor force and lend money to entrepreneurs. Entrepreneurs produce by using labor and real estate as input factors. To finance the input factors they can borrow money from the households. The author further assumes that the borrowing capacity of entrepreneurs is constrained by their collateral: the value of their housing stock.⁴ In this setting Iacoviello shows that shocks can be amplified due to a procyclical development of the real estate price and, therefore, of the borrowing capacity of entrepreneurs. Furthermore, the model is able to explain the positive relationship between consumption and real estate prices.

Bernanke and Gertler (1989) describe a very similar process in a real business cycle model. However, they consider a general capital good as an input factor for production instead of real estate. Also in their model the feedback effect between lending and real estate prices is kept alive because of a link to productivity. Each of these models relies on rational expectations and the resulting real estate cycles reflect changes in fundamentals (productivity). When we look at actual real estate price movements, however, prices seem to fluctuate much stronger than fundamentals like GDP or interest rates would justify.⁵ This fact can hardly be explained by standard rational agent models and is often associated with irrational expectations.⁶

⁴Very similar models are used in Iacoviello (2004) and Calza et al. (2007).

⁵Clayton (1997) shows that real estate prices in Vancouver fluctuate than their rational expectation values. Hott and Monnin (2008) calculate fundamental real estate prices for Japan, the Netherlands, Switzerland, the UK and the US. Their results also indicate that actual real estate prices are much more volatile than their fundamental values.

⁶Akerlof and Shiller (2009), for example, emphasize the role of irrational expectations in real estate cycles.

In this paper I show how credit and real estate cycles can be produced by irrational expectations of banks. More precisely I examine the effects of three different kinds of expectation formations on the lending behavior of banks, on real estate prices, and on mortgage losses of banks. In a first approach I show how mood swings can influence expectations and how this can generate cycles. If the default rate on mortgage loans decreases, a bank gets more optimistic about the creditworthiness of its customers. This leads to higher mortgage loans, higher real estate prices, and lower default rates. When the price increase gets too low to justify the high real estate price level, default rates increase again. Now the process is reversed and banks become more pessimistic.

In a second approach I show how momentum forecasts can produce property price cycles. If the forecast of real estate prices is influenced by their momentum, a real estate price increase has a positive effect on the forecast of future real estate prices. This, in turn, has a positive effect on the actual real estate price. Therefore, forecasts become self-fulfilling and banks have no incentive to change their forecasting model. The process is reversed after a while because forecasts rely not only on the momentum of prices, but also on the development of fundamentals.

Herring and Wachter (1999, p. 15) name another possible reason for the pronounced pro cyclical behavior of mortgages: disaster myopia. Following this idea there is a:

“... tendency over time to underestimate the probability of low-frequency shocks. To the extent that subjective probabilities (π_t) decline even though actual probabilities remain constant or increase, banks take on greater exposures relative to their capital positions and the banking system becomes more vulnerable to a disaster.”

Real estate markets are very vulnerable to this kind of disaster myopia because cycles are usually rather long and, as a result, downturns or crises occur seldom. In my third approach I show how this disaster myopia can lead to real estate price fluctuations. For all three model variations I also show that price fluctuations lead to high profits in upswing phases and to high losses when the bubbles burst.

The paper is organized as follows: In the next section I develop the basic model of banks, households, mortgages, and real estate prices. In the third section I present the three model variations and explain the occurrence of price bubbles. In the last section I offer some concluding remarks.

2 The Basic Model

Kiyotaki and Moore (1997), Iacoviello (2005), and Calza et al. (2007) use very similar general equilibrium models to describe the link between loans, real estate prices, and economic performance. Each of these models assumes that there are two goods: a consumption good and real estate. Real estate is used as an input factor for the production of the consumption good (in Kiyotaki and Moore and Iacoviello) or serves utility directly (in Calza et al.). There are two groups of agents: borrowers and lenders. One crucial difference between these two groups is that borrowers discount the future at a higher rate than lenders. This assures that borrowers want to borrow up to the limit. This borrowing constraint is given by a fixed fraction (loan-to-value) of the value of their housing stock. Aggregated income is calculated endogenously via a production function.

In the following I present the basic model for my examination of the interaction between the lending behavior of banks, real estate prices, and loan losses. This model has many features of the aforementioned models. There are two reasons, however, why my model has to differ in some aspects: Firstly, while the focus of the aforementioned models is on the borrowers sector (households) and the link to the economic performance, my examination focuses on the lenders (banks) and the link to loan losses. Therefore, I have to explicitly model the lending behavior of banks and consider heterogeneous households to get default rates between 0 and 100 percent. Secondly, I use my basic model to examine the effects of various kinds of bank expectations. In order to have the necessary flexibility, the model has to be much simpler than many other papers. Therefore, instead of using a general equilibrium model, I develop a partial equilibrium model, taking income as an exogenous factor.

2.1 The Real Estate Market

Like Kiyotaki and Moore (1997) and Iacoviello (2005), I assume that there is a fixed supply S of identical homes. In period t the price of each home is P_t . This price ensures that the demand for homes is equal to the supply. Hence, in t the total stock of homes is worth SP_t . For simplicity and without loss of generality, I assume that $S = 1$. In contrast to Kiyotaki and Moore and Iacoviello I assume that homes are only held by households (borrowers) and not by banks (lenders). This assumption does not affect

my results qualitatively⁷ but, as we will see later, it simplifies the determination of the real estate price a lot.

2.2 The Market for Mortgage Loans

The demand side of the mortgage market is given by households' demand for mortgage loans (see section 2.3). Banks supply these mortgage loans with a maturity of one period. Like Kiyotaki and Moore (1997) I assume that the mortgage rate $m > 0$ and the loan-to-value (LTV) are constant.⁸ For simplicity I assume that the LTV is 100%. In combination with the assumption that only households buy and hold the housing stock, this implies that the amount of the sum of all mortgages is equal to the value of the entire housing stock (P_t). This is a rather strong assumption. However, it reflects the empirical finding that the development of real estate prices and mortgages is highly correlated.⁹

2.3 The Household Sector

I assume that households derive their utility from consumption and housing. Further I assume that households have a very high discount rate (higher than the mortgage rate). As shown by Kiyotaki and Moore (1997), Iacoviello (2004 and 2005), and Calza et al. (2007), this implies that the borrowing constraint is binding for households. As a consequence, in combination with a LTV of 100%, households take the highest amount of mortgages they can get to purchase housing units and they use their entire income for paying their mortgage and for consumption.

I assume that there are N households, where N is very large. In period t each household owns and has to finance the same fraction $1/N$ of the housing stock by taking a mortgage loan in the amount of P_t/N .¹⁰ Hence, in period t the mortgage duty of each household is: mP_{t-1}/N . On the other hand, households have an income

⁷As long as the demand of additional participants does not react perfectly elastic on changes in prices, they would only reduce the price effects of the transactions of the households but would not eliminate them.

⁸Iacoviello (2005) and Calza et al. (2007) also assume that the LTV is constant, however, they do not assume that the interest rate is fixed. Instead of adjusting the mortgage rate, in my model banks consider and adjust the affordability. See section 2.4.

⁹See Table 1 and Figure 1.

¹⁰Since households do not save money they all have the same expected future wealth. Therefore, it is quite reasonable to assume that all households buy the same fraction of the housing stock and that banks are willing to provide the same mortgage amount to every household.

from capital gains: $(P_t - P_{t-1})/N$, which is positive if the real estate price increases and negative if the real estate price decreases. In addition to the capital gain, in each period t household i ($i = 1, \dots, N$) receives a random labor income (Y_t^i) which is uniformly distributed between 0 and \bar{Y} , where Y_t^i is independent from Y_t^j ($j \neq i$) and Y_{t-x}^i ($x > 0$). Hence, the labor income of all households in each period t is uniformly distributed between 0 and \bar{Y} . If the mortgage duties of a household exceed its total income the household becomes insolvent. Figure 2 shows which households become insolvent and which stay solvent. Thereafter, in t the probability of default (PD_t) is:

$$PD_t = \frac{(1+m)P_{t-1} - P_t}{N\bar{Y}}. \quad (1)$$

[Insert Figure 2 about here.]

I assume that insolvent households have to sell their housing units and then use their entire wealth to pay back their mortgage and the corresponding interest rate (or at least as much as they can).¹¹ In Figure 2 the vertical shaded area left of the dashed insolvency line reflects the amount of mortgage payments of the insolvent households. Since the future income of each household is independent of today's income even following insolvency a household can go straight to the next bank and ask for a new mortgage to buy a home. In this respect the households in my model are very similar to sub-prime borrowers.

Since the maturity of each mortgage is one period, solvent households refinance their mortgage every period, no matter if they buy a new (identical) home or stay in the same home. In Figure 2 the vertical shaded area right of the dashed insolvency line reflects the amount of mortgage payments of the solvent households and the horizontal shaded area reflects total consumption of households. As we can see, consumption is positively related to changes in real estate prices. This result reflects the findings of Iacoviello (2005).

2.4 The Banking Sector

The fourth element is the banking sector: I assume that banks are identical, risk neutral and cannot ex ante distinguish between the different households. However, they know,

¹¹In my model banks do not have an incentive to own real estate and to speculate on the real estate market.

at least in the basic model, the expected income of each household and its distribution. Further, I assume that there is perfect competition in the banking sector. Banks provide mortgages to households at the constant rate $m > 0$ and refinance themselves at the constant rate r , where $0 < r < m$. Hence, in $t + 1$ the interest margin income of the banking sector is $P_t(m - r)$. I assume that banks do not influence the (market) mortgage rate and only decide on the amount of mortgages (P_t/N) they give to the different households. Since banks cannot distinguish a priori between “good” and “bad” households, they also give mortgages to households that will default in the next period. Because of defaults, in period $t + 1$ banks’ earnings are reduced by the fraction ρ_{t+1} of their mortgage exposure P_t . Therefore, expected profits (π_{t+1}) of the entire banking sector in period $t + 1$ are given by:

$$E(\pi_{t+1}) = P_t[m - r - E(\rho_{t+1})]. \quad (2)$$

The vertical shaded area in Figure 3 reflects the interest rate margin income of the banks and the horizontal shaded area reflects the expected losses in $t + 1$. Expected profits of the banking sector are given by the difference between these two areas. Since I have assumed that there is perfect competition in the banking sector, expected profits are zero. Hence, in equilibrium the two areas have to be identical. If, for example, the margin income is higher than expected losses, expected profits would be positive. As a result banks would be willing to provide more or higher mortgage loans. By doing this they move the “mortgage duty” line (mP_t/N) as well as the “refinancing costs” line (rP_t/N) upwards. In addition to this, the higher amount of mortgage loans increase today’s real estate price (P_t). Given the expected real estate price in $t + 1$, this reduces the expected capital gain of households and, therefore, pushes the “income” line in Figure 3 downwards. Both effects have no influence on the interest rate margin ($m - r$) but increase the expected loss rate (ρ_{t+1}). Banks now increase the amount of mortgage loans until:

$$E(\rho_{t+1}) = m - r. \quad (3)$$

[Insert Figure 3 about here.]

In other words, competition leads to a mortgage rate which is equal to the (save) financing rate r plus a risk premium $E(\rho_{t+1})$. However, in my model banks do not

chose a mortgage rate that covers the risk premium. Instead they look at the amount of mortgage loans that households can afford at a given mortgage rate. Accordingly, banks provide mortgages as long as expected losses can be covered by the interest rate spread.¹² Therefore, my model is a simple example for credit rationing under imperfect information à la Stiglitz and Weiss (1981).

2.5 Equilibrium

Beside the labor income, expected losses mainly depend on the development of real estate prices. One can think of three different cases: First, the development of real estate prices leads to a situation where some households become insolvent and some stay solvent. Second, a huge price increase leads to a situation where all households stay solvent. Third, a strong decrease in real estate prices leads to a situation where all households become insolvent. The expected losses can be calculated for the three different cases as follows:

$$P_t E(\rho_{t+1}) = \frac{[(1+m)P_t - E(P_{t+1})]^2}{2N\bar{Y}} \quad \text{if } (1+m)P_t \geq E(P_{t+1}) \geq (1+m)P_t - N\bar{Y}, \quad (4)$$

$$P_t E(\rho_{t+1}) = 0 \quad \text{if } E(P_{t+1}) > (1+m)P_t \quad \text{and} \quad (5)$$

$$P_t E(\rho_{t+1}) = (1+m)P_t - E(P_{t+1}) - \frac{1}{2}N\bar{Y} \quad \text{if } E(P_{t+1}) < (1+m)P_t - N\bar{Y}. \quad (6)$$

In the second case expected losses are always zero. Hence, for positive interest rate margins the second case is not a possible equilibrium. With “normal” interest rate margins the third case can only be an equilibrium if real estate prices in period t are very high and expectations are that real estate prices will decrease substantially in the next period. However, since in my model the underlying fundamentals of real estate prices (number of households, income, interest rates) stay constant, in equilibrium, real estate prices have to be constant as well. Therefore, the relevant case is the first one. I define $\bar{P} = P_t = E(P_{t+1})$ as the equilibrium (benchmark) real estate price and $\bar{\pi}$ as the equilibrium (benchmark) profits. By using equation (4) I can rewrite equation (2) to:

¹²Using data from the Federal Reserve Bank’s “Loan Officer Opinion Survey” Lown and Morgan (2006) emphasize the importance of credit standards compared to the role of loan rates for bank loans.

$$\bar{\pi} = \bar{P} \left(m - r - \frac{1}{2} \frac{m^2 \bar{P}}{N\bar{Y}} \right). \quad (7)$$

Following the assumption that banks are under perfect competition and that they expect to make zero profits, the equilibrium real estate price (and therefore the equilibrium amount of mortgage loans) is given by:

$$\bar{P} = 2 \frac{(m - r)N\bar{Y}}{m^2}. \quad (8)$$

Hence, the equilibrium real estate price depends positively on the interest margin (or risk premium of banks), the number of households and their labor income and negatively on the mortgage rate. These findings are in line with the results of many studies on real estate prices.¹³

3 The Behavior of Banks

The basic idea of this paper is that there is a feedback effect between default rates, mortgage loans and real estate prices. It is easy to see that higher mortgage loans have a positive impact on real estate prices and that increasing real estate prices lower default rates.¹⁴ The important missing link, however, is the link between default rates and the supply of mortgage loans. As we have seen in section 2, the supply of mortgages is mainly driven by banks' expectations with regard to future income and future real estate prices. As long as banks make appropriate forecasts, or at least make no systematic mistakes, nothing happens. In this section, however, I argue that the behavior of banks can lead to a cyclical development of real estate prices, to above average returns for banks in the upswing phase and to losses in the downswing phase.

There are many reasons why we should look at the behavior of banks. One is that there are often explicit or implicit government guaranties for the liabilities of banks. Krugman (1998), for example, shows how this can lead to a moral hazard behavior of banks. Since banks do not bear all the risk of their decisions, they tend to

¹³In Hott and Monnin (2008), the fundamental value of houses depends on aggregated income, housing supply and mortgage rates. Case and Shiller (2003) and Holly and Jones (1997) point out that income is most important factor. Beside other factors, Himmelberg et al. (2005) consider a mortgage interest rate and an expected capital gain.

¹⁴These effects are made explicit in the basic model.

invest more into risky assets (for example the housing market) and, therefore, drive up prices. Another reason why the behavior of banks can be relevant is the informational asymmetry between lenders (banks) and borrowers (households). This can lead to adverse selection and, according to Stiglitz and Weiss (1981), to credit rationing.

This paper focuses on another aspect of the behavior of banks: expectation formation. In the following I apply three different kinds of expectation formations to the basic model that are especially relevant for real estate cycles and the current crisis in particular. Akerlof and Shiller (2009, p. 4) write:

“The idea that economic crises, like the current financial and housing crisis, are mainly caused by changing thought patterns goes against standard economic thinking. But the current crisis bears witness to the role of such changes in thinking. It was caused precisely by our changing confidence, temptations, envy, resentment, and illusion - and especially by changing stories about the nature of the economy. These intangibles were the reason why people paid small fortunes for houses in cornfields; why others financed those purchases;...”

And on page 151 the authors write:

“People appear to have different, but equally inexplicable, quirks in predicting the trajectory of real estate prices. The idea that they will always go up strongly, and even that real estate is the best investment of all, is somewhat seductive. But it has not been uniformly prominent. Outside of booms it is hard to find statements that real estate prices will always go up.”

These statements can be divided into three different aspects: Firstly, people are more confident when there is a boom and they are less confident when prices are going down. If confidence is contagious (story telling) it could lead to herding behavior and mood swings. In my first approach I demonstrate how such mood swings can lead to credit and real estate cycles. The second aspect is that people extrapolate past developments. Such momentum forecasts can become self fulfilling and, therefore, create price fluctuations. This effect is described in my second approach. The third aspect is that crises can be caused by changes in thought patterns. Such a switch

in thinking or expectations can be explained by disaster myopia. If there is a longer episode without any shocks, people tend to underestimate the probability of a shock. A sudden change in thinking can then be triggered by an unexpected or rather seldom shock. In my third approach I use disaster myopia to explain the emergence and the burst of real estate bubbles.

3.1 Mood Swings

Banks are run by humans and humans are influenced by their mood. If, for example, loss rates are low and profits high bankers might become more optimistic and underestimate the risk of an investment (e.g. a mortgage loan). This behavior is supported by the procyclicality of many risk models (e.g. Value at Risk): as long as nothing happens these risk models signal a low risk but after a shock they start to signal a high risk.

In my first approach to explain and motivate the link between default rates and the supply of mortgage loans, I assume that bank managers are subject to mood swings. Even though they know the income distribution of the entire household sector, their own customers might have an above or a below average income. If a bank is optimistic, it might assume that its screening process was very successful and that its customers have an above average income. On the other hand, if the bank is pessimistic it believes that its customers' income is below average. A consequence of this assumption is that if banks become more optimistic they are willing to provide higher mortgage loans and real estate prices increase. This leads to lower default rates and, hence, to higher profits for banks.

Further I assume that the mood of banks is positively influenced by their past profits. If banks have an excess (positive) return they become more optimistic and if they have a lower (negative) return they become more pessimistic. Or in other words, banks become more optimistic if losses on their existing loan portfolio were lower than expected and they become more pessimistic if losses were higher than expected. This assumption reflects the comovement of charge-off rates and the tightening of lending standards displayed in Figure 1.

Now assume that an external unexpected shock leads to a temporary increase in labor income. This increase in income lowers the default rate among households and increases profits of banks. Therefore, banks become more optimistic, real estate prices increase, default rates fall and banks make high profits. This process pushes the real

estate price higher and higher. However, if the real estate price and, therefore, the mortgage burden for households becomes too high to be compensated by the price increase, the process is reversed.

A very similar process is described by Lux (1995). He provides a theoretical explanation for herding behavior by introducing a positive feedback between the development of asset prices and investors' sentiment. To formalize this idea, I assume that an optimistic bank expects that the loss rate (ρ_t^o) in its loan portfolio will be:

$$E(\rho_{t+1}^o) = (1 - \delta)E(\rho_{t+1}) = (1 - \delta)\frac{1}{2}\frac{[(1 + m)P_t - E(P_{t+1})]^2}{P_t N \bar{Y}}, \quad (9)$$

where δ reflects how strong the effect of optimism is on expectations. For a pessimistic bank the expected loss rate (ρ_t^p) is:

$$E(\rho_{t+1}^p) = (1 + \delta)E(\rho_{t+1}) = (1 + \delta)\frac{1}{2}\frac{[(1 + m)P_t - E(P_{t+1})]^2}{P_t N \bar{Y}}. \quad (10)$$

Banks are not necessarily entirely optimistic or pessimistic. I assume that in period t all banks put the weight ν_t on the optimistic view and the weight $1 - \nu_t$ on the pessimistic view. Therefore, ν_t can be interpreted as the mood of the banks. In t for all banks the expected loss rate (ρ_{t+1}^m) is:

$$\begin{aligned} E(\rho_{t+1}^m) &= \nu_t E(\rho_{t+1}^o) + (1 - \nu_t) E(\rho_{t+1}^p) \\ \Rightarrow E(\rho_{t+1}^m) &= (1 - \delta - 2\delta\nu_t)E(\rho_{t+1}). \end{aligned} \quad (11)$$

As in the benchmark case in section 2.5 I assume that banks expect no changes in real estate prices ($E(P_{t+1}) = P_t$).¹⁵ Therefore, the expected loss rate under mood swings is:

$$E(\rho_{t+1}^m) = (1 - \delta - 2\delta\nu_t)\frac{m^2 P_t}{2N\bar{Y}}. \quad (12)$$

Under perfect competition this expected loss rate is equal to the interest rate spread ($m - r$). Therefore, the real estate price under mood swings (P_t^m) is given by:

¹⁵This is reasonable since the period t expectations for the loss rate in $t + 2$ are equal to the period t expectations for the loss rate in $t + 1$. Hence, the expected real estate price in $t + 1$ is equal to the real estate price in t .

$$P_t^m = \frac{2(m-r)N\bar{Y}}{m^2(1+\delta-2\delta\nu_t)}. \quad (13)$$

As we can see, this real estate price is equal to the benchmark price \bar{P} if $\nu_t = 0.5$ and the real estate price depends positively on the mood ν_t . As long as banks are more optimistic than pessimistic ($\nu_t > 0.5$) the real estate price exceeds its benchmark value and vice versa.

I assume that banks are becoming more optimistic if the excess return is positive, and they are becoming more pessimistic if it is negative.¹⁶ Under perfect competition profits are expected to be zero. Hence, there is an excess return if profits are positive: $\rho_{t-1} < m - r$.

$$\nu_t = \nu_{t-1} + \tau(m - r - \rho_{t-1})(1 - \nu_{t-1}) \quad \text{if } \rho_{t-1} \leq m - r \quad \text{and} \quad (14)$$

$$\nu_t = \nu_{t-1} + \tau(m - r - \rho_{t-1})\nu_{t-1} \quad \text{if } \rho_{t-1} > m - r, \quad (15)$$

where τ reflects how strongly the banks' mood is influenced by their profits. As we can see, the mood (ν_t) depends negatively on the realized loss rate in the previous period (ρ_{t-1}). The realized loss rate, in turn, depends negatively on the price increase and positively on the price level. As long as the real estate price increases on a moderate level, loss rates are low and, given equation (13) and (14) real estate prices increase further. However, if the price increase becomes too low to compensate for the high price level, loss rates increase, banks become less optimistic and prices decrease again.

In order to illustrate the dynamic effects of mood swings, it is not necessary to form and solve the resulting, rather complicated, difference equation. For the purpose of this paper it is sufficient to simulate the system for different parameter values. In each of the examples I assume that:

- number of households: $N = 10$,
- maximum income: $\bar{Y} = 100$,
- temporary income shock in $t=5$: $Y_t = 90$,
- mortgage rate: $m = 0.05$,

¹⁶Lux (1995) and Hott (2007) use a very similar definition.

- financing rate: $r = 0.04$, and
- degree of optimism: $\delta = 0.25$.

For the parameter τ (link between profits and mood) I consider different values. As we can see in Figure 4, the initial income shock in $t = 5$ leads to real estate price fluctuations in the following periods. For $\tau = 9.75$ the shock leads to uniform sinus shaped price cycles. With $\tau = 10$ the speed of mood adjustment is higher and the reaction to changes in profits is much stronger. This leads not only to higher amplitudes of the real estate price fluctuations but the amplitudes also increase over time. In the third example the opposite is the case: The weaker mood adjustment ($\tau = 9.5$) leads to smaller and decreasing price fluctuations. In all three examples the peaks and troughs of the cycle are not entirely symmetrical. The reason for this is that the development of the loss rates is not linear.

[Insert Figure 4 about here.]

The real estate price fluctuations in Figure 4 are generated by mood swings of the banks. These mood swings are, in turn, triggered by real estate price fluctuations. Note that, even though banks are willing to provide higher mortgage loans in upswing phases, the LTV is unchanged over the entire cycle. It is always 100%.¹⁷ However, the affordability of homes changes over time. This has an effect on default rates among households and, hence, on the profits of banks. Figure 5 displays the development of the profits of the entire banking sector. As we can see, real estate price fluctuations lead to positive profits in upswing phases and losses in downswing phases. However, profits and losses are not symmetrical: Losses are higher than profits. This has two reasons: Firstly, the real estate price cycles are not completely symmetrical themselves and, secondly, the exposure of banks is higher in downswing phases than in upswing phases.¹⁸

[Insert Figure 5 about here.]

¹⁷To be more correct, what is really unchanged is the Loan-to-Price ratio. From a theoretical point of view the fundamental value of houses should be constant over time. Hence, the real LTV is fluctuating with the real estate price cycles. However, banks can not observe the fundamental value and assume that the LTV is constant.

¹⁸The high exposure at the real estate price peak belongs to the downswing (loss) phase and the low exposure at the trough of the cycle belongs to the upswing phase.

The greater the influence of the banks' mood (high τ) the higher are the fluctuations of real estate prices and banks' profits. This emphasizes that it is important that banks base their risk assessment on objective indicators rather than a subjective assessment of the creditworthiness of their customers or just their past performance.

3.2 Momentum Forecasts

There are mainly two reasons to assume that banks base their forecasts on the momentum of prices rather than on fundamentals. First, due to securitization the distance between the borrower and the ultimate holder of the risk has increased. Therefore, it is not always clear what the underlying economic fundamentals of an asset are. Furthermore, highly diversified institutions often put different assets into rather broad classes that are not necessarily built on the underlying economic risk factors. For example AAA mortgage backed securities might be treated in the same way as a AAA corporate bond. The second reason to assume that banks base their forecasts on the momentum of prices is that their models often have a very short memory. Value at Risk (VaR) models, for example, often use a data sample of only three years. Given that real estate cycles are about 15 years long, one can see that these models consider only a phase of the cycle and, therefore, the momentum of the price development.

In this section I assume that banks base their forecasts for future real estate prices and income on the past development of these variables. Expected real estate prices ($E(P_{t+1})$) and expected income ($E(Y_{t+1})$) for the next period are given by:¹⁹

$$E(P_{t+1}) = (1 + E(w_t^P))^2 P_{t-1} \quad \text{and} \quad (16)$$

$$E(Y_{t+1}) = (1 + E(w_t^Y))^2 Y_{t-1}, \quad (17)$$

where $E(w_t^P)$ and $E(w_t^Y)$ are the expected growth rates of real estate prices and income, respectively. I assume that banks forecast these growth rates by using a very simple VAR model:²⁰

$$1 + E(w_t^P) = \left(\frac{P_{t-1}}{P_{t-k}} \right)^{\frac{\alpha}{k-1}} \left(\frac{Y_{t-1}}{Y_{t-k}} \right)^{\frac{1-\alpha}{k-1}} \quad (18)$$

¹⁹I use the price from the previous period instead of the present price as the basis for the expected price in the next period. Otherwise people would expect a certain price increase, no matter how high the price is in the present period.

²⁰By taking the log of the following equations one would get the typical form of a VAR model.

$$1 + E(w_t^Y) = \left(\frac{Y_{t-1}}{Y_{t-k}} \right)^{\frac{1}{k-1}} \quad (19)$$

where k is the number of lags and $0 \leq \alpha \leq 1$ is a parameter of the VAR. If we plug these expectations into the expected loss rate equation (4) we get the expected loss rate according to the momentum forecast model $E(\rho_{t+1}^v)$:

$$\begin{aligned} E(\rho_{t+1}^v) &= \frac{[(1+m)P_t - E(P_{t+1})]^2}{2NP_t E(Y_{t+1})} \\ \Rightarrow E(\rho_{t+1}^v) &= \frac{\left[(1+m)P_t - \left(\frac{P_{t-1}}{P_{t-k}} \right)^{\frac{2\alpha}{k-1}} \left(\frac{Y_{t-1}}{Y_{t-k}} \right)^{2\frac{1-\alpha}{k-1}} P_{t-1} \right]^2}{2NP_t \left(\frac{Y_{t-1}}{Y_{t-k}} \right)^{\frac{2}{k-1}} Y_{t-1}}. \end{aligned} \quad (20)$$

In equilibrium this expected loss rate has to be equal to the interest rate spread $m - r$. This setup has an important consequence: If an exogenous shock leads to an increasing real estate price in $t - 1$, the period t expectation for the real estate price in $t + 1$ gets higher. Following equation (4) this has a positive effect on the real estate price in t . A higher price in t has a positive effect on period $t + 1$ expectations of the price in $t + 2$. This has, in turn, a positive effect on the price in $t + 1$, and so on. This positive feedback effect is slowed down, however, by the consideration of a fundamental factor: income. As long as the real estate price increase is not accompanied by an appropriate increase in income and the consideration of the income development is strong enough (low α) the price increase is reversed at some point and the real estate price is going back again.

This mechanism is very similar to the one described by Hong and Stein (1999). They develop a model of “news-watchers” and “momentum traders”. Momentum traders can amplify the effects of shocks. The behavior of news-watchers link the price development to fundamentals. In my model agents (banks) base their forecasts on the momentum of the price as well as on fundamentals. To illustrate the impact of my assumptions I simulate the model for different sets of parameters. In all examples I use the following parameter values:

- number of households: $N = 10$,
- maximum income: $\bar{Y} = 100$,

- temporary income shock in $t=5$: $Y_t = 105$,
- mortgage rate: $m = 0.05$, and
- financing rate: $r = 0.04$.

For the parameter α and the number of lags k I consider different values. For the simulation displayed in Figure 6 $k = 2$. As we can see, the results are very similar to the results for the mood swings approach in section 3.1. Only now amplitudes of the real estate price fluctuations do not depend on the speed of mood adjustment (τ) but on the weight on the real estate price growth rate (α). However, in both models the positive feedback effect emerges because the behavior of banks has an influence on the real estate price. This creates self-fulfilling prophecies. With $\alpha = 0.5$ real estate price fluctuations have decreasing amplitudes and with $\alpha = 0.52$ amplitudes are increasing over time. Beside the real estate prices their expected values are displayed as well. As we can see, in both cases the forecasts are very accurate. The reason for this is that the forecasts are self-fulfilling. Hence, banks feel no need to change their VAR model.²¹

One reason for the price bubbles created by the VAR forecast is that it uses very short lags ($k = 2$). As shown in Figure 7, the amplitudes and the frequency of the real estate price fluctuations can be reduced by using longer lags ($k = 5, 10$). In this figure $\alpha = 0.52$.

[Insert Figure 6 about here.]

[Insert Figure 7 about here.]

real estate price fluctuations created by the momentum forecasts of banks lead, of course, also to fluctuations of their profits. These fluctuations are displayed in Figure 8 and 9.

[Insert Figure 8 about here.]

[Insert Figure 9 about here.]

²¹Hirshleifer et al. (2006) also point out that irrational trading positively affects asset prices and thereby the profits of the irrational investors.

As we have seen there are two elements that increase the adverse effects of the momentum forecasts: a high weight on the price development rather than fundamentals (high α) and short time lags (small k). This emphasizes that it is important that banks base their forecasts on fundamentals and that they consider long time series.

3.3 Disaster Myopia

From time to time it is believed that houses are very safe investments. In many cases, however, such a phase is ended abruptly by a real estate crisis. The question is: Why do people (and banks) sometimes neglect or underestimate the possibility of declining real estate prices? Herring and Wachter (1999) see a reason for this in a “disaster myopia”. Following this idea, agents underestimate the probability of a shock if previous shocks occurred long ago. This idea relies on Tversky and Kahneman’s (1982) availability heuristic. The authors write (1982, p. 164):

“The availability heuristic... uses strength of association as a basis for the judgment of frequency... Availability is an ecologically valid clue for the judgment of frequency because, in general, frequent events are easier to recall or imagine than infrequent ones. However, availability is affected by various factors which are unrelated to actual frequency.”

One of the factors that affects availability is time. If an event occurred only recently it might be more available than an event that happened long ago. In other words, banks tend to forget events over time. A reason for this can be that humans tend to forget and make mistakes but also the high turnover of staff at banks.²²

To illustrate the effects of disaster myopia on real estate prices, I make some small changes to my basic model. First, I assume that in each period there is an income shock ($Y^S < \bar{Y}$) with probability β . Banks do not know, however, if this probability is high (β^h) or low ($\beta^l < \beta^h$). They assess the probability for a high β by looking at past shocks. The a priori probability for a high β is assumed to be $Pr(h) = 0.5$. Following Bayes’ rule, under the condition that a shock (S_τ) occurred in τ , in $t \geq \tau$ the probability for β^h ($Pr_t(h | S_\tau)$) is:

²²Guttentag and Herring (1984) also consider availability heuristic when modeling the subjective probability of a shock. In addition they consider a threshold heuristic. Following this heuristic the subjective probability drops to zero if it falls below a certain threshold.

$$Pr_t(h|S_\tau) = \frac{Pr_t(S_\tau|h)Pr(h)}{Pr_t(S_\tau|h)Pr(h) + Pr_t(S_\tau|l)(1 - Pr(h))} = \frac{\beta^h}{\beta^h + \beta^l} \quad (21)$$

and under the condition that no shock (NS_τ) occurred in τ , it is:

$$Pr_t(h|NS_\tau) = \frac{Pr_t(NS_\tau|h)Pr(h)}{Pr(NS|h)Pr(h) + Pr_t(NS_\tau|l)(1 - Pr(h))} = \frac{1 - \beta^h}{1 - \beta^h + 1 - \beta^l}. \quad (22)$$

Agents do not look at just a single signal, however. In each period there is either a shock or not and these events provide a useful information. If banks consider the whole history of signals (H_t) up to period t , the probability for a high β is for example:

$$\begin{aligned} Pr_t(h|H_t) &= \frac{(1 - \beta^h)(1 - \beta^h)\beta^h(1 - \beta^h)}{(1 - \beta^h)(1 - \beta^h)\beta^h(1 - \beta^h) + (1 - \beta^l)(1 - \beta^l)\beta^l(1 - \beta^l)} \\ &= \frac{\beta^h(1 - \beta^h)^3}{(\beta^h(1 - \beta^h)^3 + \beta^l(1 - \beta^l)^3)}. \end{aligned} \quad (23)$$

In this case we have one shock and three periods without a shock. As we can see, the sequence of the events is irrelevant for the probability $Pr_t(h|H_t)$. If we want to consider disaster myopia, however, the sequence has to become relevant. To achieve this, I introduce the parameter v (with $0 \leq v \leq 1$). This parameter represents how well past events can be recalled. If $v = 1$ agents perfectly remember all past events and if $v = 0$ they only look at the current event. To formalize this, I assume that a shock in $t - x < t$ leads to a probability assessment of:

$$Pr_t(h|S_{t-x}) = \frac{(\beta^h)^{v^x}}{(\beta^h)^{v^x} + (\beta^l)^{v^x}}. \quad (24)$$

For $v = 1$ and $v = 0$, v^x and, therefore, $Pr_t(h|S_{t-x})$ is independent of the age of the signal x .²³ However, for intermediate values of v the age of the signal becomes relevant and v^x depends negatively on x . Since $0 < \beta^l < \beta^h < 1$, $(\beta^h)^{v^x}$ as well as $(\beta^l)^{v^x}$ depend negatively on v^x and, therefore, positively on x . However, since $(\beta^l)^{v^x}$ increases more with x than $(\beta^h)^{v^x}$ the probability $Pr_t(h|S_{t-x})$ decreases with x , although it stays always above the a priori probability $Pr(h) = 0.5$. Now the sequence of events is very

²³For $v = 0$ this is only true because $x > 0$. For $x > 0$, $v^x = 0$ but for $x = 0$, v^x would be 1.

relevant: The older the signal the smaller its impact on the probability assessment of banks. For the above example we get now:

$$\begin{aligned}
Pr_t(h|H_t) &= \frac{(1 - \beta^h)(1 - \beta^h)^v(\beta^h)^{v^2}(1 - \beta^h)^{v^3}}{(1 - \beta^h)(1 - \beta^h)^v(\beta^h)^{v^2}(1 - \beta^h)^{v^3} + (1 - \beta^l)(1 - \beta^l)^v(\beta^l)^{v^2}(1 - \beta^l)^{v^3}} \\
&= \frac{(\beta^h)^{v^2}(1 - \beta^h)^{1+v+v^3}}{(\beta^h)^{v^2}(1 - \beta^h)^{1+v+v^3} + (\beta^l)^{v^2}(1 - \beta^l)^{1+v+v^3}} \\
\text{or} \\
&= \frac{(\beta^h)^{v^x}(1 - \beta^h)^{\sum_{i=0}^{t-1}(v^i)-v^x}}{(\beta^h)^{v^x}(1 - \beta^h)^{\sum_{i=0}^{t-1}(v^i)-v^x} + (\beta^l)^{v^x}(1 - \beta^l)^{\sum_{i=0}^{t-1}(v^i)-v^x}}. \tag{25}
\end{aligned}$$

The general solution for a single shock in equation (25) is very similar to that in equation (24) only now the episodes with no signal are considered aswell. It is easy to see that $(1 - \beta^h)^{\sum_{i=0}^{t-1}(v^i)-v^x}$ and $(1 - \beta^l)^{\sum_{i=0}^{t-1}(v^i)-v^x}$ depend negatively on x . Since $(1 - \beta^h) < (1 - \beta^l)$, the denominator of equation (25) increases relatively more than the numerator. Hence, the overall effect of an increasing x on the probability of a high β is still negative and even more negative than in equation (24).

Given the probability of a high probability of a shock $Pr_t(h|H_t)$, in t the probability for an income shock (β_t) in the next period is:

$$\beta_t = Pr_t(h|H_t)\beta^h + (1 - Pr_t(h|H_t))\beta^l \tag{26}$$

and the period t expectation with regard to the maximum income in $t + 1$ is:

$$E_t(Y_{t+1}) = \beta_t Y^s + (1 - \beta_t)\bar{Y}. \tag{27}$$

Since $E_t[Pr_{t+i}(h|H_{t+1})] = Pr_t(h|H_t)$ with $i > 0$, today's expectation with regard to future income is identical to today's expectation with regard to the income in the next period: $E_t(Y_{t+x}) = E_t(Y_{t+1})$. Hence, similar to equation (8), the real estate price in period t is given by:

$$P_t = 2 \frac{(m - r)N E_t(Y_{t+1})}{m^2}. \tag{28}$$

Since the age of the previous shock (x) has a negative effect on the probability of a high probability of a shock $Pr_t(h|H_t)$, it has also a negative effect on the expected shock

probability β_t and, therefore, a positive effect on expected future income ($E_t(Y_{t+1})$) and today's real estate price (P_t). In other words, if there is a long episode without any shock, the estimated shock probability gets lower and real estate prices increase. However, if suddenly a shock occurs, the age of the previous shock x and, therefore the real estate price jump to a much lower level. To illustrate these effects, I simulate the model for the following parameter values:

- number of households: $N = 10$,
- maximum income: $\bar{Y} = 100$,
- income shock: $Y^S = 80$,
- high shock probability: $\beta^h = 0.2$,
- low shock probability: $\beta^l = 0.01$,
- true shock probability: $\beta = 0.2$,
- mortgage rate: $m = 0.05$, and
- financing rate: $r = 0.04$.

For the parameter v I consider different values. Shocks occur randomly with the probability $\beta = \beta^h = 0.2$. Figure 10 shows the development of the probability assessment ($Pr_t(h|H_t)$) for different values of v . As we can see, if banks do not forget previous events ($v = 1$), they learn quickly that the true shock probability is $\beta = 0.2$ and $P(h|H)$ gets close to 100%. On the other hand, if banks only consider the current period ($v = 0$) their probability assessment jumps between the result of equation (21) and the result of equation (22). Each time a shock occurs the probability for a high shock probability jumps up and it is low when there is no shock.

[Insert Figure 10 about here.]

More interesting are the cases of intermediate values of v . With $v = 0.95$ banks learn quite fast as well. However, if there are longer episodes without any shock, the

probability for a high probability of a shock can decline substantially and can even get smaller than with $v = 0$.²⁴

The changing risk assessment of banks has an effect on real estate prices. If banks believe that the shock probability is low, they are willing to provide higher mortgage loans and real estate prices rise. Figure 11 shows the development of real estate prices for $v = 0.75$ and $v = 0.95$. As we can see, in contrast to the mood swings and the momentum forecast model variations, we now do not get uniformly sinus shaped price fluctuations. If we consider disaster myopia real estate prices sharply drop after an income shock. With $v = 0.75$ real estate price bubbles are more frequent than with $v = 0.95$. If the episode without any shock is very long, however, the bubble can get bigger with $v = 0.95$. The corresponding development of the profits is displayed in Figure 12. As we can see, banks make positive profits in the upswing phases and they suffer very high losses when the bubbles burst.

[Insert Figure 11 about here.]

[Insert Figure 12 about here.]

These results show that it is important that banks consider long time series (long memory or high v) for their risk assessment. However, the results also show that it is important that past events are considered in the same objective way as recent events.

4 Conclusions

Banks are often among the victims of real estate crises. On the other hand, there is some evidence that banks also contribute to the creation of the problems. They provide more and more financial resources for real estate purchases and, thereby, help to create a price bubble. When the bubble bursts they are heavily exposed and suffer high losses.

In this paper I have shown how banks can create real estate cycles through their behavior, namely their expectation formation. They make high profits in upswing phases but suffer high(er) losses when the market turns. In my first approach banks become

²⁴It is important to note that this effect works in the other direction as well: If the true β is 0.01, banks overestimate the risk whenever a shock occurs. However, I only look at the case where banks underestimate the risk ($\beta = 0.2$).

over- or under-confident because of the good or bad performance of their mortgage loans. The higher or lower confidence leads to higher or lower loans and, therefore, to higher or lower real estate prices. In a second approach I have shown how momentum forecasts can lead to overreactions and persistent fluctuations. Finally, I have shown that disaster myopia can lead to an underestimation of risks. This creates real estate price bubbles which burst if a shock occurs.

With regard to financial stability, these findings have several implications: Firstly, they show that it is important that banks base their risk assessment on objective indicators. This also implies that procyclical risk models should be avoided. Secondly, forecasts of default rates and real estate prices should be based on their driving economic fundamentals rather than just their past development. Thirdly, it is important that banks base their risk as well as forecasting models on long time series. Otherwise the models capture only the short term momentum of default rates or real estate prices and shocks can catch banks unprepared.

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Table 1: CORRELATION BETWEEN ANNUAL GROWTH RATES OF LOANS (LOAN) AND HOUSE PRICES (HP) AND THE FRACTION OF NON-PERFORMING LOANS TO LOANS (NPL).

(SOURCES: BANK FOR INTERNATIONALE SETTLEMENTS, BANK OF ENGLAND, FEDERAL RESERVE BOARD, NORGES BANK, AND SWISS NATIONAL BANK. SAMPLE: QUARTERLY DATA FROM 1985 Q1 TO 2008 Q4.)

	JAP	NOW	CH	UK	US	Average
Correlation (Loan ; HP)	85%	55%	82%	64%	65%	70%
Correlation (HP ; NPL)	-48%	-51%	-56%	-50%	-68%	-54%

Figure 1: MORTGAGES, REAL ESTATE PRICES, CHARGE-OFF RATES, AND LENDING BEHAVIOR OF BANKS (TIGHTENING) IN THE US. SOURCE: BIS AND FEDERAL RESERVE BOARD.

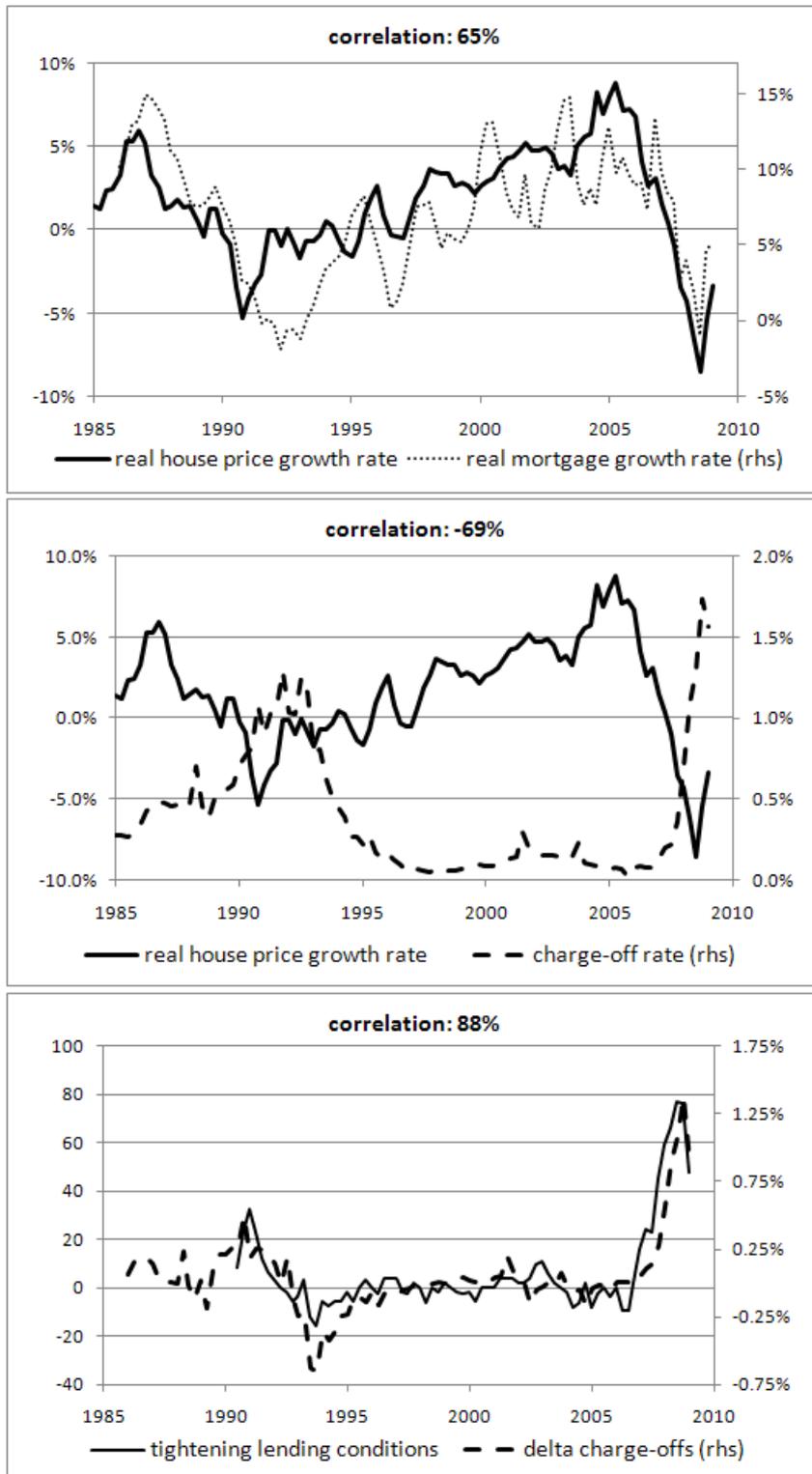


Figure 2: INCOME, CONSUMPTION, MORTGAGE PAYMENTS AND INSOLVENCIES.

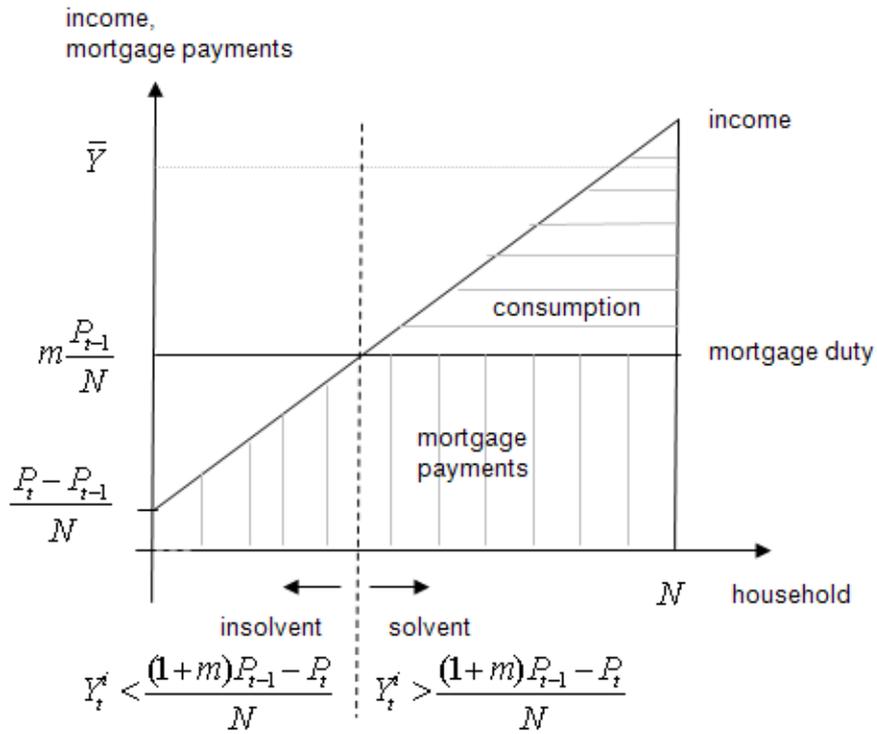


Figure 3: INTEREST RATE MARGIN, EXPECTED LOSSES AND EXPECTED PROFITS.

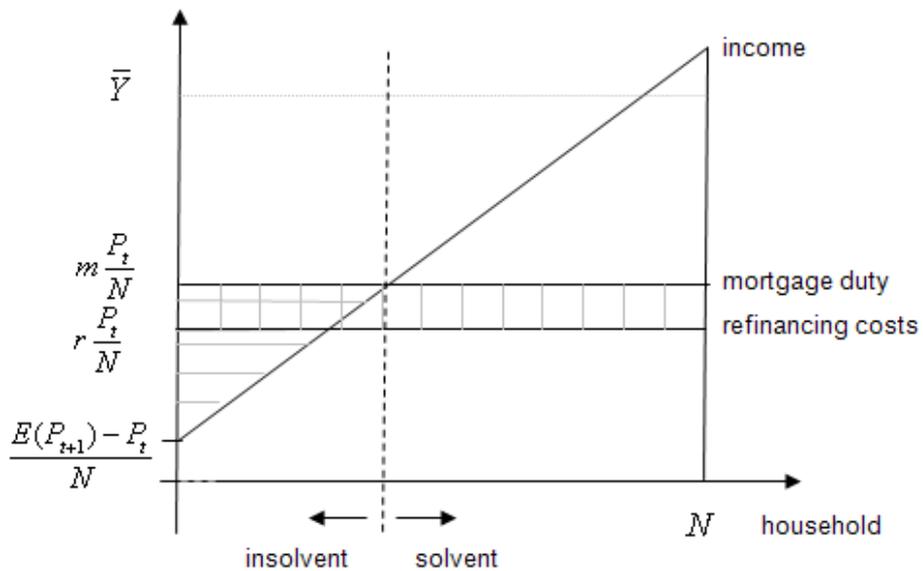


Figure 4: THREE CASES OF REAL ESTATE PRICE FLUCTUATIONS UNDER MOOD SWINGS.

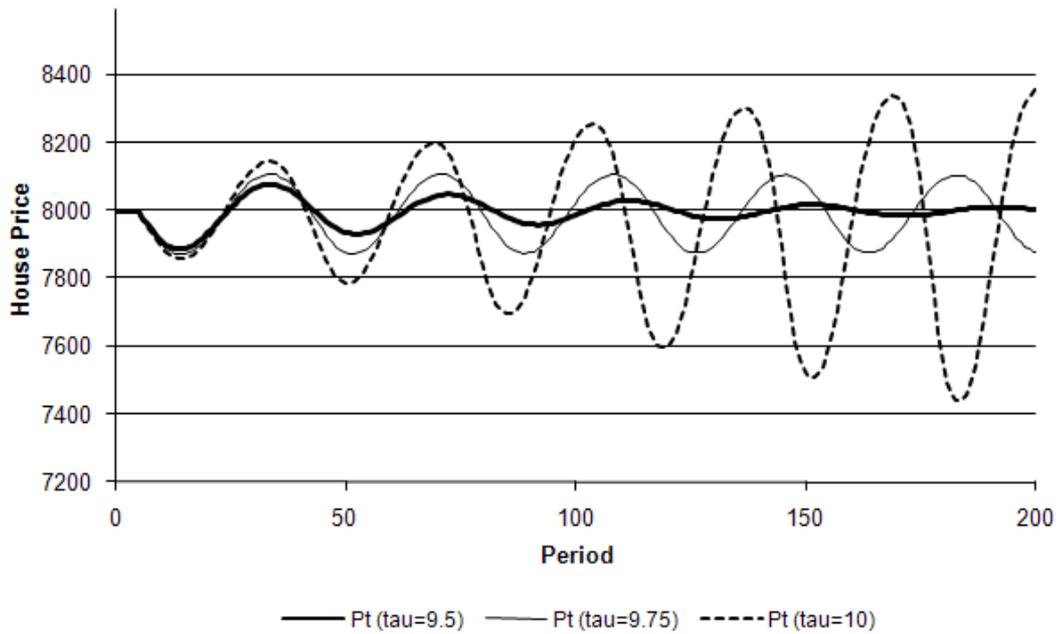


Figure 5: THREE CASES OF BANK PROFITS UNDER MOOD SWINGS.

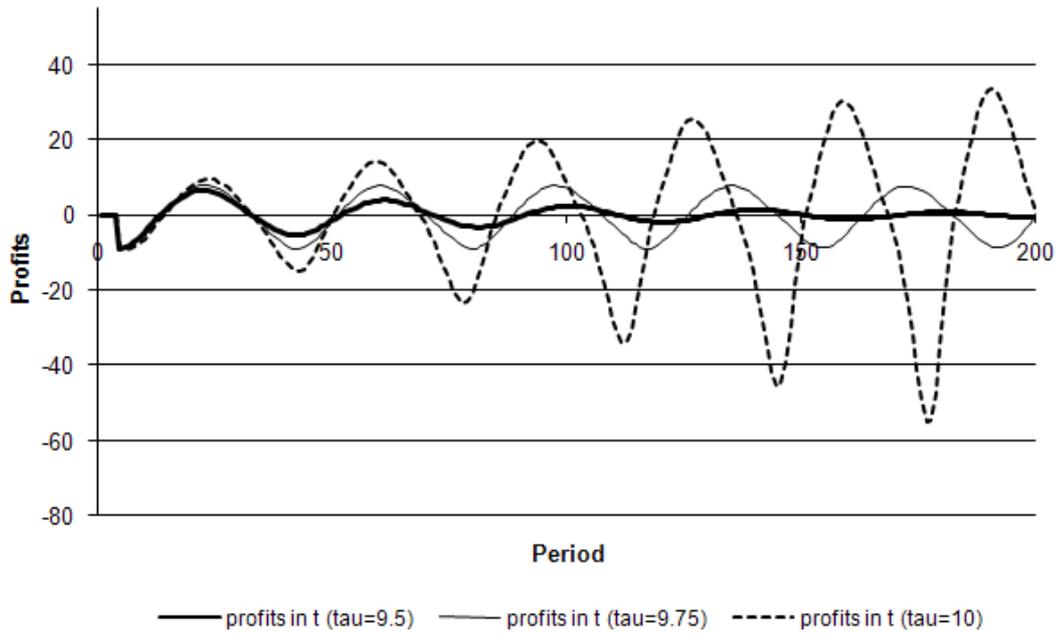


Figure 6: REAL ESTATE PRICE FLUCTUATIONS DUE TO MOMENTUM FORECASTS WITH DIFFERENT WEIGHTS ON FUNDAMENTALS.

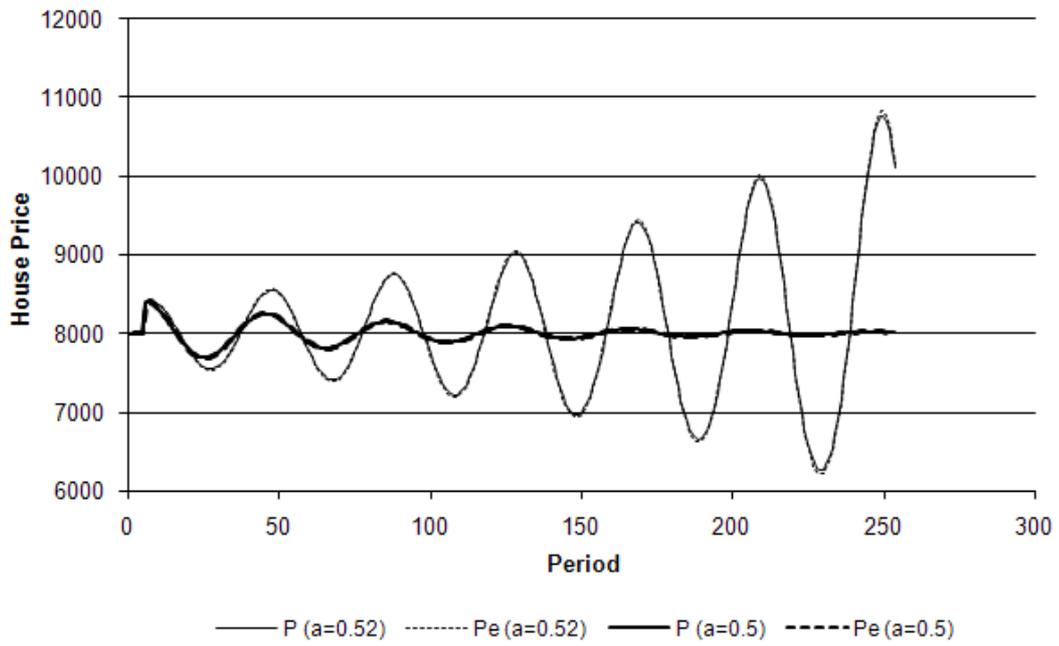


Figure 7: REAL ESTATE PRICE FLUCTUATIONS DUE TO MOMENTUM FORECASTS WITH DIFFERENT LAGS.

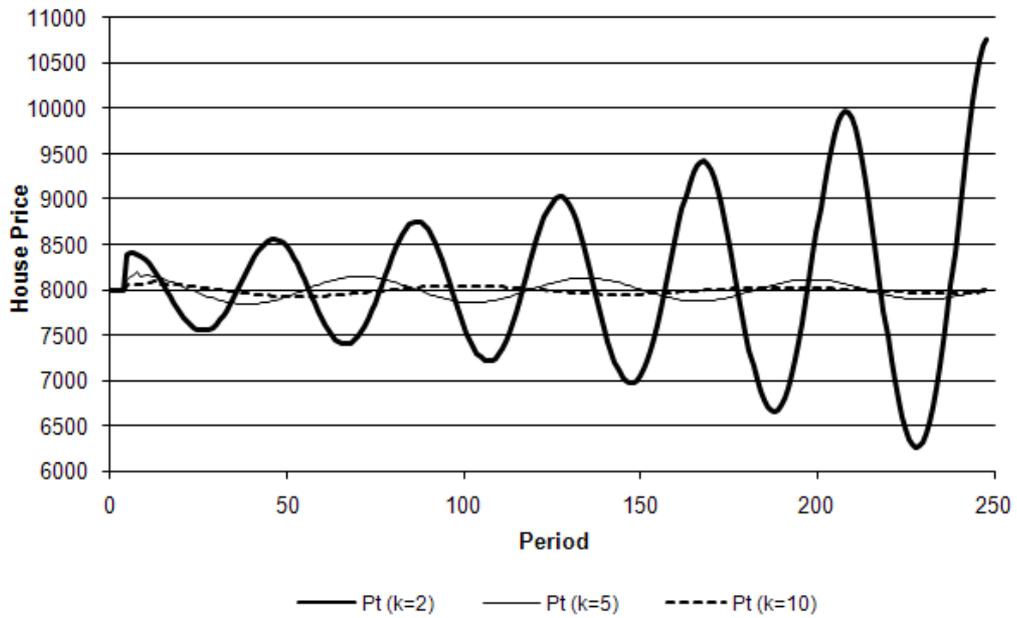


Figure 8: BANK PROFITS UNDER MOMENTUM FORECASTS WITH DIFFERENT WEIGHTS ON FUNDAMENTALS.

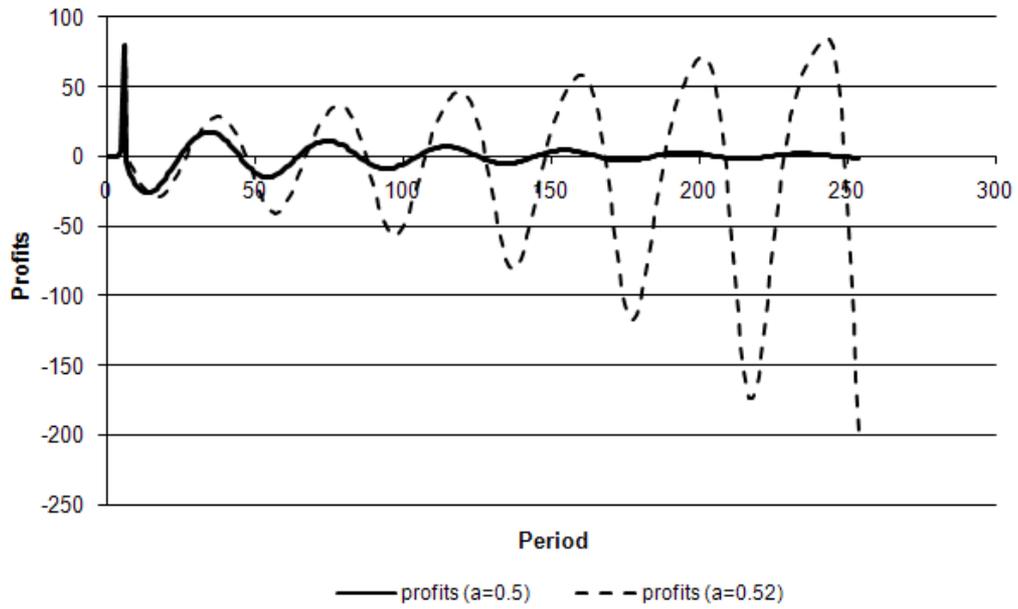


Figure 9: BANK PROFITS UNDER MOMENTUM FORECASTS WITH DIFFERENT LAGS.

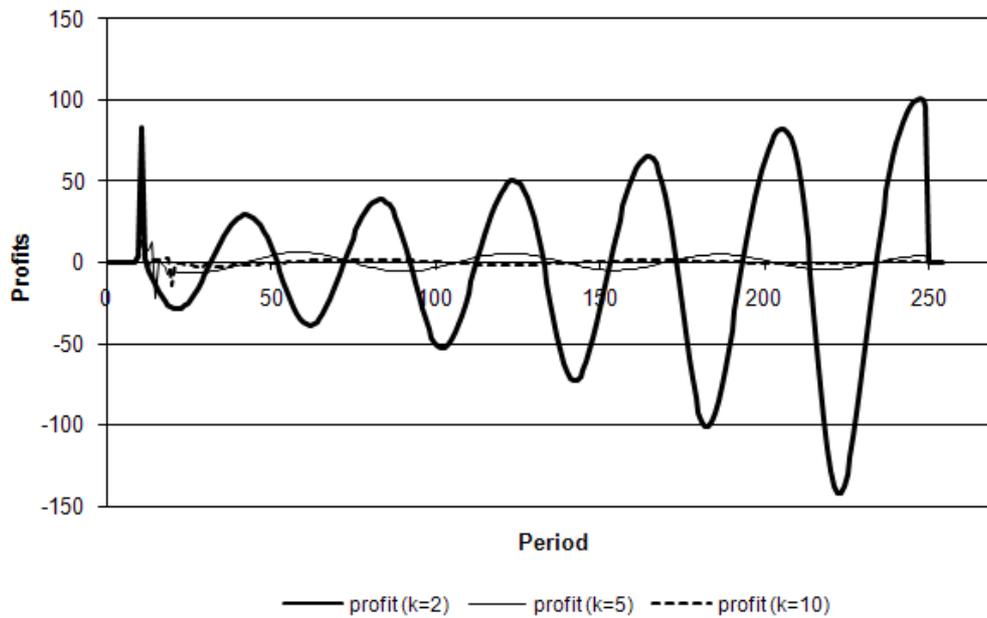


Figure 10: PROBABILITY ASSESSMENT WITH DISASTER MYOPIA.

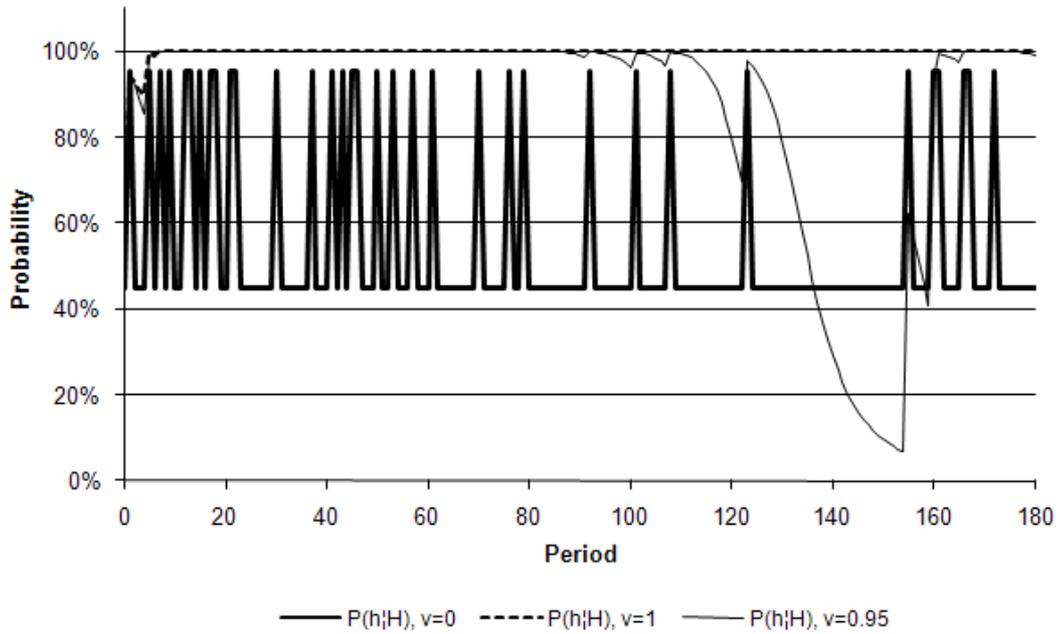


Figure 11: REAL ESTATE PRICES AND PROFITS WITH DISASTER MYOPIA.

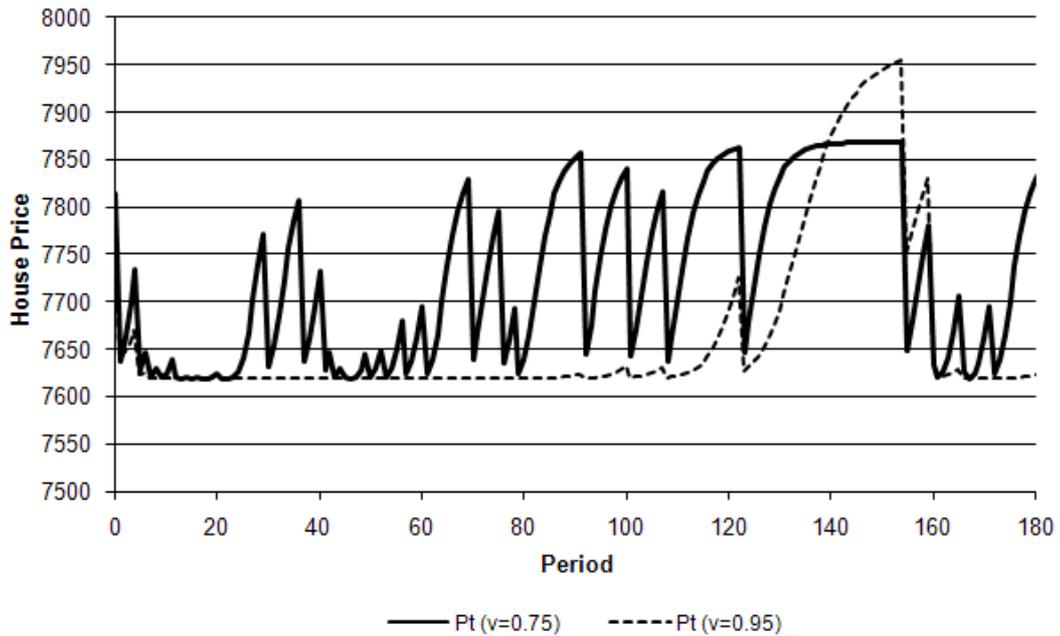
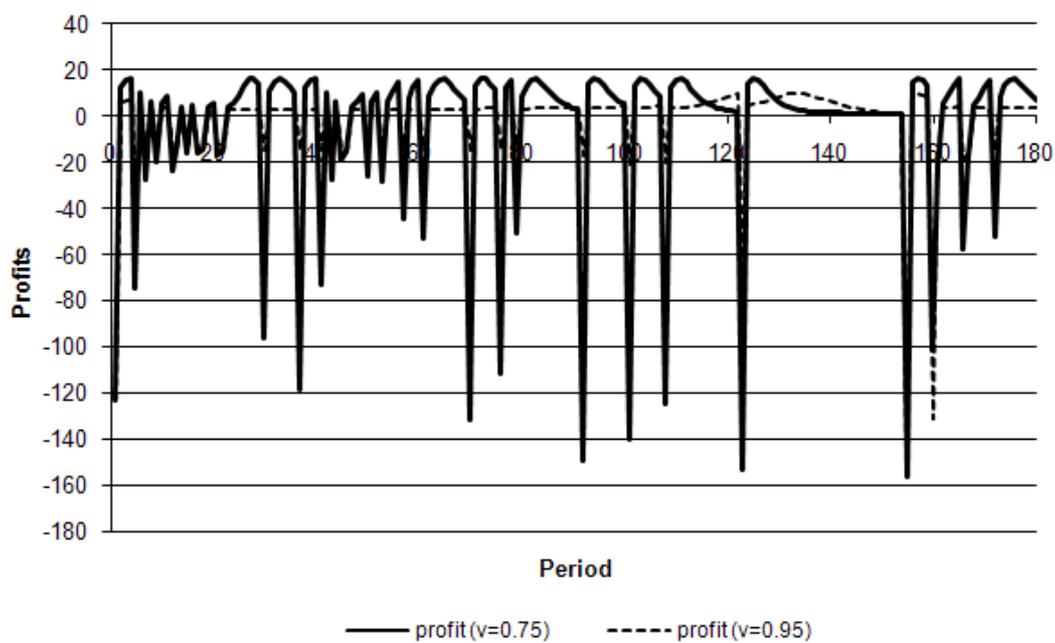


Figure 12: BANK PROFITS WITH DISASTER MYOPIA.



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