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Abstract

In this paper we analyse the influence of inflation on stock and real estate prices in two different models. Both models predict a decline of deflated stock prices and an increase of real house prices as a consequence of inflation. The first model emphasizes the role of taxation of inflationary profits. In the second model the influence of inflation on asset prices is explained by differences in the financing structure of the real estate and the goods sector. We find strong evidence in favour of the hypothesis that the financing structure is dominant in determining the influence of inflation on asset prices.

Inflation, Real Estate and Stock Prices: Evidence from West-Germany

by Bernhard Felderer and Wolfgang Rippin

Applications of capital asset pricing theory usually concentrate on the stock market of an economy. The companies' shares constitute the market portfolio, the center piece of capital asset pricing theory. Such a definition of the market portfolio is by no means appropriate. A large part of an economy's wealth consists of land, dwellings and other real estate objects which are ignored by the analysis. Ruling out real estate from the analysis has important theoretical and empirical consequences. It is a standard argument of portfolio theory that stocks become more attractive when inflation rises. This is a consequence of the increase in nominal dividends during the inflation, while interest payments on bonds lag behind. Will this argument remain valid when we add real estate as an additional asset? After a first look at the time series of stock and real estate prices in Germany we conjecture that these series are not independent[1] of each other (see the figure on page 2).

Both series exhibit inverse patterns. From 1977 to 1981 the real estate price index rose. During the same period the stock index declined. In the eighties this picture is reversed. We observe a boom in real stock prices and a decline in deflated real estate prices. There is also a remarkable increase in volatility of the stock prices in the eighties compared to the seventies.

From this negative correlation of stock and real estate prices we conjecture that both time series are driven by a common cause. Our hypothesis is that the expected rate of inflation can explain the inverse relation of stocks and real estate prices.
The following table gives an impression of inflation in West-Germany during the

[1] As an index of stock prices we have used table 49* of "Sachverständigenrat" (Council of Economic Advicers) 1992. The index of real estate prices is constructed from time series of appartment prices published by the "Ring Deutscher Makler (RDM)" (Ring of German Brokers) from seven selected metropolitan cities of West-Germany. Both time series were deflated by the price index of GNP.

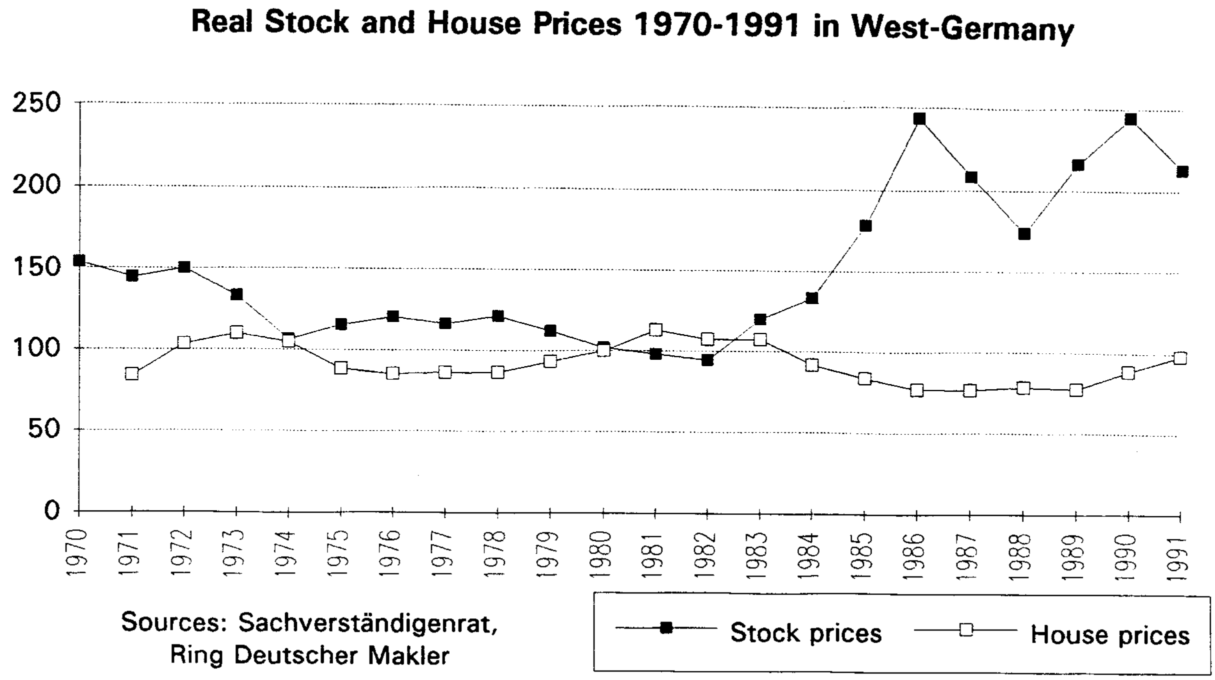

figure 1

oberservation period.

period	average rate of inflation in percent price index of GNP
1970-1975	6.43
1976-1980	4.06
1981-1985	3.25
1986-1990	2.56

The rates of inflation in both decades show significant differences, which might be explained by the change in central bank policies of all industrialised economies at the beginning of the eighties.

The data seem to be consistent with our hypothesis. The boom in real estate prices in the seventies corresponds with high inflation rates during the same period. In the eighties we observe low inflation rates an increase in stock prices and declining real estate prices. Obviously there is an inverse relation between stock prices and real estate prices.

In the following we present two models explaining the influence of the inflation rate on real estate and stock prices. In the first model the influence of inflation on asset prices is a result of nonneutralities of the tax system. According to this viewpoint based on an article by Summers[2] inflation leads to an additional tax burden for companies. So inflation disturbs the portfolio equilibrium between stocks and real estate and causes adjustment processes in the asset prices. Instead of just postulating this relationship as Summers does we use a model of a representative firm to derive the behaviour of the profit maximizing firm. The causal relationship between inflation and asset prices can be formally shown when the interest rate is integrated as an endogenous variable in the model. This nonneutrality-hypothesis turns out to be attractive in a world in which a large part of the housing stock is owner occupied and where the implicit rent of the owner is not taxed. However, in a world in which a large part of the housing stock is not owner occupied as in West-Germany this tax advantage of real estate assets relative to stocks vanishes. It is therefore necessary to search for other factors explaining the influence of the inflation rate on asset prices. The second model proposes another hypothesis: the differences in the financing structure of real estate and companies. According to this hypothesis an increase in the rate of inflation has different effects on the interest rates of foreign capital than on owner capital. If there are differences in the financing structure an increase in the inflation rate disturbs the portfolio equilibrium. As a result we arrive at adjustment paths of asset prices that are similar to the first model. The second model has explanatory power even when a large part of the housing stock is not owner occupied. After presenting these two theoretical concepts, we test both models in the third section.

I. Inflation, taxation and asset prices

The model consists of a goods sector in which a representative firm produces a consumption good and a real estate sector in which housing services are produced. We first discuss the influence of inflation on the taxes of the representative firm. This influence is a constitutional element of the arbitrage equilibrium in the stock market. The real estate sector is constructed analogously to the goods sector. We assume that the housing stock is owner occupied and that the implicit rent is not taxed. The flows

[2]Summers, Lawrence H. (1981): Inflation, Stock Market and Owner Occupied Houses, American Economic Review p. 429- 443

of output from the firm and the real estate sector constitute the aggregate supply of the economy. Aggregate demand is composed of investment in the firm and the real estate sector, which are assumed to be functions of asset prices, as well as of consumption which is also a function of asset prices. This allows us to determine endogenously the variables we are interested in: interest rate, stock price and real estate price.

In a tax system based on nominal values, an increase in inflation raises the effective tax burden on firms. Revenues are valued at the higher prices caused by inflation whereas depreciation on the firm's capital stock are based on the historical prices at the time the capital stock was installed. As a consequence, taxable profits increase when inflation rises.

Principally this problem also arises when profits from investment in real estate are taxed: revenues from renting a house are valued at a higher nominal price level. Costs of depreciation are valued at the historical installation costs. In Germany owners of housing can subtract 5 percent of installation costs from taxable income in the first seven years after the investment period. As long as houses are not owner occupied inflationary profits increase the tax burden.

Of course, some housing is owner occupied and if the implicit rent services the owner receives from owner occupation is taxed in a different way, inflation will have different effects on taxation of profits from investment in the real estate sector. The taxation of rent services from owner occupation in Germany is complicated. The investor can choose between two ways of taxation, the so called "Normalbesteuerung" (normal taxation) and the "Pauschalierungsverfahren" (determination of taxation at a flat rate). The normal taxation method treats the owner occupied housing as if it were rented to a tenant. The "Pauschalierungsverfahren" is more complicated. Rent services from owner occupation are calculated as 1.4 percent of a special value, the so called "Einheitswert" (unity value), from which interest payments on debt are substracted. For our purpose it is not necessary to explain the definition of the "Einheitswert." For us it is sufficient to know that this "Einheitswert" is much lower than the actual market value. When interest payments on debts are subtracted from the "Einheitswert", the "Pauschalierungsverfahren" has the consequence that rent services from owner occupation in many cases become zero. In so far, rent services from owner occupation are untaxed. In 1987 the law was changed and since then rent services from owner occupation are explicitly untaxed. So owner occupation is not subject to the taxation of inflationary profits. Taking taxation into account in a period of inflation investment in housing is more attractive than an investment in stocks as long as the house is owner occupied.

To be more rigouros let us define the pretax dividend D of the representative firm at time t as

$$D = p(t)F(K(t), N(t)) - w(t)N(t) - p(t)\delta K(t). \tag{1}$$

δ is the rate of depreciation on the capital stock K, N is labor, w is the nominal wage and $p(t)$ is the price level at time t. We assume that the production function $F(K(t), N(t))$ has the usual neoclassical properties and is homogenous of degree one in both arguments. The first term then defines revenues, the second term is labor costs and the third term characterizes the current costs necessary to maintain the capital stock. The firm maximizes (1) or some post-tax version of (1). We suppose that at the time when decisions are to be made, the capital stock is a given quantity for the firm. Firms cannot dispose over the capital stock at this point. This assumption is usually justified in literature[3] with the absence of a market for existing physical capital goods at which firms could trade capital goods. Once installed, capital goods deliver specialized services for the firm. Other firms cannot use these capital goods and therefore no market for physical capital goods will exist[4]. This assumption is employed in many macroeconomic models which specify investment in the way we will later on. By maximizing dividends, the representative firm can only choose N. This assumption together with the linear homogenity of production implies $Y(t) - \frac{w(t)}{p(t)}N(t) - F_K K(t) = 0$, where we have used the Euler Theorem. Notice that because there is no market for physical capital goods, we have not replaced F_K by the interest rate. Consequently dividends will not necessarily be zero at the maximum profit.

We further assume that the capital stock was bought at time $t = 0$ at the price $p(0)$. The firm is completely financed by owner capital. Notice that in (1) the depreciation of the capital stock is valued at $p(t)$ although capital goods are acquired at price $p(0)$. Of course, to maintain the capital stock intact the firm must reinvest at the price level

[3]Sargent, Thomas J. "Macroeconomic Theory" Academic Press 1979, p. 7

[4]Another justification of the assumption argues with adjustment costs of changing the capital stock. See Sargent (1979) Chapter VI

$p(t)$. Let us assume that the price level and the nominal wage grow at a constant inflation rate π:

$$p(t) = p(0)e^{\pi t}, \qquad w(t) = w(0)e^{\pi t}. \tag{2}$$

We first consider a tax system which is completely neutral with respect to changes in the inflation rate. In such a neutral tax system with τ as the firm's tax rate the nominal post tax dividend is given by

$$D_T^n = (1-\tau)(p(t)F(K(t),N(t)) - w(t)N(t) - p(t)\delta K(t)), \tag{3}$$

where we have used the index n in D_T^n to indicate *n*eutrality of this *t*ax concept. Note that in (3) depreciation is valued at the actual price level $p(t)$ and not at the historical price level $p(0)$. According to German tax law and the tax law of many other industrialized economies, depreciation on the capital stock has to be valued at the historical price level $p(0)$. Therefore (3) is not the empirical relevant post tax dividend.

To derive the correct post tax dividend, define the total tax sum T as

$$T = \tau(p(t)F(K(t),N(t)) - w(t)N(t) - p(0)\delta K(t)) \tag{4}$$

and subtract this expression from (1)

$$\begin{aligned} D_T^{nn} &= p(t)F(K(t),N(t)) - w(t)N(t) - p(t)\delta K(t) \\ &\quad -\tau(p(t)F(K(t),N(t)) - w(t)N(t) - p(0)\delta K(t)). \end{aligned} \tag{5}$$

(5) is the post tax dividend when the tax system is nonneutral (therefore the index nn) with respect to the rate of inflation. Maximizing (5) with respect to N implies the first order condition

$$(1-\tau)p(t)F_N - (1-\tau)w(t) = 0, \qquad F_N = \frac{w(t)}{p(t)}, \tag{6}$$

which is the same as we would obtain by maximizing the pretax dividend (1) or (3). Since $F()$ is linear homogenous by Eulers Theorem, we can write the first three expressions of (5) as

$$p(t)F(K(t),N(t)) - w(t)N - p(t)\delta K(t) = p(t)F_K K(t) - p(t)\delta K(t). \qquad (7)$$

Analogously we express the last three terms of (5) as

$$\tau(p(t)F(K(t),N(t)) - w(t)N - p(0)\delta K(t)) = \tau p(t)F_K K(t) - \tau p(0)\delta K(t). \qquad (8)$$

Subtracting (8) from (7) we get

$$D_T^{nn} = (1-\tau)p(t)F_K K(t) - \delta p(t)K(t) + \tau\delta p(0)K(t). \qquad (9)$$

Dividing this expression by the price level of period t and substituting $p(t) = p(0)e^{\pi t}$ delivers the real post tax dividend in a nonneutral tax system as a function of the rate of inflation

$$\frac{D_T^{nn}}{p(t)} = ((1-\tau)F_K - \delta + \tau\delta\frac{1}{e^{\pi t}})K(t). \qquad (10)$$

The effect of changes in the inflation rate on real dividends is given by the derivative of (10) with respect to π.

$$\frac{\partial \frac{D_T^{nn}}{p(t)}}{\partial \pi} = \frac{-\tau\delta t K}{e^{\pi t}} < 0 \qquad \text{for all} \quad t > 0. \qquad (11)$$

According to (10), real dividend is a nonlinear decreasing function of the inflation rate[5]

[5]Summers uses the equation

$$D = F_k(1-\tau)K - \lambda\pi K. \qquad (12)$$

The term $\lambda\pi$ reflects the influence of inflation on real dividends. Contrary to (10) the real dividend is a linear function of the inflation rate. However the qualitative implications are the same.

Let us simplify the notation and write from now on

$$D_{T,r}^{nn} = \frac{D_T^{nn}}{p(t)} = (F_K(1-\tau) - \delta + \tau\delta g(\pi))K, \qquad g(\pi) = \frac{1}{e^{\pi t}}. \tag{13}$$

The real dividends are positive as long as posttax marginal productivity is greater than the depreciation rate. They affect the real stock price per one unit of capital q by the arbitrage equation

$$\frac{D_{T,r}^{nn}}{qK} + \frac{\dot{q}}{q} = r \qquad D_{T,r}^{nn} = \frac{D_T^{nn}}{p(t)}. \tag{14}$$

Shareholders must earn the same real rate of return r from an investment in stocks, which is the sum of current return and capital gains, as from any other investment. Concentrating on equilibrium solutions with $\dot{q} = 0$ [6] and ignoring capital gains, this implies

$$q = \frac{F_K(1-\tau) - \delta + \tau\delta g(\pi)}{r}. \tag{15}$$

In an equilibrium, stock prices depend on the capital stock. Our assumption about the capital market does not allow us to derive K from the maximizing behavior of firms. Instead we postulate an investment function of the type Tobin has suggested, making investment a function of stock prices. Capital accumulation is then described by

$$\dot{K} = I(q) - \delta K, \qquad I(1) = \delta K^*, \qquad I' > 0, \tag{16}$$

where K^* is defined as the steady-state capital stock. Ignoring the capacity effect of investment and calculating the change of q with respect to changes in the inflation rate gives

$$\frac{\partial q}{\partial \pi}\Big|_{\dot{K}=0,dr=0} = \frac{\tau\delta g'(\pi)}{r} < 0. \tag{17}$$

[6] The consequence of relaxing this assumption is discussed in the appendix.

Therefore inflation reduces the real stock price even if r is unchanged. This is because a higher inflation rate increases the real tax burden on the firm. The additional tax burden reduces dividends and this leads, ceteris paribus, to a reduction of stock prices.

We model the real estate sector in an analogous way. To make investing in owner occupied housing as attractive as investing in other assets investors must obtain the same rate of return. Let H be the stock of owner occupied housing and $R(H)$ the implicit rent services from owner occupation, and denote by p_H the price of housing both measured in units of the consumption good. Then arbitrage requires[7]

$$\frac{R(H)}{p_H} + \frac{\dot{p}_H}{p_H} = r, \qquad R'(H) < 0 \tag{18}$$

Ignoring again capital gains, this implies

$$\frac{R(H)}{p_H} = r. \tag{19}$$

Investment in the real estate sector is described by

$$\dot{H} = h(p_H), \qquad h(1) = 0, \qquad h' > 0, \tag{20}$$

where we have ignored depreciation. Investment is assumed to depend on the price of the asset. As in the capital market, higher investment leads to a higher stock and by the function $R(H)$ this affects the asset price p_H. If adjustment of stocks takes a long time we can ignore the capacity effect of investment. Because (19) consists only of real variables, a partial analysis of this equation leads to the conclusion that changes in the inflation rate do not affect the asset price p_H. As long as the real interest rate r is unaffected, which is the case as long as we regard r as an exogenous variable, p_H is independent of changes in the inflation rate.

It is therefore necessary to integrate r into the model as an endogenous variable and to calculate the effect of inflation on r. We do this by equating aggregate demand to aggregate supply

[7]To derive equation (18) we have used the assumption $\dot{p}_H = 0$. The consequence of relaxing this assumption is discussed in the appendix.

$$C(\frac{w}{p}N, qK + p_H H) + I(q) + p_H h(p_H) = F(K, N) + R(H)H \tag{21}$$

$$\text{with} \qquad \frac{\partial C}{\partial(qK + p_H H)} := c_2 > 0$$

The right hand side of this equation represents aggregate supply as the sum of all produced consumption goods $F(K, N)$ and all housing services $R(H)H$ in one period. Aggregate demand is composed of consumption which depends on labor income and wealth as well as investment, which in turn depends on asset prices.

If we treat K and H as predetermined, i.e. not taking into account the capacity effect of investment, the three equations (15), (19) and (21) define a system of equations in the endogenous variables r, q and p_H. Using comparative statics we calculate the partial derivative of r with respect to π as

$$\frac{\partial r}{\partial \pi} = \frac{-\tau\delta g'(\pi)\frac{R(H)}{rp_H^2}(c_2K + I')}{-\frac{R(H)}{p_H^2}(c_2K + I')\frac{D_{T,r}^{nn}}{r^2K} - (c_2H + h + h'p_H)} < 0 \tag{22}$$

Similarly we get

$$\frac{\partial p_H}{\partial \pi} = \frac{\tau\delta g'(\pi)\frac{1}{r}(c_2K + I')}{-\frac{R(H)}{p_H^2}(c_2K + I')\frac{D_{T,r}^{nn}}{r^2K} - (c_2H + h + h'p_H)} > 0 \tag{23}$$

and

$$\frac{\partial q}{\partial \pi} = \frac{-\tau\delta g'(\pi)\frac{1}{r}(c_2H + h + h'p_H)}{-\frac{R(H)}{p_H^2}(c_2K + I')\frac{D_{T,r}^{nn}}{r^2K} - (c_2H + h + h'p_H)} < 0. \tag{24}$$

We draw the following conclusions: An increase in inflation lowers stock prices, raises the price of housing and reduces the interest rate. This result is essentially based on two effects. First, inflation raises the tax burden on firms. The higher tax burden then reduces dividends. This reduces stock prices even when interest rates remain unchanged. Secondly the decline in stock prices reduces investment demand $I(q)$. With a given aggregate supply this requires a decline in savings and respectively an increase in consumption. Therefore p_H must increase and by (19) the interest rate must decrease.

II. Inflation, financing structure and asset prices

After presenting an expanded version of Summers' model we will now discuss an alternative model capable of explaining the connection between inflation and asset prices. The hypothesis is based on the observation that investment in housing is largely financed by issuing debt. Hereafter, this hypothesis will be called the "leverage-hypothesis". Borrowers profit from unanticipated inflation because debts can be repaid with money that has a lower value than at the time when the debt contract was concluded. Because investment in the housing sector is financed by issuing debt, higher expected inflation leads to a higher demand for housing.
In this form the argument is doubtful, if not wrong. It implicitly assumes that borrowers and lenders have different inflation expectations. If they have the same expectations about inflation, the interest rate will adjust in such a way that no one can profit from inflation and there will be no additional demand for housing. If there is a long contract period and inflation is higher than expected, borrowers can make ex post profits. But the ex ante return is the determining factor for the demand for housing.

We model the impact of the financing structure on prices for stock and housing by the following four equations:

$$\frac{F_k(1-\tau)}{i_o-\pi}=q, \tag{25}$$

$$\frac{R(H)}{p_H}=(1-L)i_B+Li_o-\pi, \qquad 0<L\leq 1, \tag{26}$$

$$i_o=\alpha i_B, \qquad \alpha>1, \tag{27}$$

$$c(\frac{w}{p}N,qK+p_H H)+I(q)+p_H h(p_h)=F(N,K)+R(H)H. \tag{28}$$

Equation (25) is the equilibrium condition for the stock market. The market value of one unit of capital is equal to the discounted marginal product of capital after taxation. We have replaced $F_k(1-\tau)-\delta-\tau\delta g(\pi)$ by $F_k(1-\tau)$ because our focus here is on the financing structure and not on the influence of the tax system. To simplify the notation we have ignored depreciation. The second difference results from using another discount rate. i_0 is the nominal rate of return on equity capital. Because investment can principally be financed by bonds or equity we must distinguish i_0 from the interest rate on bonds i_B. Using i_0 in (25) we implicitly assume that the firm is completely financed by issuing stock. This assumption is of course made for the sake of simplicity. For our results it is sufficient to assume that the equity/debt ratio is higher in the goods sector than in the real estate sector.

The second equation gives us the equilibrium condition for the housing market. If we rewrite the right hand side as $(1-L)(i_B-\pi)+L(i_o-\pi)$ it is easy to interpret (26). If L is the equity/debt ratio in the real estate sector, (26) says that the real rate of return from an investment in dwellings must be equal to a weighted average of the rate of return on owner capital and the rate of return on bonds.

The third equation relates i_o to i_B. Alternatively we could model this relation, using $i_o = i_B + \theta$ with $\theta > 0$ being the risk premium. We prefer (27) for the following reason: In an economy consisting of risk neutral agents in which shareholders may receive, with the probability σ, the rate of return i_o and, with the probability $1-\sigma$, a zero rate of return, the expected rate of return from owner capital and bonds must be equal, that is $E(i_B) = E(i_0)$. If i_B is the risk-free interest rate we have $i_B = \sigma i_0$, respectively $i_0 = \alpha i_B$ with $\alpha = \frac{1}{\sigma} > 1$. The fourth equation describes the goods market as in section I. The equations (25) through (28) define a system of equations in the four endogenous variables p_H, q, i_o, i_B. The dependence of these variables on the exogenous variables π and L is again calculated using comparative statics. Bringing this system in the implicit form and differenciating all equations with respect to endogenous variables p_H, q, i_o, i_B, we find the Jacobian determinant to be

$$|\mathbf{J}| = \begin{vmatrix} 0 & 1 & \frac{F_K(1-\tau)}{(i_o-\pi)^2} & 0 \\ \frac{-R(H)}{p_H^2} & 0 & -L & -(1-L) \\ 0 & 0 & 1 & -\alpha \\ c_2H + h + h'p_H & c_2K + I' & 0 & 0 \end{vmatrix}. \tag{29}$$

Thus

$$
\begin{aligned}
|\mathbf{J}| \;=\; & \tfrac{-\alpha F_K(1-\tau)R}{(i_o-\pi)^2 p_H^2}(c_2K+I') \\
& -(c_2H+h'p_H+h)L\alpha \\
& -(c_2H+h'p_H+h)(1-L)<0.
\end{aligned} \tag{30}
$$

The change in housing prices when the inflation rate is changed is then given by

$$\frac{\partial p_H}{\partial \pi} = -\frac{(\alpha-1)(c_2K+I')(L-1)(\tau-1)F_K}{(i_o-\pi)^2|\mathbf{J}|} > 0. \tag{31}$$

Therefore real estate prices increase when the inflation rate becomes higher. From (31) we can see the reason for this result: If investment in the real estate sector is completely financed by equity, as investment in the firm sector is (that is $L=1$), we would have $\frac{\partial p_H}{\partial \pi}=0$. In this model the financing structure is the only way inflation influences real estate prices. Analogously we calculate changes in real stock prices by

$$\frac{\partial q}{\partial \pi} = \frac{(\alpha-1)(c_2H+p_Hh'+h)(L-1)(\tau-1)F_K}{(i_o-\pi)^2|\mathbf{J}|} < 0. \tag{32}$$

If we have $L<1$, stock prices decline when inflation becomes higher. Again a necessary condition for the stock price to be influenced by changes in the inflation rate is that the equity/debt ratio in the real estate sector is lower than 1.

The derivative of the interest rate for owner capital with respect to π can be written more simply using the definitions

$$
\begin{aligned}
A &:= (c_2H+p_Hh'+h)\alpha \\
B &:= \tfrac{(1-\tau)RF_K}{(i_o-\pi)^2}(c_2K+I')
\end{aligned} \tag{33}
$$

Applying these definitions we find

$$\frac{\partial i_o}{\partial \pi} = \frac{A+B}{AL+B+(c_2H+h'p_H+h)(1-L)} > 0. \tag{34}$$

This last equation highlights the way inflation influences the portfolio equilibrium. If the equity/debt ratio in the real estate sector is one ($L=1$) then we get $\frac{\partial i_o}{\partial \pi}=1$, which results from (34). Furthermore we would have $\frac{\partial q}{\partial \pi} = 0$ and $\frac{\partial p_H}{\partial \pi} = 0$. If the changes in the nominal interest rate for owner capital and the changes in the inflation rate are equal, leaving real interest for owner capital unchanged, then stock prices do not react to changes in the inflation rate.

Finally we calculate changes in the nominal interest rate[8].

$$\frac{\partial i_B}{\partial \pi} = \frac{c_2 H + p_H h' + h + B}{(c_2 H + p_H h' + h)(1 + L(\alpha - 1)) + B} > 0. \tag{35}$$

We now analyze the second exogenous variable (L) in the system. Later we will see that analyzing the influence of this variable will enable us to distinguish ,empirically, the leverage hypothesis from other hypotheses. Comparative static calculus yields the four derivatives

$$\frac{\partial p_H}{\partial L} < 0, \qquad \frac{\partial q}{\partial L} > 0, \qquad \frac{\partial i_o}{\partial L} < 0, \qquad \frac{\partial i_B}{\partial L} < 0. \tag{36}$$

An increase in the equity/debt ratio in the real estate sector leads to a reduction in the real estate price and to an increase in the stock price. Note that the financing structure in the firm sector is assumed to be constant.

In summary we get the implicit functions

$$\begin{aligned} p_H &= p_H(\underset{+}{\pi}, \underset{-}{L}), \qquad 0 < L < 1, \\ p_H &= p_H(\underset{0}{\pi}, 1) \end{aligned} \tag{37}$$

and

$$\begin{aligned} q &= q(\underset{-}{\pi}, \underset{+}{L}), \qquad 0 < L < 1, \\ q &= q(\underset{0}{\pi}, 1). \end{aligned} \tag{38}$$

[8]Notice that our results are sensitive with respect to the specification of (27). Using $i_o = i_B + \theta$ instead, the derivative $\frac{\partial p_H}{\partial \pi} = 0$ and $\frac{\partial q}{\partial \pi} = 0$ for bonds are obtained.

Empirical evidence

Both models presented above imply that an increase in the expected permanent rate of inflation is associated with an increase in real estate prices and a decrease in stock prices. In so far the tax hypothesis and the leverage hypothesis do not compete with each other. According to the leverage hypothesis there are additional explanatory variables, the equity/debt ratio in both sectors. Let us first consider the common empirical implications of both models and discuss the relevance of the financing structure later on.

The hypothesis that changes in the expected inflation rate are associated with changes in asset prices is tested by the regression

$$R_t = \alpha + \beta \Delta \pi_t^e + u_t. \tag{39}$$

R_t is defined as the sum of capital gains and the current rate earned from the asset minus a risk-free interest rate. As the risk-free interest rate we have used the short term interest rate as published by the German Council of Economic Advicers [9]. The rent series of middle quality housing published by the RDM serves as the proxy variable for the rent services from owner occupation.[10] Our house or respectively appartment price index refers to the same quality class. The series are deflated by the price index of the GNP.[11]

A special problem arises with the expected permanent rate of inflation, which is of course not observable. To estimate a time series for this variable in year t, an ARMA process is fitted to the preceding ten year data on inflation. It is then used to forecast the next ten years' inflation rate. The expected permanent rate of inflation is then calculated as a discounted weighted average of these forecasts. The discount rate is assumed to be 8 percent. The estimation of the ARMA process is based on quarterly data of the price index of GNP. Our estimation procedure gives quarterly forecast values of the inflation rate. When calculating the geometric average of quarterly

[9] Sachverständigenrat (1992)

[10] RDM: Immobilienpreisspiegel 1971-1992

[11] German Central Statistical Office yearbooks: 1971-1992

values, we get a yearly series. The ARMA process we have used is a pure first order moving average process[12]

$$\pi_t = \alpha + \beta u_{t-1} + u_t. \tag{40}$$

In most cases this model seems to be the best approximation.

Estimating (39) for the stock market for the period 1973- 1990[13] we find

$$\begin{array}{rcc} R_t^s = & 0.0534 & -33.56\Delta\pi_t^e \\ & (1.3) & (-2.12) \\ & R^2 = 0.23 & DW = 1.79. \end{array} \tag{41}$$

An increase in the permanent rate of inflation by 1 percent is associated with a decline of stock prices by 33.56 percent. This result is consistent with the predictions of the models. The slope seems to be high compared with the American results. In Summers' study the parameter has the value -7.61 with a standard deviation of 1.61. With 23 percent also R^2 is higher than for the American data. R^2 in equation (41) seems to be low compared with usual econometric studies but note that the dependent variable is the excess return in the stock market which should be a near white noise process if the efficiency market hypothesis is valid.

Applying (39) to the real estate sector we get for the period 1972-1990

$$\begin{array}{rcc} R_t^h = & 0.0164 & +35.62\Delta\pi_t^e \\ & (0.52) & (2.88) \\ & R^2 = 0.356 & DW = 0.945. \end{array} \tag{42}$$

To estimate this model we have suppressed the values for 1973 and 1974 in the regression. These years were characterized by high inflation rates. Many investors had

[12]The estimation procedure for calculating the permanent expected inflation rate is similar to Summers' procedure. Summers has used an ARMA process of order (1,1). The results from the following regressions are comparable to the American data.

[13]Values in paranthesis are t-ratios. The index s refers to the stockmarket

to renegotiate credit contracts at higher interest rates. For some investors interest payment had become so high that they had to sell their property in housing. Under such conditions actual prices do not represent market values that one would obtain by discounting future rents. This justifies the suppression of these years from the regression.

These results are consistent with the predictions of both theoretical models. However we have to be careful with the interpretation of the t-values because the Durbin-Watson test shows significant autocorrelation of the error term. According to this if the permanent inflation rate increases by one percent, real estate prices are increased by 35.62 percent. The elasticity of asset prices is high compared with the elasticities in Summers' study using the estimators -7.61 and 3.12. Such high elasticities may be due to the high stability reputation of the Deutsche Bundesbank, which could explain the low variance of the series. Small changes in the inflation rate will then be associated with large variations of asset prices.
We have checked this hypothesis by adding the variance of the permanent inflation rate series defined by $Var(\pi_t^e) = (\pi_t^e - \bar{\pi})^2$ as an explanatory variable to the regression model. For the stock market this variable does not have any significant influence. In the real estate sector we find[14]

$$\begin{array}{rcccc} R_t^h = & -0.084 & +31.315\Delta\pi_t^e & +1347.4\mathrm{Var}(\pi_t^e) & \\ & (-2.12) & (3.216) & (3.26) & \qquad (43) \\ & \hat{R}^2 = 0.5820 & DW = 0.984 & . & \end{array}$$

This result indicates that the variance of the permanent inflation rate has explanatory power. The parameter of $\Delta\pi_t^e$ is smaller but still high.

Regressions of the type (43) have not the capability to distinguish between alternative ways inflation influences asset prices. The observation that stock prices are negatively correlated and real estate prices are positively correlated to an increase in the rate of inflation therefore fits with both the tax and the leverage hypotheses.

To gain an impression of the relevance of the financing structure, we will now discuss

[14] $\hat{R}^2$ is the adjusted R^2. We report only few statistics here because (43) is not our final equation.

the leverage hypothesis explicitly. Remember that the theoretical model defines the implicit function

$$\begin{aligned} p_H &= f(\underset{+}{\pi}, \underset{-}{L}), \qquad 0 < L < 1, \\ p_H &= f(\underset{0}{\pi}, 1). \end{aligned} \tag{44}$$

To make this equation usable for empirical applications we have to consider the following problems. Note that (44) is derived from the assumption that the firm sector is completely financed by issuing stock. For empirical usage this assumption is inappropiate. The determining factor is the difference in the financing structure of the firm sector and that of the real estate sector. Let L_u be the equity/debt ratio in the firm sector and let L_i be the equity/debt ratio in the real estate sector. We replace (44) by

$$\begin{aligned} p_H &= g(\underset{+}{\pi}, \underset{+}{L_u - L_i}), \qquad L_u - L_i > 0, \\ p_H &= g(\underset{0}{\pi}, 0). \end{aligned} \tag{45}$$

We must also consider the nonlinearity of (45) in $L_u - L_i$, i.e. $\frac{\partial p_H}{\partial \pi}$ has to be a function of $L_u - L_i$. It does not seem to be unreasonable to specify the function (45) as

$$g(\pi, L_u - L_i) = \alpha + \beta(\pi(L_u - L_i)). \tag{46}$$

The third problem arises from data. We only have time series for the financing structure of firms.[15] A solution is to assume that L_i is constant in time and to make it a parameter estimated by the empirical model. This assumption is appropriate if the financing structure of the real estate sector depends on institutional factors, which change only in the very long run.

[15]German Central Statistical Office yearbooks.

According to this we specify

$$R_t = \alpha + \beta(\Delta\pi_t^e(L_u - \gamma)) + \delta \mathrm{Var}(\pi_t^e), \qquad \beta > 0, \tag{47}$$

in which γ is the equity/debt ratio in the real estate sector and in which we haved also allowed the real estate price to vary with the variance of the permanent inflation rate.

From (47) we get

$$R_t = \alpha + \beta(\Delta\pi_t^e L_u) + \theta(\Delta\pi_t^e) + \delta \mathrm{Var}(\Delta\pi_t^e), \qquad \theta = -\beta\gamma. \tag{48}$$

(48) is the regression equation with the estimators α, β, θ and δ. Therefore we can identify the equity/debt ratio γ in the real estate sector by means of the parameter restriction $\frac{-\theta}{\beta} = \gamma$. The leverage hypothesis predicts $\beta > 0$, $\theta < 0$ and furthermore $\beta > -\theta$. Otherwise γ would not be smaller than 1. Last but not least, the estimation should give a realistic value of γ.

On the other hand, if the leverage hypothesis is wrong and asset prices are influenced through inflation by other channels of transmission, we would have $\beta = 0$ and $\theta \geq 0$. After some experiments we choose the following model for the period 1972-1989[16].

$$\begin{array}{lllll}
R_t^{*h} = & -0.13457 & +1171.5(\Delta\pi_t^e L_u)^* & -340.9961(\Delta\pi_t^e)^* & +1451.4 \ \mathrm{Var}(\pi_t^e)^* \\
 & (-5.1817) & (3.9821) & (-3.7389) & (6.0976) \\
 & [.000] & [0.002] & [0.003] & [.000] \\
 & -0.22846D1 & -59.0987D2^* & & \\
 & (6.7014) & (-2.24506) & & \\
 & [.000] & [.046] & & \\
 & \chi^2_{LM} = .053499 & \chi^2_{RESET} = 3.3527 & \chi^2_{He} = 2.7979 & \\
 & \qquad [0.819] & \qquad [0.068] & \qquad [0.094] & \\
 & \hat{R}^2 = 0.9133 & DW = 1.7160 & &
\end{array} \tag{49}$$

[16]There is no observation for the variable L_u for the year 1987. We ignored the year 1987 in the regression

In this regression[17] we have included the two dummy variables $D1$ for the intercept term and $D2$ for the parameter of $(\Delta\pi_t^e L_u)^*$. $D1$ and $D2$ are defined by

$$D1 = \begin{cases} 1 & \text{for observations in} \quad 74, 75, 82, 83 \\ 0 & \text{for all other obervations} \end{cases}$$

and

$$D2 = \begin{cases} (\Delta\pi_t^e L_u)^* & \text{for observations in} \quad 74, 75, 82, 83 \\ 0 & \text{for all other obervations} \end{cases}$$

.

The variables indexed with an asteriks (*) are derived from the original variables by the formula $x^* = log(1 + x)$. Because all values of x are less then 1 in absolute values the approximation $x^* \simeq x$ works very well. We have transformed the variables in this way because the regression results with the orginal variables indicates a signifcant misspecification in the functional form. The parameters have been estimated very similar in both regressions but the statistic of the transformed regression is improved. So the Durbin-Watson-stastic is increased by 0.23 and all standard errors are reduced. The χ^2_{LM} value reports the Lagrange multiplier test of first order residual serial correlation. It is reported here because the Durbin-Watson test is in the inconclusive region. According to this test we do not reject the null hypothesis of no serial correlation at the very comfortable 0.819 significance level. The F-Version of this test gives the probability value 0.863. Thus although the Durbin-Watson test does not allow the conclusion of no first order serial correlation in the residuals the LM-test does. The χ^2_{RESET} value tests for the signifance of the square fitted values in the regression (49). This test which can be employed to detect misspecifiaction of the functional form has been improved by the transformation of the data[18]. It indicates no misspecification of the functional form at the 5 percent significance level. The F-Version of this test gives the probability 0.148. The χ^2_{He}-test is a test for heteroscedasticity of the residuals based on a regression of squared residuals on squared fitted values. According to this test we do not reject the null hypothesis of no heteroscedasticity (the probability

[17] Values in [.] are the probalility values of falsely rejecting the null hypothesis

[18] Without transformation the test is significant at the 0.013 level for the LM-Version and at the 0.039 for the F-Version

of the F-Version is 0.106). We have also made a Chow- test for the stability of the parameters using the observations of the period 1972-1980 for the estimation. The F -value for this test is 0.78297 with probability value 0.618. We therefore do not reject the hypothesis of the stability of the parameters. Of course, once included the dummy variables the regression does not exhibit structrual changes any more.

We turn now to the interpretation of the parameters. Note first that all parameteres except the parameter for the dummy $D2$ which is significant at 5 percent level are highly signicant. The crucial parameters β and θ have the expected sign. β is significantly greater than zero and θ is signifcantly lower than zero. With 0.91404 the adjusted R^2 is large. Furthermore β is greater than $-\theta$. For γ we have $\frac{340.9961}{1171.5} = 0.2911$, which is lower than the average value of the equity debt ratio in the firm sector 0.3036. This result is consistent with the prediction of the model if the leverage hypothesis is correct.

The significance of the two dummy variables indicate structural changes in 1974 and 1975 as well as in 1982 and 1983. In these years we observe the lowest excess return in the real estate market corresponding with the crisis in the real estate market. Such structural changes are not unreasonable in the light of the theory. Note that the specification of (49) is based on the assumption that the unobservable equity/debt ratio in the real estate market is constant. This is of course only a crude simplification and it seems reasonable that banks change their lending policy when they observe a recession in real estate prices. It is possible to determine the equity/debt ratio in the periods when structural changes occur, if the regression (49) is written explictly for periods $t = 74, 75, 82, 83$

$$\begin{aligned} R_t^{*h} = \; & (-0.13457 - 0.22846) + (1171.5 - 59.0987)(\Delta\pi_t^e L_u)^* - 340.9961(\Delta\pi_t^e)^* + ... \\ & \text{für} \quad t = 74, 75, 82, 83 \end{aligned}$$

implying a equity/debt ratio in the real estate sector of $\frac{340.9961}{1171.5-59.0987} = 0.3065$. This ratio is plausible since it is higher than for the other observations implying a more careful lending policy of banks facing a recession in real estate prices. The value is lower than the equity/debt ratio in the firms sector in the years 1974 and 1975 where we observe 0.3136 and 0.3097 and higher in the years 1982 and 1983 observing 0.2955 and 0.297 and lower as the mean of these four observations which is 0.3039.

To make these results robust against possible misspecification of the regression (49), we have reestimated the covariance matrix by the procedure suggested by White[19]

coefficient	adjusted t-ratio	probability
−0.13457	−4.8456	.001
1171.5	3.6306	.004
−340.9961	−3.4115	.006
1451.4	6.0649	.000
−0.22846	−10.3703	.000
−59.0987	−4.2015	.001

Comparing these results with the results of (49) we see that all estimators are still highly significant. The t-ratio for the dummy variable $D2$ is even significant at the 1 percent level.

The empirical application of the leverage hypothesis to the stock market is much more difficult. The model treats the financing structure as an exogenous variable. Whereas this is a reasonable assumption for the real estate sector, it seems inappropriate for the firm sector. In reality the financing structure is a part of the firm's policy and may depend on the stock price. An empirical model should consider this. Especially OLS-estimators would not be unbiased because under these assumption L_{ut} would not be independent of the error term ($\text{cov}(L_{ut}, v_t) \neq 0$). Other estimation methods such as the instrument-variable method suffer from a lack of good instruments for L_{ut}[20]. Nevertheless the results indicate that the financing structure plays a dominant role in determining real estate prices. Comparing the two competing models (43) and (47) we see that the explanatory power can be essentially increased by adding the financing structure to the set of explanatory variables. In this sense the leverage hypothesis dominates the tax hypothesis.

[19]White, H. 1980 "A hetereoskedasticity consistent covariance matrix estimator and a direct test of heteroskedasticity" Econometrica 48, pp. 817-38

[20]We have experimented with lagged values of L_{ut} but this does not improve the fit of the original equation

Summary

Observing a negative correlation between stock and real estate prices for houses we have presented two theoretical models with the ability to explain stock prices and prices for dwellings endogenously via macroeconomic factors. In both models asset prices are essentially driven by changes in the expected rate of inflation. Whereas the tax hypothesis explains the connection between asset prices and inflation through differences in the taxation of firms compared to the taxation of the leverage hypothesis emphasizes the difference in the financing structure of the real estate sector and that of the goods sector. Both hypotheses were tested with data from the German stock and real estate market in the period 1972-1990. It was shown that indeed changes in the expected rate of inflation causes asset prices to change as predicted by the models. Consequently empirical evidence is consistent with both models. Furthermore we explicitly tested the importance of the financing structure in determinating asset prices by treating the financing structure in the real estate sector as an estimator of the empirical model. It was shown that all parameters have signs and values which can well be explained by the levarege hypothesis. Explanatory power can be essentially increased by adding the financing structure as an explanatory variable, whereas tax considerations do not explain these results. However to get better empirical evidence for the importance of nonneutralities of the tax system in the determination of asset prices, a more sophisticated empirical model is necessary. In any case the assumption that the housing stock is owner occupied is not needed for the leverage hypothesis. For the German economy exhibiting low rates of owner occupation compared with the United States the leverage hypothesis is more attractive.

Appendix

In this appendix we discuss the consequences of relaxing the assumptions $\dot{q} = 0$ and $\dot{p_H} = 0$. This is done by determining these variables endogenously and assuming that agents have rational expectations respectively perfect foresight. Then for the tax-hypothesis we get the following system of differential equations:

$$\dot{q} = rq - \frac{D}{K}, \tag{50}$$

$$\dot{K} = I(q) - \delta K, \tag{51}$$

$$\dot{p_H} = rp_H - R(H), \tag{52}$$

$$\dot{H} = h(p_H), \tag{53}$$

$$C(\frac{w}{p}N, qK + p_H H) + I(q) + p_H h(p_H) = F(K, N) + R(H)H. \tag{54}$$

To keep the model analytically tractable we do not determine r by (54) enodogenously and postualte in accordance with our findings in the text the relationship $r = r(\pi)$ with $r_\pi < 0$.

The system (50)–(54) is then decomposed into two seperated two dimensional systems which are connected only by the exogenous relationship $r = r(\pi)$. These two systems can be analyzed seperatly in phase-diagramms in the (q, K) and the (p_H, H) plane to determine the time pathes of q and K by (50) and (51) and the time pathes of p_H and H by (52) and (53). The $\dot{q} = 0$-Locus and the $\dot{K} = 0$ have the derivatives

$$\frac{dq}{dK}|_{\dot{q}=0} = -\frac{-D_K K^* + D}{rK^{*2}} < 0 \tag{55}$$

and

$$\frac{dq}{dK}|_{\dot{K}=0} = \frac{\delta}{I'(q^*)} > 0. \tag{56}$$

The eigenvalues of the system (50) – (51) satisfy

$$\begin{vmatrix} r-\lambda & \frac{-D_K K^*+D}{K^{*2}} \\ I'(q^*) & -\delta-\lambda \end{vmatrix} = 0 \tag{57}$$

with the solutions

$$\begin{aligned} \lambda_1 &= \frac{-(\delta-r)}{2} + \frac{((\delta-r)^2+4(\frac{-D_K K^*+D}{K^{*2}} I'(q^*)+r\delta))^{1/2}}{2} \\ \lambda_2 &= \frac{-(\delta-r)}{2} - \frac{((\delta-r)^2+4(\frac{-D_K K^*+D}{K^{*2}} I'(q^*)+r\delta))^{1/2}}{2} \end{aligned} \tag{58}$$

Because of $I'(q) > 0$ und $D_K < 0$ we get two real roots one of them $\lambda_1 > 0$ and the other $\lambda_2 < 0$. The system is saddlepoint stable with DD in figure 2 on page 26 as the saddlepath.

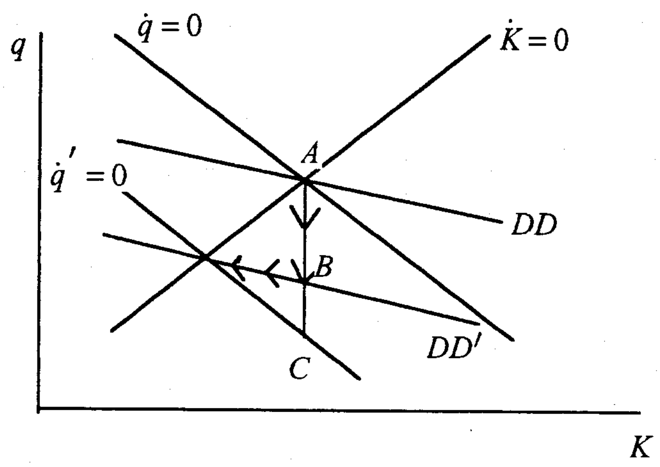

figure 2

The derivative of the DD-Locus is derived from dividing the two equations

$$\begin{aligned} q-q^* &= c_{12}e^{\lambda_2 t} \\ k-k^* &= c_{22}e^{\lambda_2 t}, \end{aligned} \tag{59}$$

such that we get

$$q-q^* = \frac{c_{21}}{c_{22}}(k-k^*). \tag{60}$$

We find the relation $\frac{c_{21}}{c_{22}}$ from the solution of the eigenvector problem

$$\begin{pmatrix} r-\lambda_2 & \frac{-D_K K^* + D}{K^{*2}} \\ I'(q^*) & -\delta-\lambda_2 \end{pmatrix} \begin{pmatrix} c_{21} \\ c_{22} \end{pmatrix} = 0 \tag{61}$$

which is

$$\frac{c_{21}}{c_{22}} = \frac{-D_K K^* + D}{K^{*2}(\lambda_2 - r)} < 0. \tag{62}$$

Applying the same analyses for the system (52)-(53) we get the phasediagramm of figure 3 on page 27.

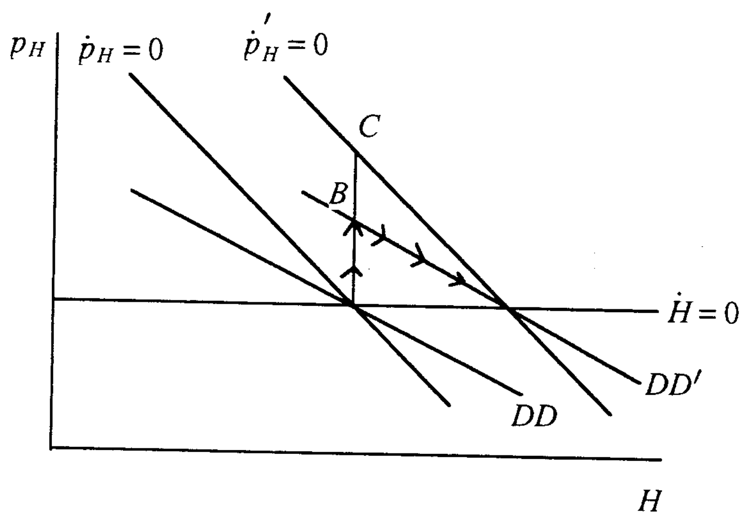

figure 3

The consequences of relaxing the assumptions $\dot{q} = 0$ and $\dot{p_H} = 0$ can be seen if we study the the adjustment pathes when the systems are confronted with a shock in the rate of inflation.

An increase in the rate of inflation drives $\dot{p_H} = 0$-Locus to the right, because we have

$$\frac{\partial p_H}{\partial \pi}|_{\dot{p_H}=0} = -\frac{r_\pi}{r} > 0. \tag{63}$$

The $\dot{H} = 0$-Locus is unchanged. The new stable saddlepath is given by DD'. Under the assumption $\dot{p_H} = 0$ the system jumps initially to the point C, whereas under rational expectations only the point B is achieved. The assumption $\dot{p_H} = 0$ therefore leads to an overestimation of the initial jump in the house price but the qualitative behaviour of the system is correctly predicted by the model with myopic expectations.

In a similar way we can interpret the phasediagramm in figure 2.

The difference of the two assumptions is measured by the distance AC and AB.

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