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Joint adjustment of house prices, stock prices and output towards short run equilibrium

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Abstract — *A dynamic IS-LM model including stocks and houses as additional assets will be analyzed in this paper. Providing also housing services, a major consumption item for most households, houses create an additional link between the monetary and the real sector of the economy. The adjustment path of output, house prices and stock prices after exogenous policy shocks will be derived within a rational expectation setup. This will show how different reaction patterns of asset prices are related to different elasticities of housing services demand. These general analytical results are contrasted with relevant empirical work, particularly Lastrapes [2002], leading to the identification of plausible elasticity ranges. The particular results for those shed new light upon the ongoing discussion about demand effects from real estate wealth and about determinants of house price fluctuations.*

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1   Introduction

House price movements have recently attracted renewed attention in the aftermath of some spectacular ups and downs in various countries, documented for example in Englund and Ioannides [1997]. Because expenditures for housing services account for an important fraction of total consumption expenditures and houses are the major asset position of median households, it has been questioned what the macroeconomic causes and consequences of these house price movements are (Herring and Wachter [1999], IMF [2000], Girouard and Blöndal [2001] or Barata and Pacheco [2003]). Amongst the suspected consequences wealth effects upon aggregate demand play the most important role (e.g. Case, Quigley and Shiller [2001], Sutton [2002] or Boone and Girouard [2002]). An often cited channel for these effects (e.g. Deaton [1991], Kiyotaki and Moore [1995]) are changing borrowing constraints due to changing house prices, a feature linked to the important collateral function of houses.

In this paper we look for a simultaneous determination of house prices, stock prices and output during adjustments towards short run equilibrium rather than investigating unidirectional types of causality amongst these variables. The framework we use is a version of the dynamic IS-LM model of Blanchard [1981] adapted to include houses as additional assets and to include demand for housing services. Our approach is complementary to the predominantly econometric literature in this field because it attempts to trace analytically the joint movements of the relevant variables across time after exogenous, disequilibrating policy shocks.

Relevant empirical findings regarding the correlation pattern amongst our key variables can be found in numerous studies. Some typical results are contained for example in IMF [2000] or Boone and Girouard [2002]. According to these studies stock price and house price fluctuations are clearly positively correlated in the long run perspective. But this correlation vanishes in the short run perspective, which is our concern here. House prices and GDP on the other hand seem less if at all correlated. Other empirical evidence, which pertains to our analysis more particularly is presented in Lastrapes [2002], who investigated the reaction of house prices upon monetary shocks within a VAR framework. We will identify stylized conditions for housing services demand, which leads to resulting adjustment and correlation patterns in line with this empirical evidence.

The paper proceeds with an exposition of the basic model equations in section 2. The comparative static results, corresponding to an IS-LM type of reasoning, are discussed in section 3. The adjustment dynamics of the key variables is analyzed in section 4, followed by a brief summary.

2   The model

The following model is an adaptation of Blanchard [1981]. Rental houses as assets and a demand function for rental housing services is added. The consols in Blanchard's model are dropped to keep the analysis tractable. To avoid complications arising from the inextricably linked investment and consumption considerations, necessary to properly model owner occupied housing, we do not deal with the latter.

Focussing on the short run the rental housing stock $\bar{H}$ will be assumed fix and normalized to $\bar{H} = 1$, i.e. construction activity and depreciation will be neglected. In line with the bulk of the housing literature it is assumed that each housing unit also offers one

unit of housing services, the supply of which therefore is also fixed at 1. If fully utilized the total housing stock would yield real rental income R to its owners. But empirically vacancy rates of rental units in the US for example always exceeded 5% in the eighties and increased beyond 7% for the 1990s as documented in Rosen [1996]. So we consider a demand for housing services $H_c(t)$ at time t falling short of supply as generic case.[1] This disequilibrium characterization of rental housing markets is also in line with Smith, Rosen and Fallis [1988, p. 50]. Therefore actual rental income will be $H_c(t)R$.

A composite consumption/investment good serves as numeraire, i.e. the prices for stocks (q), houses (P_h) and housing services (R) are expressed in units of this composite good. With $y_c(t)$ denoting output of the composite good sector at time t aggregate real income y is thus defined as

$$y(t) = y_c(t) + RH_c(t) \tag{1}$$

The composite good-price and rental rates R are assumed fixed in this short run analysis. So neither price elasticity of housing services demand is an issue here nor the substitution elasticity between housing services and the composite good. A justification for the assumption of a fixed rental rate R can be found for example in Smith et al. [1988, p. 50], who state that *"changing demand conditions are reflected first in changed vacancies and prices (rents) are affected only after a lag of approximately 6-24 months."* The demand for housing services $H_c(t)$ at time t is thus modelled as

$$H_c(t) = h_0 + h_1 y_c(t) \tag{2}$$

For simplicity we ignore the possibility that house owners might also have demand for rented housing services. Therefore demand for housing services depends only on the composite good sector income y_c only rather than on y. But it would not qualitatively alter the results if $y_c(t)$ in (2) were to be replaced by with $y(t)$.

Regarding the demand for the composite good we consider a separate wealth effect via changing house prices in addition to Blanchard's wealth effect via stock prices.[2] This leads to the following definition of the demand for the composite good

$$d_c(t) = d_0 + d_1 y(t) + d_2 q(t) + d_3 P_h(t) \tag{3}$$

In a series of recent papers the real wealth effect upon consumption from changing house prices has been found to be significant and, for European countries, to exceed the stock market wealth effect considerably. Barata and Pacheco [2003, p. 11] state that *"the housing market appears to be more important than the stock market as a factor influencing consumption."* They report corresponding elasticities of consumption between 0.1 and 0.2 for various European countries, roughly the range of figures reported in Case et al. [2001]. Greenspan [1999] gives a figure of roughly 0.05 for the US and similar figures are reported for the G7 countries in Girouard and Blöndal [2001].

Unfortunately these elasticity figures stem from econometric specifications without a separate equation for housing services demand. Most often simply aggregate consumption demand is specified, where expenditures for housing services are lumped together with those for other consumption items. So empirical evidence does not tell to which extent

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[1] By skipping the equilibrium perception of the market for housing services, our treatment of houses sidesteps the theoretical problem of overdetermination of demand for houses due to their dual nature as asset and consumption items, as stated for example in Flavin and Yamashita [2002].

[2] The consols in Blanchard's model, which are replaced with houses here, do not carry such wealth effects. This is why some clearcut results for policy effects upon asset price adjustments do not carry over to the present model.

housing services demand per se might be subject to such wealth effects. Our rational for the differential treatment of wealth effects is that primarily low income groups without substantial amounts of either houses or stocks demand rental housing services, so that wealth effects upon demand for housing services is negligible. The evidence provided in Boone and Girouard [2002], that wealth effects upon consumption are higher for low income groups, does not contradict our rational, because it applies to aggregate consumption once again.

Money market equilibrium will be formalized exactly as in Blanchard, using variables m and p to denote nominal money supply resp. prices in log terms:

$$i(t) = l_1 y(t) - l_2(m - p) \tag{4}$$

Monetary policy is assumed to control real money supply, thus $(m-p)$ is considered as an exogenous constant. To ensure positive nominal interest rates for any non-negative composite good output level y_c we assume

$$l_1 R h_0 - l_2(m-p) > 0 \tag{5}$$

From (4) the elasticity of liquidity demand with respect to income can be derived as $l_1 y / l_2$. Assumption (5) therefore implies a sufficiently high elasticity of liquidity demand with respect to income.

Profits of the composite good sector are assumed to depend linearly upon output of this sector:

$$\pi(t) = a_0 + a_1 y_c(t) \tag{6}$$

It is assumed that asset prices are determined via portfolio equilibrium conditions, i.e. with equal rates of returns across asset types prevailing. For simplicity potential risk differentials between investments in houses resp. stocks are ignored. House price and stock price are thus assumed to instantaneously adjust such that all assets are always willingly held. The relevant portfolio equilibrium conditions are

$$i(t) = [\pi(t) + \dot{q}^e(t)]/q(t) \tag{7}$$
$$i(t) = [H_c(t)R + \dot{P}_h^e(t)]/P_h(t) \tag{8}$$

where superscripts ^{e} denote expected values of the corresponding prices. Condition (7) states, that the rate of return on stocks π/q plus expected capital gains $\dot{q}^e/q$ must equal the interest rate, i.e. the rate of return on bonds. Likewise Condition (8) states that the rate of return on houses $H_c R/P_h$, taking the utilization rate of the housing stock H_c into account, plus expected capital gains $\dot{P}_h^e/P_h$ must equal the interest rate. It will be assumed that expectations are formed rationally so that

$$\dot{q}^e = \dot{q}, \quad \dot{P}_h^e = \dot{P}_h. \tag{9}$$

Portfolio equilibrium is assumed to hold at every instant. So substituting expected with actual price changes in (7) and (8) according to (9) determines the first two adjustment equations. Regarding the composite good instead sluggish quantity adjustment to demand is assumed, or more precisely

$$\dot{y}_c(t) = f_y \left[d_c(t) - y_c(t) \right] \tag{10}$$

where f_y denotes the speed of composite good market adjustment. Substituting from (1)-(4) and (6) into these adjustment equations yields a core dynamic system in 3-variable state space:

$$
\begin{aligned}
\dot{q}(t) &= q(t) \left[l_1(1 + R h_1) y_c(t) + l_1 R h_0 - l_2(m - p) \right] - (a_0 + a_1 y_c(t)) \\
\dot{P}_h(t) &= P_h(t) \left[l_1(1 + R h_1) y_c(t) + l_1 R h_0 - l_2(m - p) \right] - [h_0 + h_1 y_c(t)]R \\
\dot{y}_c(t) &= f_y \left\{ d_0 + [d_1(1 + R h_1) - 1] y_c(t) + d_1 R h_0 + d_2 q(t) + d_3 P_h(t) \right\}
\end{aligned} \tag{11}
$$

3 Equilibrium and Comparative Statics

In the following we use notation $\bar{q}$, $\bar{P}_h$ and $\bar{y}_c$ (and eventually $\bar{i}$) to describe steady state values (here synonymously referred to as equilibrium values) of these variables. An IS-LM plus asset markets equilibrium may be characterized as steady state of (11), i.e.:

$$
\begin{align}
0 &= \bar{q}[l_1(1 + Rh_1)\bar{y}_c + l_1 Rh_0 - l_2(m-p)] - a_0 - a_1\bar{y}_c \tag{12} \\
0 &= \bar{P}_h[l_1(1 + Rh_1)\bar{y}_c + l_1 Rh_0 - l_2(m-p)] - h_0 R - h_1\bar{y}_c R \tag{13} \\
0 &= f_y[d_0 + \{d_1(1 + Rh_1) - 1\}\bar{y}_c + d_1 Rh_0 + d_2\bar{q} + d_3\bar{P}_h] \tag{14}
\end{align}
$$

From these equations the equilibrium composite good $\bar{y}_c$ output can be derived. Using definitions (27) and (28) from the Appendix it can be written compactly as $\bar{y}_c = 0.5[-k_1 \pm \sqrt{k_1^2 + 4k_2}]$, where k_1 and k_2 are terms constructed from the exogenous variables. So theoretically there exist two equilibria. But condition (5) implies $k_2 > 0$ and therefore the smaller solution $\bar{y}_c = 0.5[-k_1 - \ldots] < 0$ is economically meaningless. Thus we are left with the unique economically plausible equilibrium

$$
\bar{y}_c = 0.5\left[-k_1 + \sqrt{k_1^2 + 4k_2}\right]. \tag{15}
$$

Based on (15) one can verify, that the present framework corresponds to a standard IS-LM model with respect to the impact of basic economic policies as far as comparative statics is concerned, i.e.[3]

$$
d\bar{y}_c/dm > 0, \ d\bar{y}_c/dd_0 > 0, \ d\bar{i}/dm < 0, \ d\bar{i}/dd_0 > 0. \tag{16}
$$

It should be noted that for an assessment of the employment impact of any exogenous shocks to this system only the value of $d\bar{y}_c$ is relevant rather than $d\bar{y}$, because eventual changes in the income from the rental housing sector have no employment impact in this short run perspective with fixed housing supply.

Now define the following key variables with regard to the qualitative aspects of comparative statics and adjustment dynamics:

$$
\begin{align}
c_{13} &= \bar{q}l_1(1+Rh_1) - a_1 = \{a_0 l_1(1+Rh_1) - a_1[l_1 Rh_0 - l_2(m-p)]\}/\bar{i} \tag{17} \\
c_{23} &= \bar{P}_h l_1(1+Rh_1) - h_1 R = R[h_0 l_1 - h_1 l_2(m-p)]/\bar{i} \tag{18}
\end{align}
$$

These variables are 2 of 9 coefficients of the Jacobian matrix describing system (11) and the only ones with indeterminate sign (for the remaining 7 see Appendix). Given (5) one can see that the sign of c_{13} hinges on the elasticity of profits with respect to income (equal to revenues here), determined via a_0 and a_1. If (but not only if) this elasticity is > 1, then $a_0 < 0$ and consequently $c_{13} < 0$. Within our short run model capital stock is fixed and thus involves fixed costs. So, unless output expansion involves higher wages, a profit elasticity >1 indeed appears more plausible and therefore also $c_{13} < 0$. The case of $c_{13} > 0$ instead, labelled the "bad news" case in Blanchard [1981] would imply a dominance of the interest increasing effect over the profit expansion effect of higher output in the determination of equilibrium stock prices according to (12). We will not further investigate this possibility but restrict attention to the $c_{13} < 0$ case in the subsequent discussion.

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[3] To avoid an unnecessary lengthy exposition we use differential dm to describe a change in monetary policy rather than $d(m-p)$. But as can be easily verified this has no impact upon our results as the relevant derivatives are the same in both cases.

Likewise the sign of c_{23} hinges on the elasticity of demand for housing services with respect to income, determined via h_0 and h_1. If this elasticity is sufficiently low the result will be $c_{23} > 0$. Although not directly comparable, empirical evidence in this regard points towards ball park elasticity figures around 0.8, with values typically higher for permanent income and lower for current income (see for example Quigley [1979] or DiPasquale and Wheaton [1996]). Furthermore this elasticity seems to have decreased over the years as found for example in Linneman, Megbolugbe, Wachter and Cho [1997], who state a figure of 0.19 for the 1990s. So empirical evidence lends support to an elasticity <1, particularly with current income as used here. This implies $h_0 > 0$, but is not enough to ensure $c_{23} > 0$. Accordingly results for both possibilities for the sign of c_{23} will be presented.

The impact of different values of c_{13} resp. c_{23} upon comparative statics can be seen from the derivatives of equilibrium stock and house prices with respect to economic policy variables:

$$
\begin{align}
d\bar{q}/dm &= \left[l_2 \bar{q} - c_{13}(d\bar{y}_c/dm) \right] / \bar{i} \tag{19} \\
d\bar{P}_h/dm &= \left[l_2 \bar{P}_h - c_{23}(d\bar{y}_c/dm) \right] / \bar{i} \tag{20} \\
d\bar{q}/dd_0 &= -c_{13}(d\bar{y}_c/dd_0)/\bar{i} \tag{21} \\
d\bar{P}_h/dd_0 &= -c_{23}(d\bar{y}_c/dd_0)/\bar{i} \tag{22}
\end{align}
$$

where $d\bar{y}_c/dm$ and $d\bar{y}_c/dd_0$ have uniquely positive signs according to (16). With $c_{13} < 0$ expansionary monetary or fiscal policy definitely has positive impact upon equilibrium stock prices as can be seen from (19) and (21). Regarding (20) it should be noted particularly that for $c_{23} > 0$ the equilibrium house price not necessarily goes up with increasing equilibrium output. This problem is ultimately rooted in the two potential channels for wealth effects, opening the possibility of counter movements of equilibrium asset prices as equilibrium income changes. So for comparative statics not only the sign of c_{23} is important, but also the absolute values. If c_{23} is moderately positive (we will refer to this as $c_{23} \gtrsim 0$), the equilibrium house price will still increase with output, but if c_{23} is sufficiently large (we'll refer to this case as $c_{23} \gg 0$), equilibrium house price will actually fall.

These two possibilities associated with $c_{23} > 0$ are related to the cases of low (<1) resp. very low ($h_1 \to 0$) income elasticities of housing services demand. Because the empirical literature cited above provides ample evidence of short run elasticities below one, we will consider these two possibilities explicitly along with the $c_{23} < 0$ case, i.e. three different possibilities for values of c_{23}.

4 Adjustment dynamics

We are interested in the joint adjustment path of income, stock price and house price following shocks to the money supply ($dm \neq 0$) or to autonomous composite good demand ($dd_0 \neq 0$). The latter type of shock in the sequel will be synonymously called a fiscal policy shock. Output of the composite good is assumed to adjust gradually to changing demand conditions. House and stock prices instead are modelled as jump variables, which satisfy the portfolio conditions at any instant and whose changes are always correctly anticipated. The stability of this system is therefore guaranteed along a unique saddlepath, upon which the economy returns immediately after eventual disequilibrating shocks by discrete jumps in asset prices. As derived in the Appendix this saddlepath which the variables will follow during adjustment from one equilibrium to the next can be described in terms of the

change in equilibrium composite good output $\Delta \bar{y}_c$ as

$$q(t) \quad = \quad \bar{q} - \Delta \bar{y}_c \, e^{\lambda t} \, c_{13}/(\lambda - c_{11}) \tag{23}$$

$$P_h(t) \quad = \quad \bar{P}_h - \Delta \bar{y}_c \, e^{\lambda t} \, c_{23}/(\lambda - c_{11}) \tag{24}$$

$$y_c(t) \quad = \quad \bar{y}_c - \Delta \bar{y}_c \, e^{\lambda t} \tag{25}$$

Variables $\bar{y}$, $\bar{q}$ resp. $\bar{P}_h$ refer to the new equilibrium values towards which the system will converge in response to an exogenous shock at time $t = 0$. Variable λ denotes the single negative Eigenvalue of the system. From (23) one can verify that for $c_{13} < 0$ we get $\Delta \bar{y}_c \, e^{\lambda t} c_{13}/(\lambda - c_{11}) > 0$ and $d[\Delta \bar{y}_c \, e^{\lambda t} c_{13}/(\lambda - c_{11})]/dt < 0$. So (23) tells that, after an initial discrete jump at $t = 0$, the stock price will keep increasing during the adjustment phase upon an expansionary shock ($\Delta \bar{y}_c > 0$). Analogously the house price will increase according to (24) if $c_{23} < 0$ and decrease if $c_{23} > 0$, although knowledge of the sign of c_{23} in general is not sufficient to tell whether the change in equilibrium house price associated with $\Delta \bar{y}_c$ is positive or negative.

Using (23) - (25) one can determine the slope of the saddlepath in various perspectives, of which we need just the following two for subsequent graphical exposition of results:

$$dq/dy_c|_{\text{ saddlepath}} = c_{13}/(\lambda - c_{11}), \qquad dP_h/dy_c|_{\text{ saddlepath}} = c_{23}/(\lambda - c_{11}) \tag{26}$$

Thus these slopes have unique sign for given signs of c_{13} and c_{23}, irrespective of their absolute values. For interpretation of these slopes just consider the example of $c_{23} > 0$: In this case the low elasticity of demand for housing services implies that increasing income drives up the interest rate faster than the vacancy rate. So the rate of return on rental houses would decrease while the interest rate (the return on bonds) kept increasing, thus shifting asset demand from houses towards bonds. Therefore house price will fall along with increasing income to compensate for this disequilibrating tendency and to secure portfolio equilibrium.

The initial jumps of asset prices in response to unanticipated policy shocks are derived in the Appendix. As can be easily verified from (39)-(42) stock price and house price will invariably jump upwards towards the stable saddlepath after an unanticipated expansionary policy shock (whether fiscal or monetary) when $c_{13} < 0$ and $c_{23} < 0$. But when $c_{23} > 0$ the direction of the initial jump is no longer clear.

All qualitatively relevant aspects of the involved adjustment dynamics can be represented graphically. Figures 1 - 4 depict typical saddlepaths of q in (y_c, q)-space and P_h in (y_c, P_h)-space. The composite good output y_c is measured along the horizontal axis. Prices q (circles) and P_h (triangles) are measured along the vertical axis and are scaled such, that for the new steady state $(\bar{y}_{c1}, \bar{q}_1, \bar{P}_{h1})$ the two prices are equidistant from zero. Note that any other points from our 3-variable state space, like the old steady state $(\bar{y}_{c0}, \bar{q}_0, \bar{P}_{H0})$, will typically require a representation via two points on top of each other. Note also that the relative slopes of the saddlepaths in these figures depend upon the scaling of asset prices and thus have no meaning per se.

The case of an unanticipated expansionary monetary shock for a high elasticity of housing services demand with respect to current income ($c_{23} < 0$ and, as always: $c_{13} < 0$) is depicted in Figure 1. From (16) we know that under these conditions equilibrium income will rise with expansionary monetary policy and so will equilibrium stock and house prices. (26) shows that both saddlepaths are upwardly sloping in (q, y_c)-space resp. (P_h, y_c)-space. Furthermore, as can be verified from (39) and (40), both asset prices in this case must initially jump upwards.

Figure 1: Adjustment to monetary expansion when $c_{23} < 0$
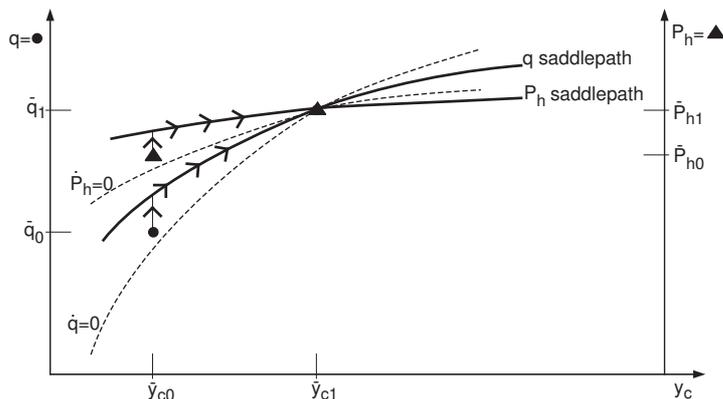
The shapes of these saddlepaths become flatter as y_c increases. This can be inferred from the analysis of the $\dot{P}_h = 0$ function in (P_h, y_c)-space derived from (13) and of the $\dot{q} = 0$ function in (q, y_c)-space derived from (12) (these functions are drawn as dashed lines in our figures). This analysis reveals that the slopes of these functions become flatter as y_c increases and that the slopes of the corresponding saddlepaths always have the same sign as these functions but are smaller in magnitude.

To the extent that house price fluctuations are owed to changes in monetary policy, we should thus expect to observe strong positive correlation between short run movements of stock prices and house prices according to Figure 1. Note also that a Figure like 1 represents the adjustment dynamics resulting from changes in fiscal policy as well, which further strengthens the argument for the stated positive correlation. But the figures reported in IMF [2000] or Boone and Girouard [2002] do not show such a correlation. So either short run data variability during the sample periods of these studies were dominated by influences other than fiscal or monetary policy, or the assumptions underlying Figure 1 are wrong. According to Figure 1 we should furthermore observe unequivocally rising house prices in the short run as response to expansionary monetary policy. But this contradicts relevant results from Lastrapes [2002] (see more below). Empirically therefore the crucial assumption of a high elasticity of housing services demand underlying Figure 1 seems farfetched.

For a low income elasticity of housing services demand (the $c_{23} \gtrsim 0$ case), equation (24) implies, that the saddlepath will have a negative slope with regard to P_h. Yet, according to (20) equilibrium house price will rise within our classification scheme. This implies that immediately after the expansionary monetary shock the house price must overshoot the new, higher equilibrium value followed by a lasting gradual decline. This is the case depicted in Figure 2.

For a very low income elasticity of housing demand finally (the $c_{23} \gg 0$ case) the price adjustment follows the downward path depicted in Figure 3, although it can not be proven in general, that the initial jump of the house price in this case is upward. But definitely the new equilibrium house price P_{h1} will be lower in this case than the old one P_{h0}.

The above results lend themselves to comparison with the empirical results from Lastrapes [2002], who analyzes the impact of money supply shocks upon house prices within a VAR framework based on high-frequency (monthly) US data. His results indicate that initial house price increases for existing homes in reaction to expansionary monetary shocks peak roughly after a quarter for two different model specifications. This rapid increase then is followed by a gradual decline. In the model identified with short term restrictions house

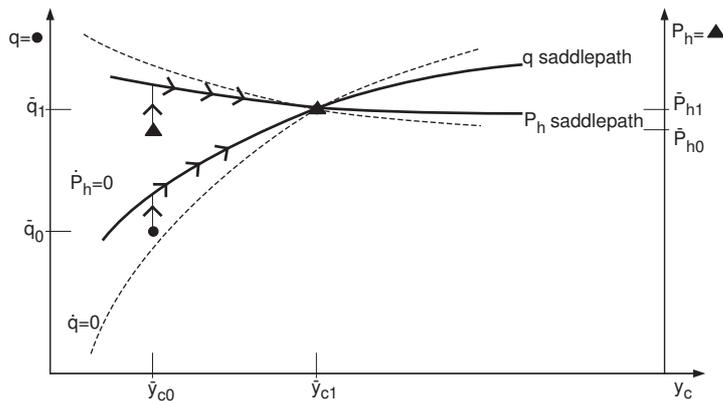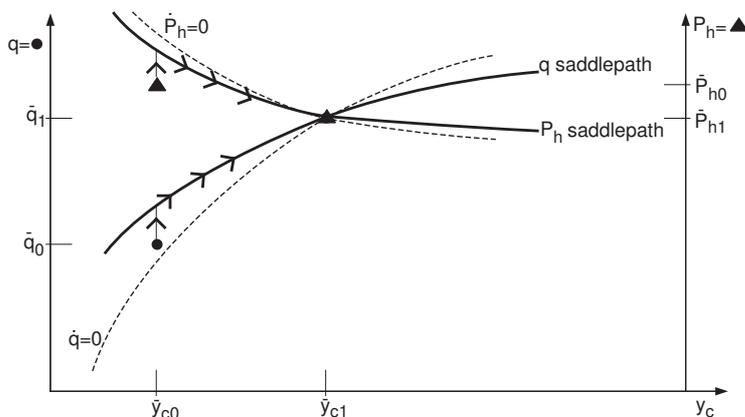Figure 2: Adjustment to monetary expansion when $c_{23} \gtrless 0$

Figure 3: Adjustment to monetary expansion when $c_{23} \gg 0$

prices then fall within 1.5 years below the starting levels and keep falling over a 5 year period. These VAR results are not strictly comparable to the results from our model, for example because Lastrape's analysis is based on prices for owner occupied houses rather than rental units. Nevertheless we consider the evidence as clearly in favor of parameter values $c_{23} > 0$, because Lastrape's empirical results are well proxied by our low resp. very low elasticity cases, whereas they can not be replicated with the high elasticity $c_{23} < 0$ case.

Turning to expansionary fiscal policy now, represented in this model as $dd_0 > 0$, we want to note primarily that overshooting of the house price can not occur. As (26) and (42) show, either the slope of the saddlepath is positive AND the initial jump of the house price is positive, or both are negative. So the relevant diagram to represent the $c_{23} < 0$ case for expansionary fiscal policy would look just like Figure 1. The more plausible $c_{23} > 0$ case instead is depicted in a separate Figure 4, because the initial jump of the house price in this case is definitely negative unlike in the case of expansionary monetary policy. A comparison of Figure 4 with figures 2 and 3 tells that monetary policy due to overshooting leads to more volatility of house prices than fiscal policy. Furthermore one can see that expansionary fiscal policy will have a depressing effect upon house prices in the short run in this case.

Figure 4: Adjustment to fiscal expansion when $c_{23} > 0$
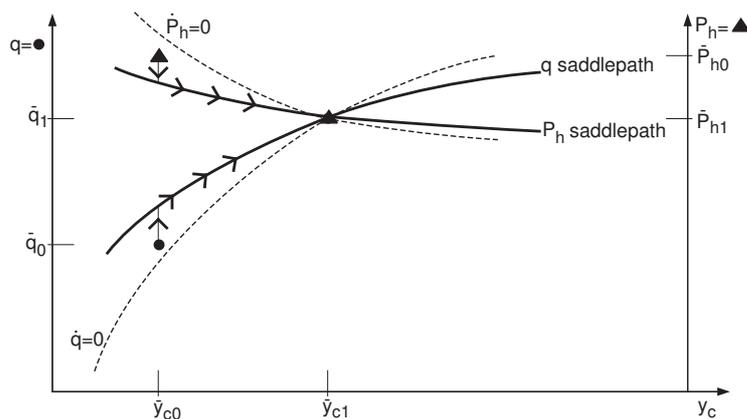
5 Summary

The analysis presented above shows that we should expect overshooting reactions of house prices upon monetary shocks, when income elasticity of the demand for housing services is low. Results for this scenario correspond well with recent findings from econometric work, whereas results for a high elasticity contradict these findings and are therefore not reported in this summary. The analysis also shows, that such overshooting reactions of house prices can not result from fiscal policy shocks. Thus for any given ultimate change in house prices due to economic policy shocks, the associated volatility of house prices during adjustment is much higher for monetary policy than for fiscal policy.

The link between house prices and aggregate demand (real estate wealth effects) has been investigated in some empirical studies recently, motivated by an ongoing discussion about the potential problems with fluctuating house prices. The present study shows, that this real estate wealth effect is irrelevant for the basic pattern of asset price adjustments, although it affects equilibrium output and prices. Expansionary fiscal policy exerts a negative short run impact upon house prices and thus this wealth effect indeed weakens the output expanding effect of such policy. Expansionary monetary policy instead might gain efficacy from this wealth effect via increasing house prices for a medium range of income elasticities of housing services demand. But empirical evidence is not sufficient to reject the possibility of a very low elasticity of housing services demand, in which case also expansionary monetary policy leads to decreasing house prices.

Some readers may rather want to interpret as "land" what we label "houses" here, because in our short term analysis the stock of houses is assumed fixed, neglecting construction activity and depreciation. In this sense the analysis presented may apply more to land than to houses. But land costs account for as much as 20-40% of house prices internationally (Girouard and Blöndal [2001]), so the results of our model analysis in the "land"-interpretation do carry over clearly to some extent to the "house"-interpretation.

The political concern about large house price fluctuations calls for future research which more explicitly models the transmission channel of changing house prices. Rather than just working via the wealth effect upon demand, the collateral function of houses is likely for example to affect money supply as well. Furthermore it is clearly desirable to introduce owner occupied housing into the framework for better coverage of the general problem with house prices.

Appendix

The **variables** k_1 **resp.** k_2 used in the text are defined as

$$k_1 = \frac{l_1 Rh_0 - l_2(m-p)}{l_1(1+Rh_1)} - \frac{d_0 + d_1 Rh_0}{1 - d_1(1+Rh_1)} - \frac{d_2 a_1 + d_3 h_1 R}{[1 - d_1(1+Rh_1)]l_1(1+Rh_1)} \quad (27)$$

$$k_2 = \frac{[d_0 + d_1 Rh_0][l_1 Rh_0 - l_2(m-p)] + d_2 a_0 + d_3 h_0 R}{[1 - d_1(1+Rh_1)]l_1(1+Rh_1)} \quad (28)$$

Note that by (5) the numerator of k_2 is positive. Expression $d_1(1+Rh_1)$ appearing in the denominator is the marginal propensity to consume the composite good out of aggregate income, which we assume to be smaller than one as usual. So also the denominator is positive giving $k_2 > 0$ as mentioned in the text.

The **coefficients of the Jacobian matrix** of system (11) are c_{13} and c_{23} as defined in (17) resp. (18) plus the following

$$
\begin{aligned}
c_{11} &= l_1(1 + Rh_1)\bar{y}_c + l_1 Rh_0 - l_2(m - p) > 0 \quad (c_{11} = \bar{i}) & (29) \\
c_{22} &= l_1(1 + Rh_1)\bar{y}_c + l_1 Rh_0 - l_2(m - p) > 0 \quad (c_{22} = \bar{i}) & (30) \\
c_{31} &= f_y d_2 > 0 & (31) \\
c_{32} &= f_y d_3 > 0 & (32) \\
c_{33} &= f_y (d_1(1 + Rh_1) - 1) < 0, & (33)
\end{aligned}
$$

while $c_{12} = 0$ and $c_{21} = 0$. Using these definitions the system (11) can be linearized around the equilibrium as

$$
\begin{bmatrix} \dot{q} \\ \dot{P_h} \\ \dot{y}_c \end{bmatrix} = \begin{bmatrix} c_{11} & 0 & c_{13} \\ 0 & c_{22} & c_{23} \\ c_{31} & c_{32} & c_{33} \end{bmatrix} \begin{bmatrix} q - \bar{q} \\ P_h - \bar{P}_h \\ y_c - \bar{y}_c \end{bmatrix} \quad (34)
$$

So the characteristic equations to analyze the dynamic properties of this model are

$$
\begin{bmatrix} (\lambda_k - c_{11}) & 0 & -c_{13} \\ 0 & (\lambda_k - c_{22}) & -c_{23} \\ -c_{31} & -c_{32} & (\lambda_k - c_{33}) \end{bmatrix} \begin{bmatrix} \varepsilon_{k1} \\ \varepsilon_{k2} \\ \varepsilon_{k3} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \quad k = 1, 2, 3
$$

where the λ_k's are the characteristic roots (Eigenvalues) and ε_{ki} the coefficients of the corresponding Eigenvectors. Normalizing $\varepsilon_{k1} = 1$ and using the fact that $c_{11} = c_{22}$ there are three possible ways to express ε_{k2} and ε_{k3}:

$$\varepsilon_{k2} = \frac{c_{23}}{c_{13}} = \frac{(\lambda_k - c_{11})(\lambda_k - c_{33}) - c_{31}c_{13}}{c_{32}c_{13}} = \frac{c_{31}c_{23}}{(\lambda_k - c_{22})(\lambda_k - c_{33}) - c_{32}c_{23}} \quad (35)$$

$$\varepsilon_{k3} = \frac{(\lambda_k - c_{22})}{c_{13}} = \frac{(\lambda_k - c_{11})}{c_{13}} = \frac{c_{31}(\lambda_k - c_{22})}{(\lambda_k - c_{22})(\lambda_k - c_{33}) - c_{32}c_{23}} \quad (36)$$

The general dynamics of the linearized system are therefore described as

$$
\begin{aligned}
q(t) &= \bar{q} + A_1 e^{\lambda_1 t} + A_2 e^{\lambda_2 t} + A_3 e^{\lambda_3 t} \\
P_h(t) &= \bar{P}_h + A_1 \varepsilon_{12} e^{\lambda_1 t} + A_2 \varepsilon_{22} e^{\lambda_2 t} + A_3 \varepsilon_{32} e^{\lambda_3 t} \\
y_c(t) &= \bar{y}_c + A_1 \varepsilon_{13} e^{\lambda_1 t} + A_2 \varepsilon_{23} e^{\lambda_2 t} + A_3 \varepsilon_{33} e^{\lambda_3 t}
\end{aligned}
$$

So, with distinct roots, the solution of the system is

$$
\begin{aligned}
q(t) - \bar{q} &= A_1 \mathbf{e}^{\lambda_1 t} + A_2 \mathbf{e}^{\lambda_2 t} + A_3 \mathbf{e}^{\lambda_3 t} \\
P_h(t) - \bar{P}_h &= \tfrac{c_{23}}{c_{13}} \left(A_1 \mathbf{e}^{\lambda_1 t} + A_2 \mathbf{e}^{\lambda_2 t} + A_3 \mathbf{e}^{\lambda_3 t} \right) \\
y_c(t) - \overline{y_c} &= \tfrac{1}{c_{13}} \left(A_1(\lambda_1 - c_{11})\mathbf{e}^{\lambda_1 t} + A_2(\lambda_2 - c_{11})\mathbf{e}^{\lambda_2 t} + A_3(\lambda_3 - c_{11})\mathbf{e}^{\lambda_3 t} \right)
\end{aligned}
\tag{37}
$$

We assume a rational expectation equilibrium with distinct roots, one being negative (corresponding to the sluggish variable y_c) and two being positive (corresponding to the two jump variables q and P_h). To determine the stable saddlepath we set $A_2 = A_3 = 0$ and assume for simplicity that initially, i.e. at time $t = 0$, the economy starts from a steady state with composite good output $\bar{y}_{c0}$, so $y_c(0) = \bar{y}_{c0}$. Under these conditions the stable saddlepath can be expressed entirely as a function of the change in equilibrium output $\bar{y}_{c1} - \bar{y}_{c0}$ which we will denote $\Delta \bar{y}_c$. Furthermore we skip the k-index in the text because only the negative Eigenvalue is relevant for studying saddlepath dynamics. So λ in the text refers to the single negative Eigenvalue and ε_2 and ε_3 to the second resp. third coefficient of the Eigenvector corresponding to λ. This yields $A_1 = (\bar{y}_{c0} - \bar{y}_c)/\varepsilon_3 = -\Delta \bar{y}_c/\varepsilon_3$ and thus

$$
q(t) = \bar{q} - \Delta \bar{y}_c \, e^{\lambda t}/\varepsilon_3, \quad P_h(t) = \bar{P}_h - \Delta \bar{y}_c \, e^{\lambda t}\varepsilon_2/\varepsilon_3, \quad y_c(t) = \bar{y}_c - \Delta \bar{y}_c \, e^{\lambda t}
\tag{38}
$$

Finally substituting c_{23}/c_{13} for ε_2 according to (35) and $(\lambda - c_{11})/c_{13}$ for ε_3 according to (36) gives (23)-(25).

The **initial jumps of asset prices** towards the stable saddlepath are derived as follows: First we only consider small exogenous shocks such that changes in the equilibrium values of the relevant variables can be approximated. For example the change in equilibrium output of the composite good sector due to a change in money supply from m_0 to m_1 is approximately $\bar{y}_{c1} - \bar{y}_{c0} \simeq (m_1 - m_0) \, d\bar{y}_c/dm$. Analogously we proceed for stock price and house price and for fiscal policy shocks. Using (19)-(25) and the fact that $\bar{i} = c_{11}$ then yields the following approximations for the jumps in asset prices:

$$
q(t=0, m_1) - \bar{q}_0 \simeq \frac{(m_1 - m_0)}{c_{11}} \left[l_2 \bar{q}_0 - c_{13} \frac{d\bar{y}_c}{dm} \left(\frac{\lambda}{\lambda - c_{11}} \right) \right]
\tag{39}
$$

$$
P_h(t=0, m_1) - \bar{P}_{h0} \simeq \frac{(m_1 - m_0)}{c_{11}} \left[l_2 \bar{P}_{h0} - c_{23} \frac{d\bar{y}_c}{dm} \left(\frac{\lambda}{\lambda - c_{11}} \right) \right]
\tag{40}
$$

$$
q(t=0, d_{01}) - \bar{q}_0 \simeq -c_{13} \frac{d\bar{y}_c}{dm} \left(\frac{d_{01} - d_{00}}{c_{11}} \right) \left(\frac{\lambda}{\lambda - c_{11}} \right)
\tag{41}
$$

$$
P_h(t=0, d_{01}) - \bar{P}_{h0} \simeq -c_{23} \frac{d\bar{y}_c}{dm} \left(\frac{d_{01} - d_{00}}{c_{11}} \right) \left(\frac{\lambda}{\lambda - c_{11}} \right)
\tag{42}
$$

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