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336/2009

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WIFO Working Papers, No. 336
April 2009

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2009/088/W/0

The Financial Crisis as an Overshooting Phenomenon

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Abstract

Inspired by Dornbusch's model of exchange rate overshooting we develop a theory of stock market behaviour. The idea is that stock market prices overshoot and undershoot their long-run equilibrium values which are determined by the development in the real economy. The overshooting is fuelled primarily by a loose monetary policy. The simple macro model consists of three markets – the money market, the stock market and the goods market – interacting with different speeds of adjustment. The goods market slowly adjusts relative to the money and the asset market. This model can explain some of the major features of the global financial crisis, having its origin in the loose monetary policy in the United States and spreading its recession-plagued effects all over to the world economy. The model focuses primarily on the monetary interpretation of the present crisis leaving aside the complex interactions of the real estate bubble in the USA, followed by the innovation of new financial instruments which were sold all over the world, hoping to disperse the risks involved with it. Nor does this model deal with the institutional aspects of the financial crisis (the failed behaviour of banks, the banking crises, unregulated financial markets etc.). These are questions of better international regulation of the financial industry touched upon by the G20 summit in London.

JEL classification: E32; E44; E52; F41.
Keywords: Financial Crisis; Open Economy Macroeconomics; Stock Markets; Business Cycles.

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Contents

1. Introduction

The present global financial crisis is a unique singular event happening all fifty or hundred years like the rare specific constellation of planets. All possible negative events happened together (Murphy's law) and were not limited to just one country or region but spread world-wide. It started as the burst of a real estate bubble in the United States. Creative bankers bundled the mortgages risks into a mortgage pool and partitioned it into CDOs (Collateralized Debt Obligations). One of these financial innovations was the ABS (Asset Backed Securities). A series of securities (tranches) were created backed by the pool of mortgages and these products were sold to banks and insurances world-wide. The burst of the US housing market, plummeting prices combined with increased interest rates made many house owners in the US insolvent. Hence, the value of the mortgage converged to zero (subprime credits). The bankruptcy of Lehman Brothers accelerated the global crisis. Banks all over the globe had to downgrade the value of these toxic papers and came in trouble with liquidity. What follows was a banking crisis not only in the USA but in nearly all industrial countries. Banks did not trust each other (break-down of interbank trade) and restricted its credit business (credit squeeze). Over indebted consumers (mostly in the US) and credit-restricted private investors led to a breakdown of private aggregate demand. Hence, the financial crisis, in a second round via a contraction of world trade triggered a world-wide recession in the real economy.

In contrast to the last world wide Great Depression of 1929 the policy makers reacted quickly and in the right direction. Firstly with a massive injection of liquidity by the major national banks (Fed, ECB, BoE, Bank of Japan, etc.) and a quick easing of monetary policy leading to near-zero interest rates in the USA and a further injecting liquidity by a policy of quantitative easing. Similar monetary policy actions were taken in Europe and Asia. In addition, fiscal policy became expansionary. The USA agreed upon an Economic Recovery Packages amounting to 800 bn USD or 5% of US GDP over two years. The EU agreed upon a European Economic Recovery Plan (EERP) amounting to 200 bn € (or 1.5% of GDP), together with the automatic stabilizers it should lead to a fiscal impulse to the European economies of 400 bn € or around 3.3% of EU GDP. Whether this Keynesian policy mix may help to prevent a sliding into depression or to which degree it is able to mitigate the present recession in the industrial world is an open question. Although politicians – in contrast to the inaction or wrong action in 1929 - do the right thing, the fight seems one against windmills. This politicking may be wise from a politico-economic point of view; it may nevertheless economically only crackle and surely end in an accumulation of huge public debts. A quite

disappointing example was the long-lasting stagnation after the massive banking crisis in Japan in the nineties in spite of massive policy intervention[2].

This paper deals with the macroeconomic interpretation of the causes of the present global financial crisis. Inspired by Dornbusch's model of exchange rate overshooting we develop a theory of stock market behaviour. The idea is that stock market prices overshoot and undershoot their long-run equilibrium values which are determined by the development of the real economy. The overshooting is fuelled primarily by a loose monetary policy. The simple macro model consists of three markets – the money market, the stock market and the goods market – interacting with different speeds of adjustment. The goods market slowly adjusts relative to the money and the asset market. This model can explain some of the major features of the global financial crisis, having its origin in the loose monetary policy in the United States and spreading its recession-plagued effects all over to the world economy. The model focuses primarily on the monetary interpretation of the present crisis leaving aside the complex interactions of the real estate bubble in the U.S., followed by the innovation of new financial instruments which were sold all over the world, hoping to disperse the risks involved with it. Nor does this model deal with the institutional aspects of the financial crisis (the failed behaviour of banks, the banking crises, unregulated financial markets etc.). These are questions of better international regulation of the financial industry touched upon by the G20 summit.

In chapter 2 we highlight some stylized facts of the present financial crisis. The stock market overshooting model, firstly for a closed economy, is exposed in chapter 3. A graphical representation explains the mechanism involved in the theory. Simulations with the calibrated model demonstrate the model's dynamic behaviour. The model is then expanded to the open economy case and demonstrated by simulations in chapter 4. That the model is able to capture the major features of international spillovers or contagion of the financial crisis is demonstrated in chapter 5. With our stock market overshooting model we can also demonstrate (in chapter 6) that a volatile monetary policy may lead to boom-bust cycles. Conclusions are drawn in chapter 6.

[2] Reinhart and Rogoff (2009) collected and compare the successes or failures in the aftermath of financial crises. OECD (2009A) tried to evaluate the economic impact of the fiscal packages in its 30 industrial member states. The GDP effects range only from 0.1 to 1.6 per cent of GDP in 2009 and 2010, respectively (see OECD, 2009A, p. 117). The detailed fiscal packages are collected in OECD (2009B). Rancière, Tornell and Westermann (2008) – surprisingly - found that countries that have experienced occasional financial crises have, on average, grown faster than countries with stable financial conditions. They found a robust negative link between skewness and GDP growth in a large sample of countries over 1960-2000.

2. Stylized Facts of the Financial Crisis

The present global financial crisis has all aspects of a great economic crisis: it started as usual as the burst of a housing bubble (for the identification of similarities of past crises, see Reinhart and Rogoff, 2008; OECD, 2008, p. 29; IMF, 2009; The Economist, 2009, p. 57 ff.) in the United States. Because clever banking experts innovated new financial products (e.g., CDOs, ABS, etc.) in connection with the mortgage and loans of US housing, bundled them and sold this papers not only in the USA but to many banks in the world, the US financial crisis spread over to the industrial world. The bankruptcy of one of the largest investment bank, Lehman Brothers Holdings Inc. on 15 September 2008 intensified the contagion, in particular in Europe. So the present crisis is a housing crisis, followed by a banking crisis and spread over to Eastern Europe in the form of a balance of payments and currency crisis. Due to the banking crisis with the following credit squeezes (for an overview of theoretical explanations for this kind of crisis, see Hahn, 2008) and the loss of mutual creditworthiness between banks (the still stand of interbank trade), the financial crisis dramatically affects the real economy via shrinking consumption and investment. Due to the highly globalized world the volume of world trade dropped dramatically since 2008. Therefore we have a global financial and economic crisis (a double crisis) resembling in many respects those of 1929 and the following years[3].

The dramatic situation in the real economy is best documented by the hopeless chasing the shrinking development by practically all institutional economic forecasters (EU, IMF, OECD, World Bank) and national forecasting institutions since the late 2008. The dimension of the false prognosis reaches around 4 to 5 percentage points of real GDP in the major industrial countries which can be identified as real "costs" of the crisis.

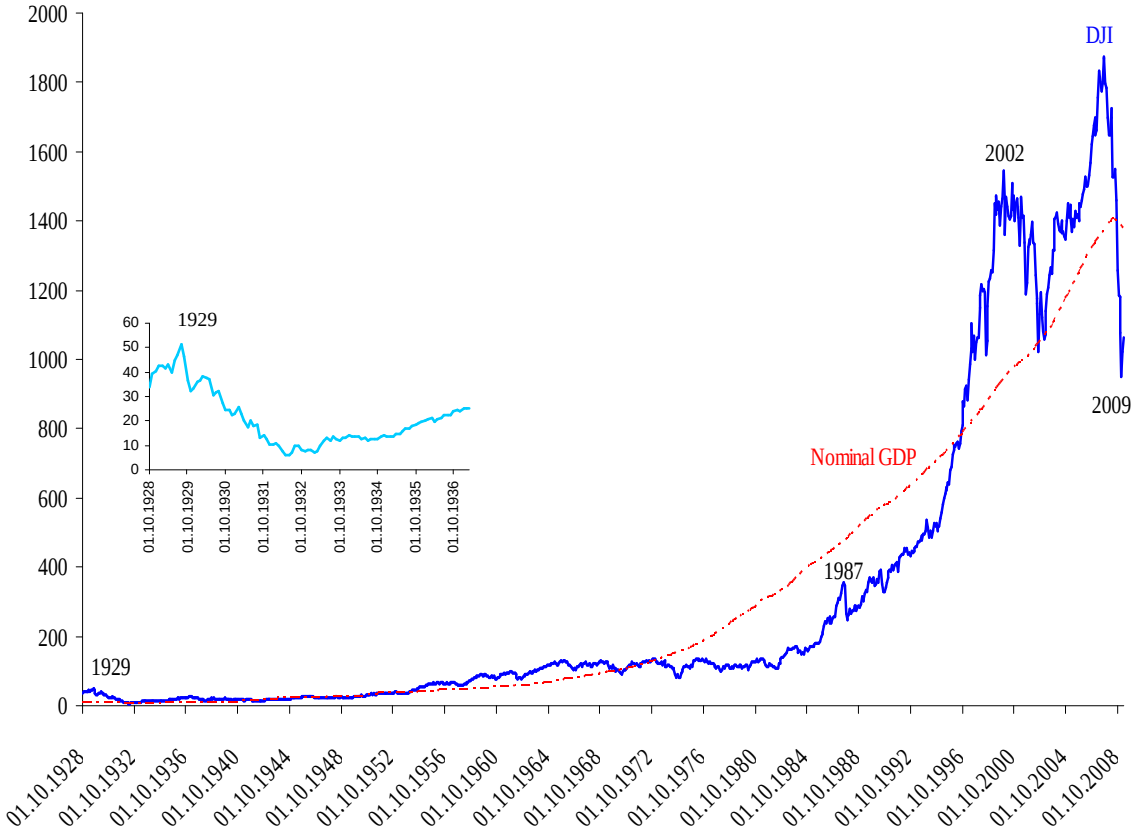
The financial crisis has already caused severe economic and political victims: Iceland went near bankrupt. Ireland is already in depression[4], most industrial countries slipped into recession (see OECD, 2009). The crisis caused also its political toll. In the Czech Republic, in Hungary, Iceland and Latvia the government was washed away, in some countries major changes in the government (e.g. in Spain) takes place. Some Eastern and South East European countries (Hungary, Latvia, Serbia, Romania and Ukraine) had to be supported by balance of

[3] For popular descriptions of the Great Depression, see Galbraith (1954); Kindleberger (1973); for a comparison of the Great Depression with the New World Economic Crisis, see Krugman (2008). For an interpretation of the present crisis from a behavioural point of view (animal spirit) see Akerlof and Shiller (2009).

[4] There is no widely accepted definition of depression. The Economist (2009, p. 57) suggests two principal criteria for distinguishing a depression from a recession (NBER definition: two consecutive quarters of falling GDP): i) a decline in real GDP that exceeds 10%, or ii) one that lasts more than three years. According to a bonmot by President Harry Truman "It's a recession when your neighbour loses his job. It's a depression when you lose yours".

payments assistance by the IMF[5], the World Bank and the EU. Also Turkey makes use of IMF assistance. At the G20 summit in London on 2 April 2009 (see G20, 2009), an agreement was reached to treble resources available to the IMF to $750 billion and additional other measures were announced summing up to a programme of $1.1 trillion to support to restore credit, growth and jobs in the world economy. The major part of these extra credit facilities may be devoted to the developing countries, but it also is thought of as a financial reserve to rescue those Eastern European countries suffering the most from the crisis.

Figure 1: Dow Jones Industrial Average and nominal GDP, USA: 1928-2009
(Index: 1M1970=100)



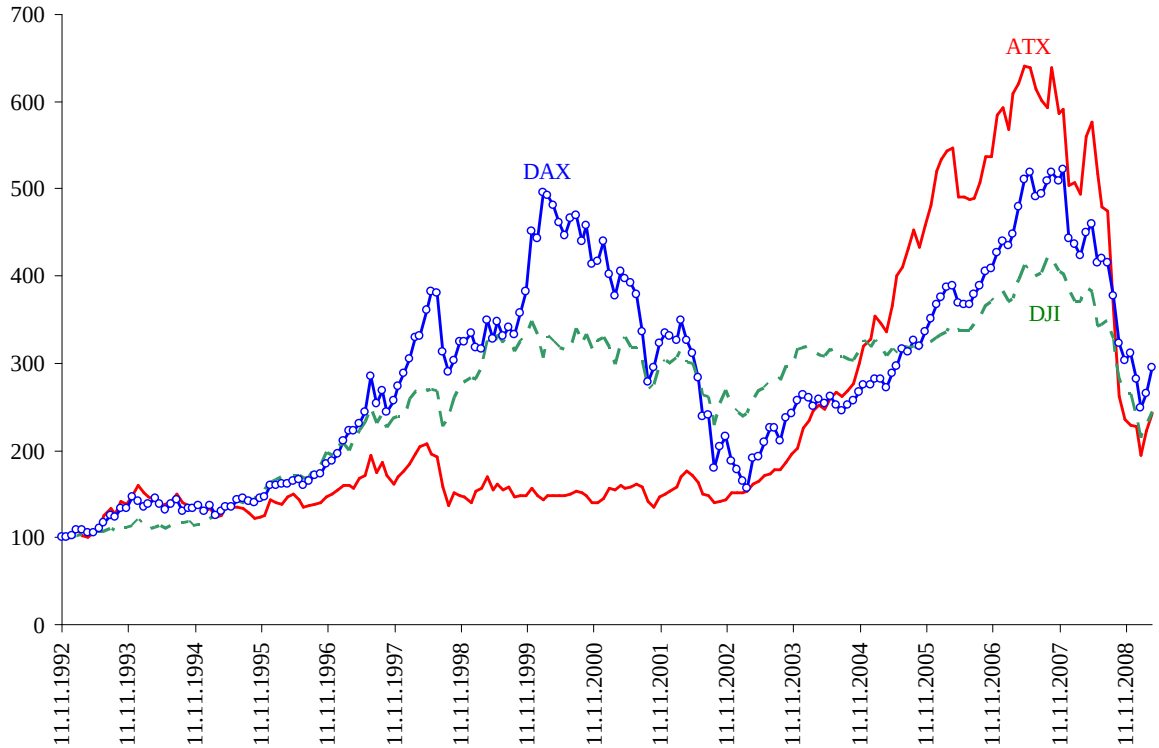
Sources: DJI = http://de.finance.yahoo.com; Nominal GDP = U.S. Department of Commerce: Bureau of Economic Analysis (series GDPA, interpolated from annual figures). Average annual growth between 1970 and 2009: DJI = +6.3%, nom. GDP = 6.9%; between 1929-2009: DJI = +4.3%, nom. GDP +6.1%.

After the big depression in 1929, the US economy exhibited at least three major stock market crises: 1987, the dot.com crises 2002 (in the aftermath of 9/11/2001) and the big financial crisis 2007-2009 (see Figure 1). Only the 1929 and the 2009 crises infected the

[5] The concrete rescue actions taken by the IMF in the present financial crisis (IMF crisis lending) are documented on its homepage: http://www.imf.org/external/np/exr/key/finstab.htm

whole world. The two crises of 1987 and 2002 were ordinary stock market crises limited to the USA. In the nineties Japan endured a banking crisis with a stagnation and deflation period, lasting over a decade. Asia and Russia both slipped into a balance of payments crisis in 1997/99. Argentina had also a balance of payments or currency crisis in 1998. Then there were more local crises, like the Tequila crisis in Mexico in 1994/95 and the Savings & Loans crisis in the US in the eighties. Possible world-wide contagion was discussed but did not happen in the crises of the nineties. Many specific models were developed to understand the particular mechanism of the balance of payments and currency crises (see Flood and Garber, 1984; Jeanne, 1997; Krugman, 1979; Obstfeld, 1986, 1991, 1996).

Figure 2: Stock Markets behaved differently in the USA, in Germany and in Austria: 1992-2009 (Index: 11M1992=100)



Source: DJI = http://de.finance.yahoo.com; DJI = Dow Jones Industrial Average; DAX = Frankfurt stock market index; ATX = Vienna stock market index.

Although the whole world drives into a recession and there seems to be a simultaneous contraction in the stock markets the development of stocks were quite differently before. In Figure 2 we just exhibit the developments of stock market indices of three countries since the early nineties. In the USA the Dow Jones Industrial Index (DJI) was much less volatile compared to the DAX of Germany and the ATX of Austria. The development in Austria was very smooth until 2004 when the EU enlarged by 10 new member states, followed by

Bulgaria and Romania in 2007. The EU enlargement opened up a new window of opportunities to invest in these new emerging markets in Eastern Europe. This was widely used by Austrian industrial companies but very intensely also by the banking sector. The FDI inflow into the new EU member states increased considerably and led to a stock market boom in Austria. The crash was more dramatic in the ATX than in the DAX or DJI in 2008-2009.

From time to time, also non-economists tried to explain crisis phenomena (unstable behaviour) in the stock markets. Based on the mathematical concept of chaos theory developed by Thom (1972), Zeeman (1974) was the first to interpret a stock market crisis as the interaction of two kinds of traders (one group consists of fundamentalists, the other of chartists) which may lead to catastrophic breaks (to a cusp catastrophe) in the development of stock market indices. Aschinger (1987, 2001) tried to explain the US stock market crash 1987 with explanations along the lines of catastrophe theory. Although the stock market is inherently unstable the catastrophe theory – although mathematically extremely challenging – has not very much economic flesh to explain the cause, the diffusion and overall economic consequences of stock market crises.

We therefore refer to the macroeconomic explanation of the outbreak of the present financial crisis and its propagation into the real economy. We primarily interpret the present crisis as caused by a too loose monetary policy in the USA. Inspired by the idea of Dornbusch (1976) that exchange rates may overshoot we interpret the stock market behaviour similarly. The stock market prices overshoot when the activities of stock market agents are fuelled by a loose monetary policy. In the present context it seems that Greenspan overheated the economy[6] and in particular he inspired the financial community to build up bubbles (see Figure 3).

The present financial crisis may have been causes by three major events (see for this interpretation Anna Schwartz in NZZ, 2009, p. 13):

(1) The monetary policy in the USA was too expansionary inspiring all kinds of stock market speculations;

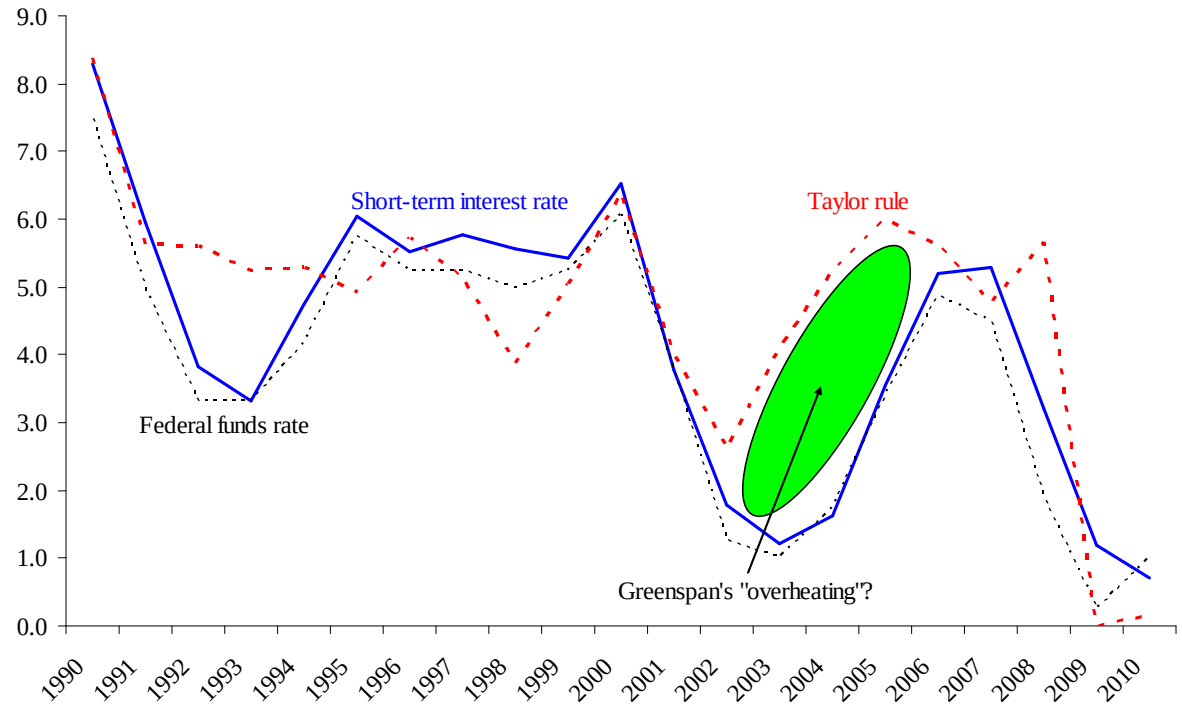
(2) the government under president Clinton intervened directly into the housing market and favoured with its cheap housing policy poor families (via Fannie Mae and Freddie Mac), leading to subprime credits;

(3) The financial sector invented not well enough (at least concerning the risks involved in it) engineered products (e.g. creative bankers bundled the mortgages risks into a

[6] We borrowed this consideration from Taylor (2009) who also interpreted the US monetary policy as one which was way too expansionary compared to one which would be in conformity with the Taylor rule.

mortgage pool and partitioned it into CDOs - Collateralized Debt Obligations, selling this toxic paper all over the world).

Figure 3: Greenspan's Overheating the US Economy?



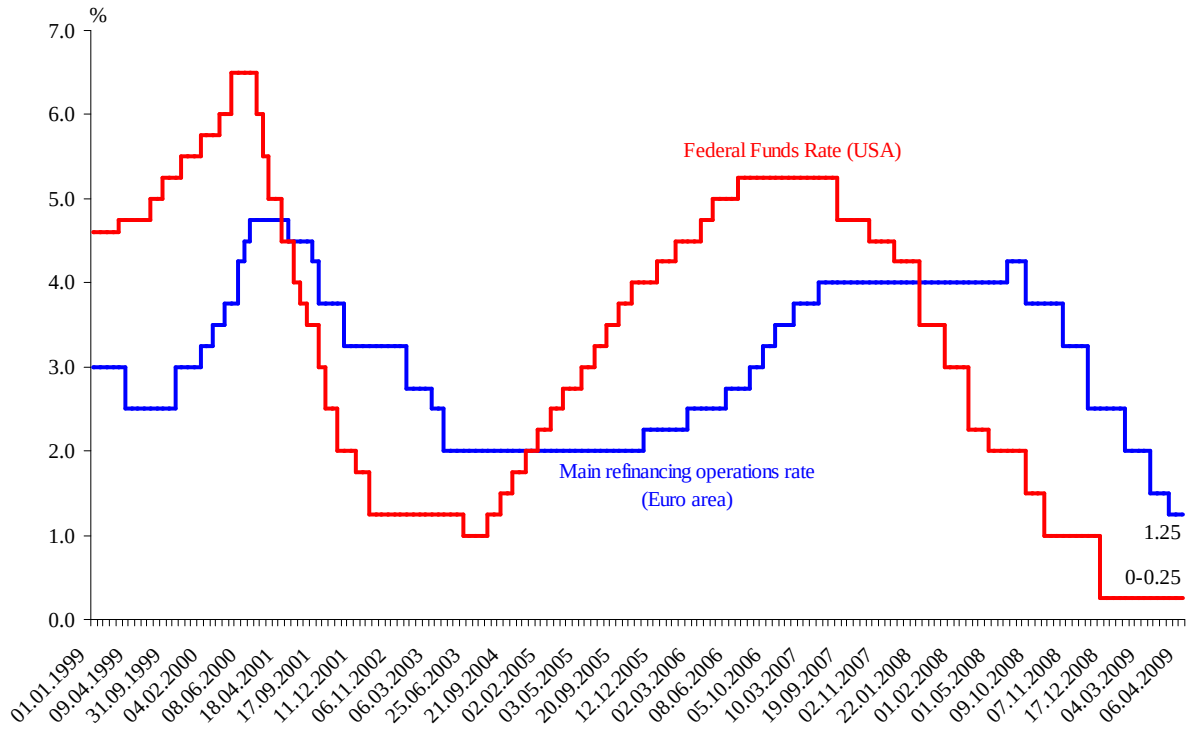
Sources: European Commission: AMECO data base and OECD Economic Outlook: Interim Report, March 2009. Federal funds rate: Federal Reserve Bank of New York. 2009 and 2010 forecasts. Taylor rule 2009 and 2010 with zero floor; according to the formula the resulting interest rates would be -3.2% in 2009.
Applied Taylor rule: i = 2.0 + p% + 0.5*(p% - 2.7) + 0.5*(y% - 2.5); the target values for the inflation rate (p%) and the growth rate of real GDP (y%) are averages of the period 1990-2010.

All these (monetary) stimuli led to an overheating of the stock market prices. This, as in any speculative bubble cannot last forever. If monetary policy swings back to a more restrictionist stance and if expectations on rising prices break the bubble bursts and the stock prices adjusts back to normal long-run values. According to the equilibrium growth models by von Neumann (1945) or by the Fisher equations (Fisher, 1930), the long-run stock market prices converge to the growth rates of the real economy. Then one is back in the long-run equilibrium. A comparison of the long-run development of the DJI and nominal GDP in the USA (see Figure 1) shows that the long-run growth rates are quite similar, although they diverge when the values of great crises (1929, 2009) are taken into account.

The Fed and the ECB, apparently have learned their lessons from the Great Depression. Interest rates were reduced by nearly 5 and 4 percentage points, respectively by

the Fed and the ECB within just a few months (see Figure 4). This was to avoid the failure of the Great Depression, postulated by the Friedman-Schwartz hypothesis in their monumental "Monetary History of the United States, 1867-1960" (see Friedman and Schwartz, 1963). The F-S hypothesis says that a more accommodative monetary policy could have greatly reduced the severity of the Great Depression of 1929 and the following years. This hypothesis was confirmed by model simulations with alternative Taylor rules by Christiano, Motto, and Rostagno (2004) applying an estimated DSGE model for the US economy calibrated to data for the 1920s and 1930s. Bernanke (1983), in contrast to the leading explanation of the correlation between the conditions of the financial sector and of the general economy by Friedman and Schwartz (1963), who stressed the effects of the banking crisis on the supply of money. Although Bernanke agrees that money was an important factor in 1930-33, he nevertheless stresses the non-monetary factors such as institutional failures of banks and the whole financial industry, in short a reduction in the "quality" of financial services, primarily credit intermediation. Many aspects of the wrongdoing in the present crisis could – besides the market failures due to wrong or absent regulations – also be interpreted as institutional failures.

Figure 4: Monetary Policy learned the Lessons from the Great Depression



Sources: ECB and Fed.

As we will demonstrate later with our model of stock market overshooting the ups and downs of monetary policy (see Figure 4) might also induces boom-bust cycles.

3. A Stock Market Overshooting Model for the Closed Economy

We will assume a closed economy with a functioning stock market. The model combines a slow adjustment of goods markets relative to money and asset markets. Departing from Dornbusch (1976) we study the stock market overshooting over its long-run equilibrium values after a short-run money shock. This produces also an overheating in the real economy. Only after the slow adjustment in the goods market has reached its equilibrium income values, we are in the long-run equilibrium in all three markets: money, goods and stock markets, all reach their long-run equilibrium values at increased money supply, higher price levels and long-run stock market prices which are in line with the long-run equilibrium growth rate of income.

3.1 The Stock Market

The stock market is modelled in combination with the money market. An injection of money via an easing of monetary policy decreases interest rates below its long-run values. This enhances an expansion on the stock market via an error correction mechanism (*ECSM*):

$$i = i^* + ECSM\ , \tag{1}$$

where the error correction mechanism is modeled as follows:

$$ECSM = \theta(\overline{p}^{sm} - p^{sm})\ . \tag{2}$$

Equation (2) states that the error correction is proportional to the discrepancy between the long-run stock market price, $\overline{p}^{sm}$, and the current price, p^{sm}. The coefficient of adjustment θ is for the present taken as a parameter. The adjustment parameter represents the behaviour on the stock market (the inclination of traders to overshoot - or for short the “greed” parameter) and it indicates also the necessity to correct these exuberances later. The idea behind this mechanism is that, in the long-run stock markets tend to develop in line with the overall activity of an economy, according to the equilibrium growth model by von Neumann (1945) or by the Fisher equations (Fisher, 1930). The long-run stock market price is assumed known, and an expression for that can be derived by setting $\dot{p} = 0$ and $i = i^*$ in the long-run where markets clear (see equation (9)).

3.2 The Money Market

The domestic interest rate is determined by the condition of equilibrium in the domestic money market. The demand for real money balances is assumed to depend on the

domestic interest rate and real income and will, in equilibrium, equal the real money supply ($m^s - p$). Assuming a conventional demand for money, the log of which is linear in the log of real income and in interest rates, we have[7]

$$m^d = p + \phi\, y^d - \lambda\, i\,. \tag{3}$$

Combining (1), (2), and (3) will give us a relationship between the current stock market price, the goods price level, and the long-run stock market price, given that the money market clears and net asset yields are equalized:

$$p - m^d = -\phi\, y^d + \lambda\, i^* + \lambda\theta(\bar{p}^{sm} - p^{sm})\,. \tag{4}$$

Equation (4) can be simplified by noting that with a stationary money supply long-run equilibrium will imply equality between interest rates, because current and expected stock market prices are equal. This implies that the long-run equilibrium goods price level, $\bar{p}$, will equal

$$\bar{p} = m^d + (\lambda\, i^* - \phi\, y^d)\,. \tag{5}$$

Substituting (5) in (4) gives us a relationship between the stock market price and the goods price level:

$$p^{sm} = \bar{p}^{sm} - (1/\lambda\theta)(p - \bar{p})\,. \tag{6}$$

Equation (6) is one of the key equations of the model. For given long-run values of stock market prices and goods prices, it serves to determine the current stock market price as a function of the current level of goods prices.

3.3 The Goods Market

The goods market reacts very slowly to disturbances originating from policy interventions or from outside. It consists of two equations, the price change and the aggregate demand.

The demand for domestic output (real GDP) y^d depends on real stock market prices $(p^{sm} - p)$, long-run real income or potential output ($\bar{y} = y^{PO}$), real public expenditures (g) and nominal interest rates (i). The demand function is assumed to have the form

$$y^d = \delta(p^{sm} - p) + \gamma\bar{y} + g - \sigma i\,, \tag{7}$$

where potential output and public expenditures are exogenously given; the latter can be changed by active fiscal policy. δ, γ, σ are behavioral parameters. y^d, $\bar{y}$, p and g denote

[7] Equation (3) is obtained by taking the logarithm of the money market equilibrium condition $M / P = Y^{\phi} \exp(-\lambda i)$.

the logs of the real income, potential output, price level and real public expenditures. These variables are to be interpreted as deviations from their long-run equilibrium values. In departing from Dornbusch (1976) we substitute the term relative price of domestic goods (the real exchange rate), influencing net-exports with the term real stock market prices $(p^{sm} - p)$[8]. Taking this into consideration, we allow for an additional source of financing domestic demand. However, skipping the real exchange rate as determinant of net-exports, we restrict our model to a model for a closed economy in which net-exports are exogenous. In the next chapter we will augment the model to one for an open economy which allows also for exchange rate determination. We note that an increase in the stock market prices p^{sm} or a decrease in the domestic price level (p) raises demand, as does an increase in income ($\bar{y}$) and public expenditures (g) or a reduction in interest rates (i).

The rate of increase in the price of domestic goods, $\dot{p}$, is described in (2) as proportional to an excess demand measure:

$$\dot{p} = \pi (y^d - \bar{y}) . \tag{8}$$

The speed of adjustment, π, could be either infinite (full price flexibility) or zero (Keynesian type flexibility). We assume a sticky price adjustment, i.e. one between these two extreme cases.

We note that the long-run equilibrium stock market price implied by (1) is

$$\bar{p}^{sm} = \bar{p} + (1/\delta)\left[\sigma i^* + (1-\gamma)\bar{y} - g\right] , \tag{9}$$

where $\bar{p}$ is defined in (5). From (9) it is apparent that the long-run stock market price depends with the conventional homogeneity properties on monetary variables, but obviously on real variables, too.

The price equation in (8) can be simplified by using the definition of the long-run rate in (9) and the fact that interest differences equal the error correction mechanism, $i - i^* = \theta(\bar{p}^{sm} - p)$, to become a first-order linear differential equation with constant coefficient and constant nonhomogeneity

$$\dot{p} = -\pi\left[(\delta + \sigma\theta)/\theta\lambda + \delta\right](p - \bar{p}) = -\upsilon(p - \bar{p}) , \tag{10}$$

Where[9]

[8] Stock market prices can be identified with indices like the Dow Jones Industrial (DJI) or the DAX or the ATX etc.

[9] The rate of convergence to equilibrium is a function of the adjustment coefficient in the error correction mechanism θ in (2). In case of perfect foresight, in order to correctly predict the actual path of stock market prices it must be true that $\theta = \nu$. The consistent adjustment coefficient, $\tilde{\theta}$, obtained as the solution to equation

$$\upsilon \equiv \pi\left[(\delta + \sigma\theta)/\theta\lambda + \delta\right]. \tag{11}$$

The price adjustment equation in (10) can be solved to yield the following differential equation[10]:

$$p(t) = \bar{p} + (p_0 - \bar{p})\exp(-\upsilon t), \tag{12}$$

Which shows that the price of domestic output will converge to its long-run level at a rate determined by (11). Substitution of (12) in (6) gives the time path (differential equation) of the stock market price

$$\begin{aligned} p^{sm}(t) &= \bar{p}^{sm} - (1/\lambda\theta)(p_0 - \bar{p})\exp(-\upsilon t) \\ &= \bar{p}^{sm} + (p_0^{sm} - \bar{p}^{sm})\exp(-\upsilon t). \end{aligned} \tag{13}$$

From (13) the stock market price will likewise converge to its long-run level.

3.4 A Graphical Representation of the Model

The interaction of the three markets, the goods, the money and the stock market can be studied either separately (like in Dornbusch, 1976, p. 1166, 1169 or in Obstfeld-Rogoff, 1996, p. 613). Here we follow the exposition as in Gärtner-Lutz (2004), S. 103 and in Breuss (2006, p. 308, 313).

The *goods market* is represented in the first quadrant of Figure 5. The equilibrium locus is named IS curve[11]. The positive slope of this curve is one and is derived from the goods market equations (7) and (8). Substituting (8) into (7) and considering that prices are constant in equilibrium, i.e. $\dot{p} = 0$ and, hence $y^d = \bar{y}$ one can solve for p:

$$p = p^{sm} + \frac{g}{\delta} - \frac{(1-\gamma)\bar{y}}{\delta} - \frac{\sigma i}{\delta} \tag{14}$$

In order to sustain equilibrium in the goods market the stock market prices and the goods market prices must change proportionally.

If prices at given stock market prices increase, real financial wealth decreases and reduces domestic demand. In this disequilibrium position on the goods market, demand is below potential output ($y^d < \bar{y}$) and we are above the IS curve (the case of a recession).

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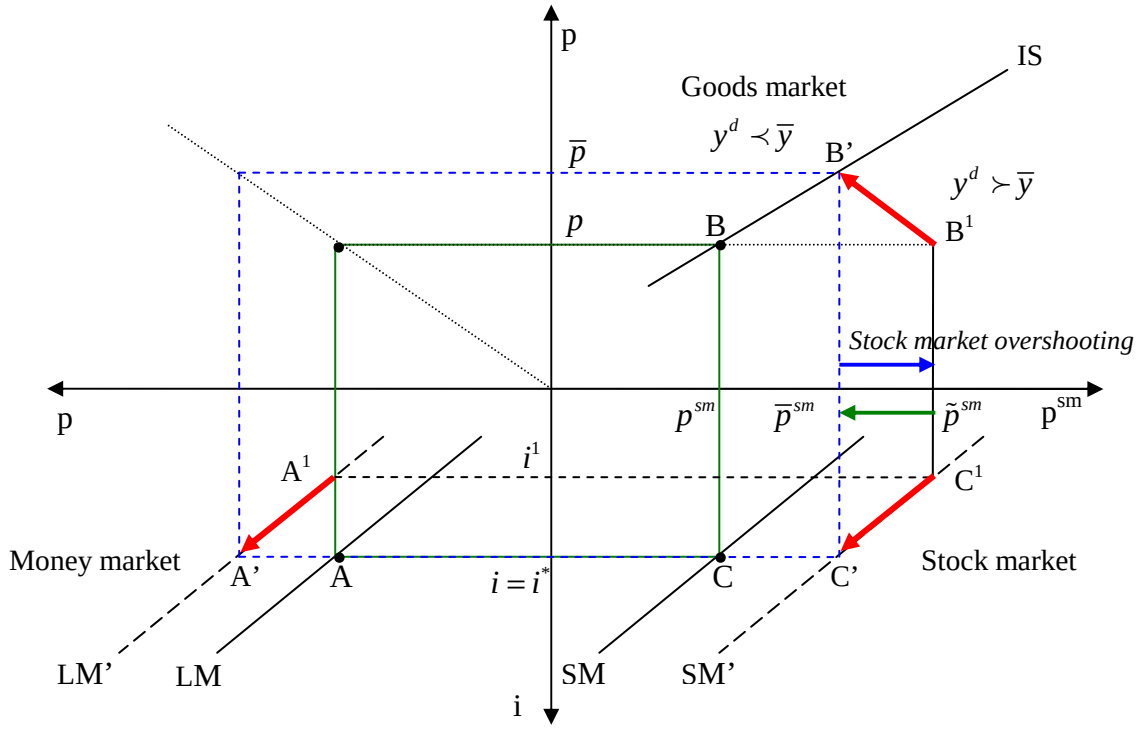
(2) if $\theta = \nu$, is a function of the structural parameters of the economy (see Dornbusch, 1976, p. 1167):
$\tilde{\theta}(\lambda, \delta, \sigma, \pi) = \pi(\sigma/\lambda + \delta)/2 + \left[\pi^2(\sigma/\lambda + \delta)^2/4 + \pi\delta/\lambda\right]^{1/2}$.

[10] For solving differential equations, see Chiang (1984), chapter 14.

[11] The IS curve represents the combination of goods prices relative to stock market prices at constant prices. Therefore it would be more appropriate to call this curve the $\dot{p} = 0$ curve.

Analogously, if goods prices decline at given stock market prices there will be excess demand ($y^d > \bar{y}$) and we are below the IS curve (the case of a business cycle upswing or boom).

Figure 5: Stock Market Overshooting Model: Closed Economy



The *money market* is drawn in the third quadrant of Figure 5. In equilibrium, one can derive the LM curve by solving equation (3) for the interest rate, i:

$$i = \frac{1}{\lambda}(p - m + \phi y^d) \tag{15}$$

The positively sloped LM curve states for which p/i combinations a given nominal money supply (m^s) will be demanded ($m^s = m^d$). If goods prices increase real money supply decreases ($m^s - p$). In order to match with the decreasing money demand, interest rate i must also increase. Because of the flexible interest rate, demand for money is balanced with the supply of money at each period of time and we are always in equilibrium in the money market.

The *stock market* is represented in the second quadrant of Figure 5. The equations (1) and (2) describe its equilibrium. Substituting (2) into (1) one gets

$$i = i^* + \theta(\bar{p}^{sm} - p^{sm}) \tag{16}$$

The negative relationship of interest rate, i and stock market prices, p^{sm} ist depicted by the SM curve. Given the long-run interest rate, i^* and the long-run stock market price, $\bar{p}^{sm}$ an equilibrium on the stock market can occur at different combinations of actual interest rates i and stock market prices p^{sm}. The SM curve says that the stock market is in equilibrium only if an increasing interest rate is accompanied by a respective declining stock market price and vice versa. The economic rational behind this relationship is the fact that an easing of monetary policy (e.g. in the Greenspan period in the years 2002-2005) leads to a boom or bubble on the stock market because it was cheap to buy stocks on credit. This gave rise to an overshooting of the stock market prices over its long-run values. The error correction mechanism built-into equation (2) warrants that this bubble will be corrected downwards so that stock market prices will converge to its long-run equilibrium values.

At the outset we are in *equilibrium* on all three markets in the points A, B and C. If money supply increases, the LM curve shifts to left to LM'. Because of the asymmetry in the speed of adjustment on the different markets – slow adjustment in the goods market and the rapid adjustment on the money and stock markets – one has to differentiate between the adjustment in the short and in the long-run.

Long-run adjustment: In the long-run the interest rate is equal to and fixed at the long-run rate ($i = i^*$). The potential output ($\bar{y}$) is fixed, too. The excess supply of money can therefore only be adjusted to demand of money by increasing the goods prices. This reduces the real money supply back to its original value. The long-run equilibrium on the *money market* shifts horizontally from A to *A'*. In the long-run the nominal money supply increases by the same rate as the goods prices, according to the quantity theory of money ($Mv \equiv PY$).

On the *goods market*, the original equilibrium would only occur if the real stock market price reaches its original value $(p^{sm} - p)$. However, the price level increases to $\bar{p}$ and, hence, also the stock market price must increase to $\bar{p}^{sm}$. The equilibrium on the goods market changes from B to *B'*.

$\bar{p}^{sm}$ is the new equilibrium price of *stock markets*. The stock market is in the long-run equilibrium in point *C'* at prices $\bar{p}^{sm}$ and interest rate i^*. C' is situated on the new stock market equilibrium curve *SM'*.

Short-run adjustment: Due to the assumed slow adjustment at the goods market, in the short-run the only variable to adjust excess supply to demand for money is the flexible

interest rate. An expansionary monetary policy leads to a decrease of the interest rate from i to i^1 and we are at position A^1 on the new *LM'* curve. The fall of the interest rate below its long-run equilibrium i^* leads to a correction on the stock market in order to fulfil the equilibrium condition of equation (1). In the course of this correction, the stock market price $\tilde{p}^{sm}$ overshoots above its long-run value $\bar{p}^{sm}$. This *overshooting* mechanism is analogous to that of Dornbusch (1976) in case of exchange rates. Overshooting the stock market prices leads to a disequilibrium on the goods market in point B^1, because the increase in real stock markets $(p^{sm} - p)$ mock a higher potential for expanding production over potential output. This excess demand for domestic goods induces an increase in the goods price levels and slowly, the adjustment from B^1 to *B'* takes place on the goods market. During this adjustment process the interest rate gap $i < i^*$ shrinks and, on the stock market we walk downwards the *SM'* curve from C^1 to *C'* and on the money market from A^1 to *A'*. The endpoint is again the long-run equilibrium on all three markets.

Overshooting phenomenon: From (4), noting that $d\bar{p}^{sm} = dm^d = d\bar{p}$, we obtain a formal expression for the impact of a monetary expansion on the current stock market prices:

$$dp^{sm} / dm^d = 1 + 1/\lambda\theta . \qquad (17)$$

Equation (17) confirms that in the short run, before goods market prices can react ($dp = 0$) the stock market prices increase faster than money supply, i.e. stock market prices will overshoot[12]. The extent of overshooting will depend on the interest response of money demand and the adjustment coefficient of the error correction mechanism on the stock market.

3.5 Simulations

By calibrating the stock market overshooting model with some plausible values it is possible to demonstrate the dynamic behaviour of the model. We have chosen the following parameter values:

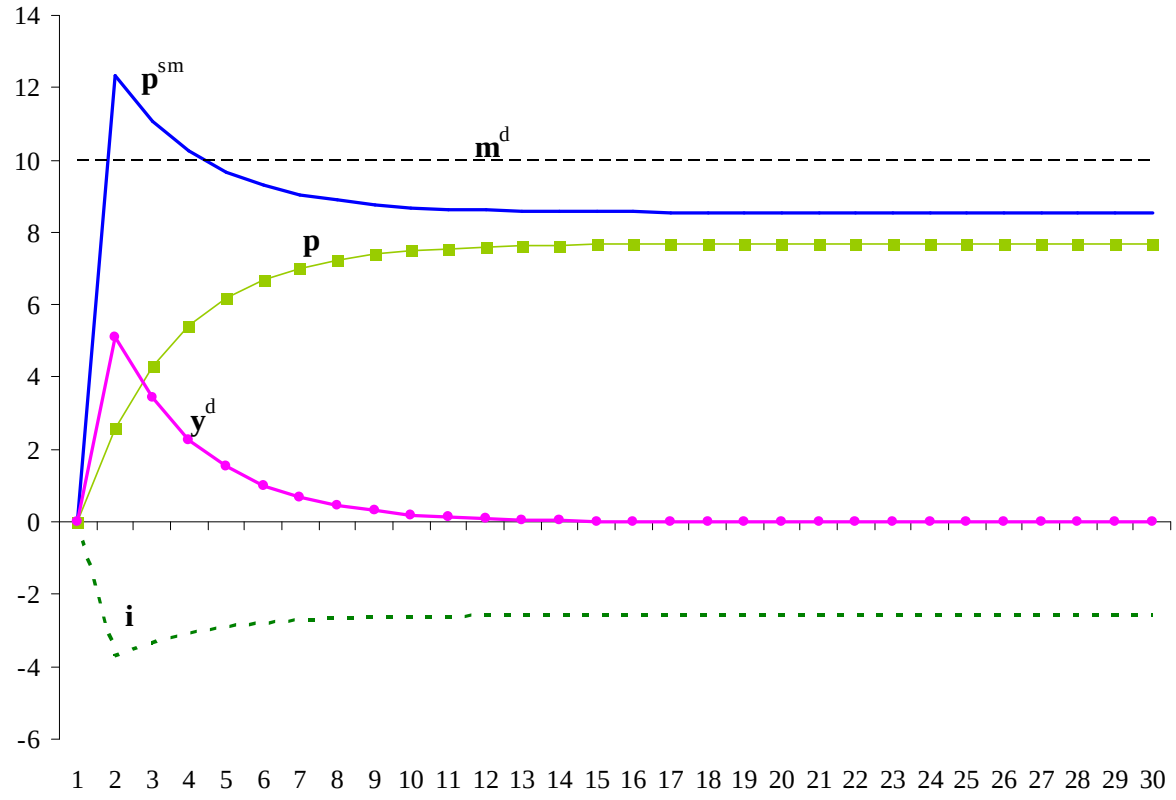
$\pi = 0.5$, $\delta = 0.3$, $\gamma = 0.4$, $\sigma = 0.8$, $\phi = 0.8$, $\lambda = 0.9$, $\theta = 0.3$. The model is solved with Eviews 6.0 by inverting the money demand equation (3) and solving for the interest rate (i). Similarly, the stock market equations (1) and (2) are solved for the current stock market price (p^{sm}). The speed of adjustment – according to equation (11) - implied by our calibration

[12] In case of rational expectations concerning the adjustment path of stock market prices – in analogy to the solution for rational expectations concerning the development of exchange rate changes in Dornbusch (1976, p. 1170) – one can obtain the following equation of the overshooting phenomenon (by substituting the expression of footnote 9): $dp^{sm} / dm^d = 1 + 1/\lambda\tilde{\theta} = 1 + 1//(\pi(\sigma/\lambda + \delta)/2 + \left[\pi^2(\sigma/\lambda + \delta)^2/4 + \pi\delta/\lambda\right]^{1/2})$.

exercise is: $\nu = 0.96$. The variables are to be interpreted as deviations from their long-run equilibrium values which are zero. The simulation runs over a fictitious period of 30 years. For the results of the model simulations see Figure 6.

A 10% increase in the supply of money m^d immediately leads to a decline in interest rates (i). As expected from the theoretical model stock market prices p^{sm} overshoot, i.e. they increase by more than 10%. The boom on the stock market leads to the impression on the goods market that real financial wealth has increased and hence creates also a boom in the demand of domestic goods. Real GDP (y^d) jumps over its potential long-run values and creates a business cycle upswing. Only slowly, goods market prices (p) adjust and bring the goods market into equilibrium, i.e. real GDP shrinks. The inherent correction mechanism leads to an adjustment of the stock market prices down to its long-run values. In the long-run all three markets converge to their equilibrium values.

Figure 6: Simulated Stock Market Overshooting Model: Closed Economy



4. A Stock Market and Exchange Rate Overshooting Model for the Open Economy

In the following we combine the original overshooting mechanism of exchange rates by Dornbusch (1976) with our error correction mechanism leading to an overshooting in the stock markets. By doing so, we generate a model for a small open economy with four markets: goods market, money market, stock market and international capital market. Besides considering the equations which represent the international capital market we have only to adjust the equation for the aggregate demand on the goods market. Instead of a graphical representation we demonstrate the two overshooting mechanisms by a simulation of this adjusted model

4.1 Model Adjustments

International Capital Market and Exchange Rates

Here we implement the original mechanism of the exchange rate overshooting by Dornbusch (1976, p. 1162-1163). The international capital market is characterized by an arbitrage condition which says that assets denominated in terms of domestic and foreign currency are assumed to be perfect substitutes given a proper premium to offset anticipated exchange rate changes. Accordingly, if the domestic currency is expected to depreciate, interest rates on assets denominated in terms of domestic currency will exceed those abroad by the expected rate of depreciation. That relationship is expressed in (18) where i is the domestic interest rate, i^f is the given world rate of interest, and $E(\dot{e})$ is the expected rate of depreciation of the domestic currency. The equilibrium on the international capital market is represented by the following arbitrage condition:

$$i = i^f + E(\dot{e})\,. \tag{18}$$

The hypothesis on the expectations formation distinguishes between the long-run exchange rate, to which the economy will ultimately converge, and the current exchange rate. Denoting the logarithms of the current and long-run rate by e and $\bar{e}$, respectively, we assume with Dornbusch (1976, p. 1163) that

$$E(\dot{e}) = \varepsilon(\bar{e} - e)\,, \tag{19}$$

where ε is the coefficient of adjustment, taken as a parameter. As Dornbusch (1976, pp. 1167 ff.) demonstrated this adaptive expectation mechanism is consistent also with perfect foresight.

Taking into consideration two overshooting mechanism, one on the stock market and one on the international capital market, we are confronted with two exogenous, long-run

interest rates, i^* the long-run domestic interest rate and i^f the long-run world interest rate. We therefore assume that both are identical, $i^* = i^f$.

Goods Market

Equation (7) representing aggregate demand on the goods market for the closed economy case is now extended by the influence of real exchange rates on net-exports. This makes the model one of an open economy:

$$y^d = \rho(e - p) + \delta(p^{sm} - p) + \gamma\bar{y} + g - \sigma i \,. \tag{20}$$

The demand for domestic output depends now also on the relative price of domestic goods, $e - p$, also called the real rate of depreciation[13].

4.2 Simulations

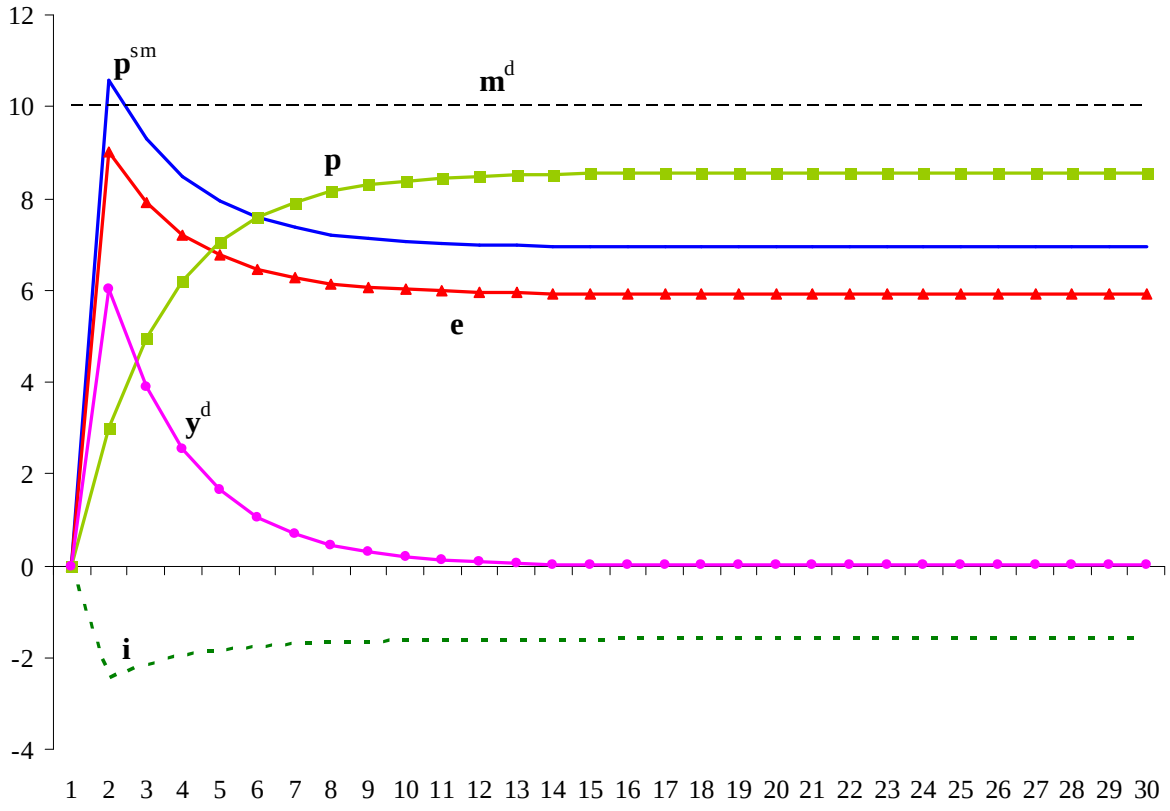
In addition to the chosen parameters of the stock market overshooting model for the closed economy in section (3.5) we have two new parameters which we calibrate with: $\rho = 0.3$ and $\varepsilon = 0.27$. The adjustment parameter in the error correction mechanism on the stock market is slightly changed to: $\theta = 0.23$. The model is then solved again with Eviews 6.0 by solving the money demand equation (3) for the current domestic interest rate (i). The stock market equations (1) and (2) are solved for the current stock market price (p^{sm}) as before. And the equations (18) and (19), representing the equilibrium on the international capital market, is solved for the exchange rate e . At the outset all variables are assumed to be in equilibrium and, hence they are deviations of the actual values from their equilibrium values, are therefore all zero. The results of the model simulations are presented in Figure 7.

A 10% increase in the supply of money m^d immediately leads to a decline in interest rates (i). In this model version, taking two overshooting mechanism into account, the interest rate effect is smaller than in the model for the closed economy. As expected from the theoretical model stock market prices p^{sm} overshoot, i.e. they increase more than by 10%. However, according to our calibration, the increase of the exchange rate (the depreciation) is smaller than the increase in money supply, implying that there is no true overshooting effect in the international capital market. This, however, depends only on the parameter constellation chosen. A double-overshooting effect is not impossible in this model context. The boom on the stock market and the real depreciation leads to a boom in the demand of

[13] The complete relative price argument in this equation is ($e + p^* - p$) where p^* is the logarithm of the foreign price level. Setting the foreign price level equal to unity implies that $p^* = 0$.

domestic goods. Real GDP (y^d) jumps over its potential long-run values and creates a business cycle upswing. Only slowly, goods market prices (p) adjust and bring the goods market into equilibrium, i.e. real GDP shrinks. The inherent correction mechanism for stock market prices and the expectation formation mechanism for the exchange rates lead to an adjustment of the stock market prices and exchange rates down to their long-run values. In the long-run all four markets converge to their equilibrium values.

Figure 7: Simulated Stock Market and Exchange Rate Overshooting Model: Open Economy



5. The Overshooting Model with International Spillovers

The stock market and exchange rate overshooting model can also be used to study the spillovers in a two-country setting. Here we assume that in the large economy, in the United States the monetary shock (e.g. in the Greenspan period) occurs and that it has spill-overs to the small country Austria. Stock market prices in the USA are represented by the Dow Jones Industrial index (DJI) and in Austria by the ATX. The model has links via goods trade and via the international capital markets in the tradition of the two-country Mundell-Fleming model.

5.1 A Two-country Model

The international capital market and the spill-over mechanism of the exchange rate is the same as in the previous section. The only exception is that the foreign interest rate is no longer fixed but determined endogenously within the model context of both countries. The stock market overshooting mechanisms are the same as before with the assumption that in both countries the stock market prices, after the overshooting following a monetary policy shock, adjust to their respective long-run values. The assumed long-run interest rates may differ from country to country, but are assumed as deviations from the equilibrium, and are, therefore zero.

Goods Market

The equation (20) representing aggregate demand on the goods market for the closed economy case is now extended by the spill-over effects as follows. In home we have:

$$y^d = \rho(e-p) + \delta(p^{sm} - p) + \gamma\bar{y} + g - \sigma i + \eta_1 y_f^d, \tag{20a}$$

And in foreign, we define the aggregated demand function with spill-overs as

$$y_f^d = -\rho(e-p_f) + \delta(p_f^{sm} - p_f) + \gamma\bar{y}_f + g_f - \sigma i_f + \eta_2 y^d \tag{20b}$$

The demand for domestic output in home is now also influenced by the demand in foreign, y_f^d. When assuming two countries of different size, one can calibrate the spill-over parameter, η with different values.

The rate of increase in the price of domestic goods, $\dot{p}$, described in (2) is adjusted for price spillovers from abroad as follows. For home (the large country):

$$\dot{p} = \pi(y^d - \bar{y}) + \beta_1(p_f + e) \tag{21a}$$

and for foreign (the small country):

$$\dot{p}_f = \pi(y_f^d - \bar{y}_f) + \beta_2(p - e). \tag{21b}$$

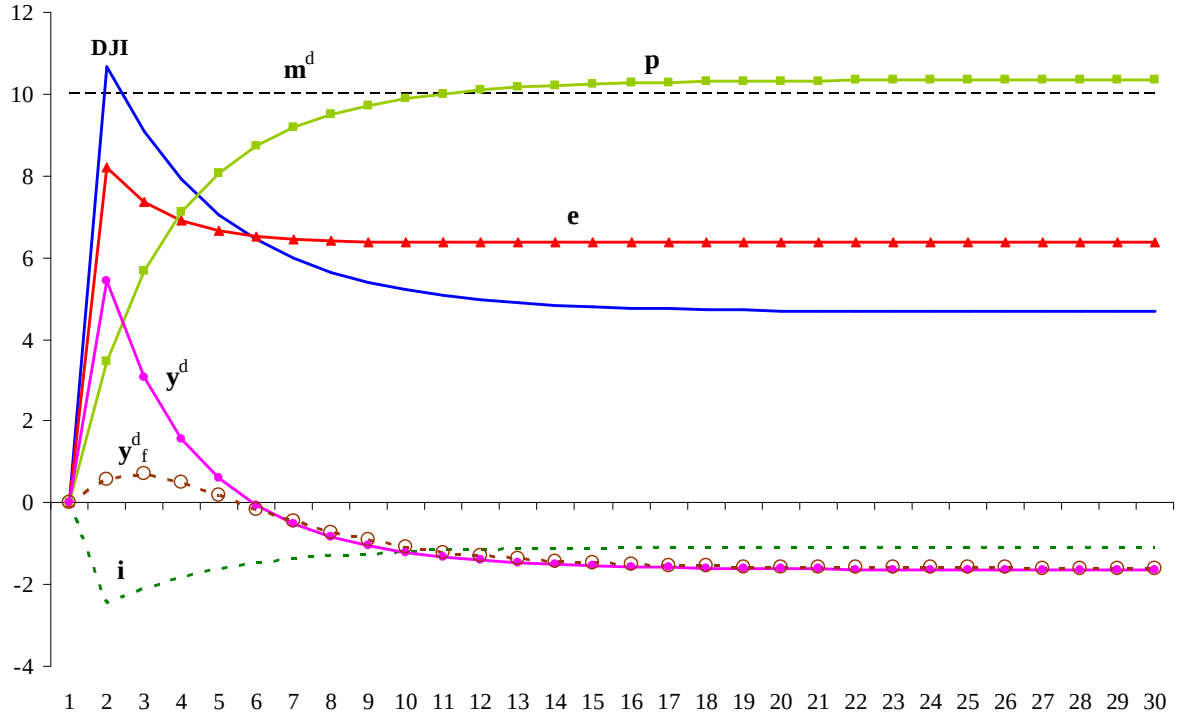
In both countries imported prices, corrected for the exchange rate changes influence also the development of domestic prices[14]. The parameter β may in a two-country case with asymmetric country sizes differ from each other in the same way as the spill-over parameter in the equation for aggregate demand of domestic goods.

[14] With this usual model specification we consider also the transmission of world raw material prices from one country to the other. According to Schulmeister (2009) the huge boom in world raw material and oil prices up to the middle of 2008 was the forerunner of the present global economic crisis.

5.2 Simulations

The parameterisation is the same for both countries as in sections 3.5 and 4.2. In order to capture the different size of both countries (home = large = U.S.; foreign = small = Austria), the spillovers coefficients in the price and goods demand equations are calibrated differently: $\beta_1 = \eta_1 = 0.10$ and $\beta_2 = \eta_2 = 0.20$.

Figure 8a: Simulated Stock Market and Exchange Rate Overshooting Model with spill-overs: USA

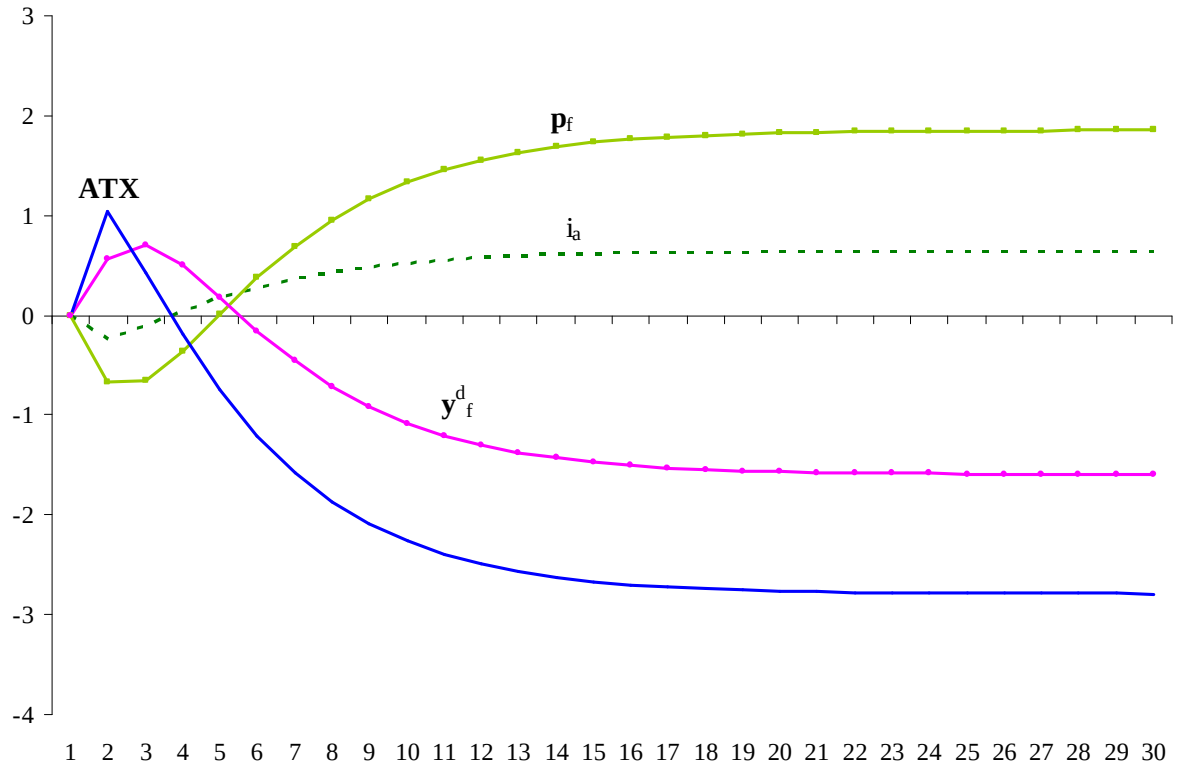


DJI = Dow Jones Industrial = stock market price (P^{sm}) in USA; Y^d_f = real GDP development in Austria.

A 10% increase in the supply of money M^d immediately leads to a decline in interest rates (i) in home (U.S.; see Figure 8a). In the very short-run this spills over also to the small foreign country (Austria; see Figure 8b). As expected from the theoretical model stock market prices p^{sm} overshoot, i.e. they increase more than by 10%. Also the exchange rate increases, i.e. home depreciates. Increases of share prices and depreciation of the exchange rate (USD/€) creates a boom in home. Share price and output increases spill also over to foreign, but only in the short-run. In the medium and long-run the appreciation of the € dominates the income effects stemming from home and, hence output and share prices start to decline. Parallel to this development interest rates increase in foreign, adding to the decline in output and share prices (see Figure 8b). In home as well as in foreign the break of the bubble on the stock

market (the correction of stock market price overshooting) leads to a recession in the real economy ($y^d < \bar{y}$).

Figure 8b: Simulated Stock Market and Exchange Rate Overshooting Model with spill-overs: Austria



ATX = stock market price (p^{sm}) in Austria.

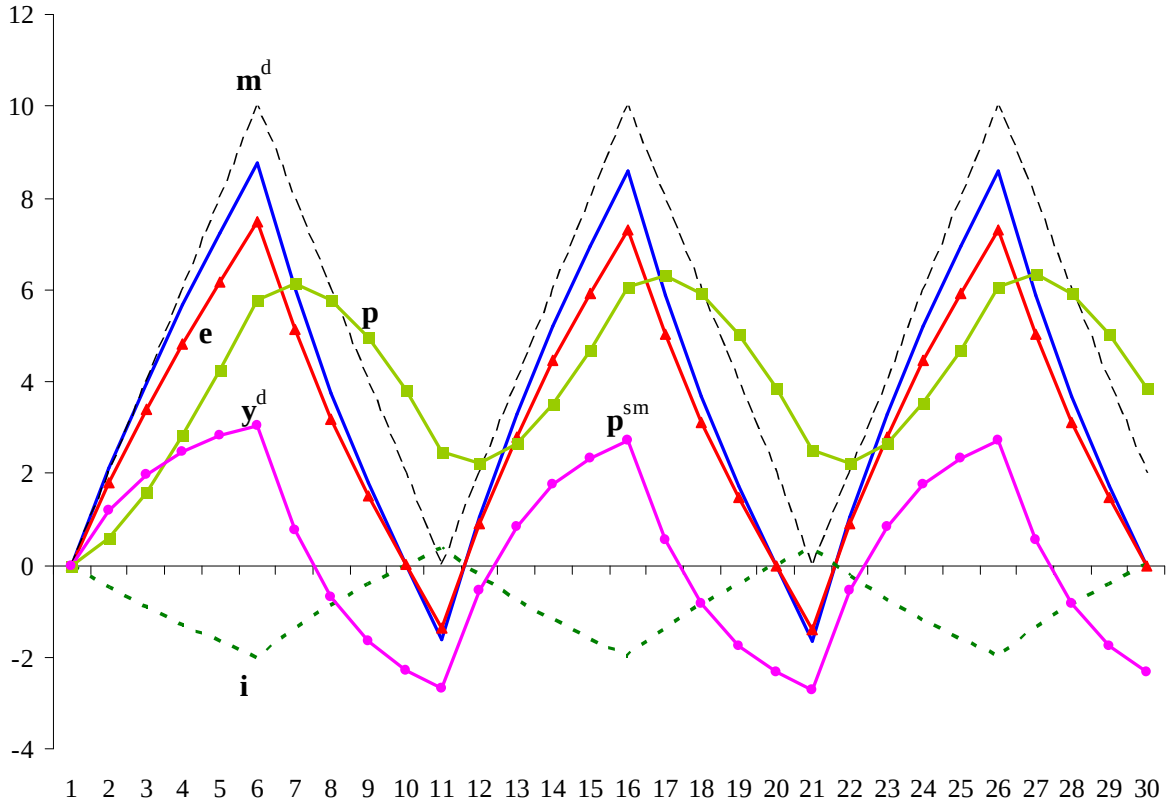
6. Boom-Bust Cycles in the Stock Market Overshooting Model

If our overshooting model is able to roughly capture the major features of the development leading to the present financial crisis it should also be able to predicting the future outcome of the present recession/depression following the deepest financial crisis since the Great Depression of 1929.

Whereas Greenspan could be blamed of having ignited the financial overshooting via its too easy monetary policy during 2002-2005, the present massive flooding of the economy by the Fed and other National Banks around the globe could lead to the next overshooting in stock markets. This would then be to blame to Bernanke, the present president of the Federal Reserve Board of the United States. However, as the theoretically calculated Taylor rule would indicate even “negative” interest rates in 2009 (see Figure 3; footnote) the US monetary policy should be even more expansionary given the grim forecasts for GDP and inflation. So the “quantitative easing” in addition to the near-zero interest rate policy by

Bernanke is adequate to counter the present crisis, also in the light of the Talyor rule philosophy.

Figure 9: Boom-bust Cycles caused by ups and downs in monetary policy



Anyhow, the up and down of monetary policy reaction (see Figure 4) can lead to boom and bust credit and also economic cycles[15]. This is demonstrated with our model via simulations in Figure 9. The definitions of the variables are the same as in the previous experiments.

Monetary overheating leads to the overshooting phenomena in the stock market and exchange rates and to an economic upswing. A following monetary restraint leads to the contrary, namely eventually to a recession ($y^d < \bar{y}$). Parallel to the boom-bust cycles our model also replicates the usual cycles in prices following business cycle fluctuations.

[15] For the explanations of boom-bust cycles, see also Tornell and Westermann (2002).

7. Conclusions

Inspired by Dornbusch's model of exchange rate overshooting we developed a theory of stock market behaviour. The idea is that stock market prices overshoot and undershoot their long-run equilibrium values which are determined by the development in the real economy. The overshooting is fuelled primarily by a loose monetary policy. The simple macro model consists of three markets – the money market, the stock market and the goods market – interacting with different speeds of adjustment. The goods market slowly adjusts relative to the money and the asset market. This model can explain some of the major features of the global financial crisis, having its origin in the loose monetary policy in the United States and spreading its recession-plagued effects all over to the world economy. The model focuses primarily on the monetary interpretation of the present crisis leaving aside the complex interactions of the real estate bubble in the USA, followed by the innovation of new financial instruments which were sold all over the world, hoping to disperse the risks involved with it. Nor does this model deal with the institutional aspects of the financial crisis (the failed behaviour of banks, the banking crises, unregulated financial markets etc.). These are questions of better international regulation of the financial industry touched upon by the G20 summit in London.

The hopeless race of forecasters to capture the dramatic slump of the real economy around the globe since mid 2008 indicates that we are still working with nice-weather macro economic models, i.e. with wrong models. In order to understand the global turbulences following the financial crisis a new crisis macro economics is needed. Our simple model may help to deliver some insights into the complex interactions of monetary policy and the (greedy) behaviour of financial agents in the stock market and its consequences in the real economy.

8. References

Akerlof, G., and Shiller, R., *Animal Spirits*, Frankfurt am Main: Campus-Verlag, 2009.

Aschinger, G., „Eine Katastrophentheoretische Erklärung des Börsenkrachs 1987“ (https://www.unifr.ch/spc/UF/94avril/aschinger.html)

Aschinger, G., *Währungs- und Finanzkrisen: Entstehung, Analyse und Beurteilung aktueller Krisen*, München: Verlag Vahlen, 2001.

Bernanke, Ben S., “Nonmonetary Effects of the Financial Crisis in Propagation of the Great Depression”, *The American Economic Review*, Vol. 73 (3), June 1983, 257-276.

Breuss, F., *Monetäre Außenwirtschaft und Europäische Integration*, Frankfurt am Main: Peter Lang – Europäischer Verlag der Wissenschaften, 2006.

Chiang, A.C., *Fundamental Methods of Mathematical Economics*, 3rd Ed., Singapore: McGraw-Hill, 1984.

Christiano, L., Motto, R., Rostagno, M., “The Great Depression and the Friedman-Schwartz Hypothesis”, Federal Reserve Bank of Cleveland, Working Paper 03-18, January 2004 (ECB Working Paper No 326, March 2004).

Dornbusch, R., „Expectations and Exchange Rate Dynamics“, *Journal of Political Economy*, Vol. 84, No. 6, December 1976, 1161-1176.

Fisher, I., *The Theory of Interest*, New York: The Macmillan Co., 1930.

Flood, R.P., Garber, P.M. „Collapsing Exchange-Rate Regimes: Some linear examples“, *Journal of International Economics*, Vol. 17, 1984, S. 1-13.

Friedman, M. and Schwartz, A. J., *A Monetary History of the United States, 1867-1960.* Princeton: Princeton University Press (for the National Bureau of Economic Research), 1963.

Galbraith, J. K., *Der Große Crash 1929: Ursachen, Verlauf, Folgen*, München: Finanzbuch-Verlag, 2008 (The Great Crash 1929, Boston: Houghton Mifflin Co., 1954).

Gärtner, M., Lutz, M., *Makroökonomik flexibler und fester Wechselkurse*, 3. Auflage, Berlin-Heidelberg-New York: Springer-Verlag, 2004.

G20 (Group of Twenty), London Summit – Leaders’ Statement, London, 2 April 2009.

Hahn, F.R., “A Primer on Financial System Meltdown: The Economists’ View”, WIFO Working Papers, No. 333, December 2008.

IMF, *World Economic Outlook*, Washington, April 2009.

Jeanne, O., „Are currency crises self-fulfilling? A test“, *Journal of International Economics*, Vol. 43, Nos. ¾, November 1997, S. 263-286.

Kindleberger Ch. P., *Die Weltwirtschaftskrise 1929-1939*, Geschichte der Weltwirtschaft im 20. Jahrhundert, Band 4, München: dtv Wissenschaftliche Reihe, 1973

Krugman, P., „A Model of Balance-of-Payments Crises, *Journal of Money, Credit and Banking*, Vol. XI, No. 3, August 1979, 311-325.

Krugman, P., *Die neue Weltwirtschaftskrise*, Frankfurt am Main: Campus-Verlag, 2009 (*The Return of Depression Economics and the Crisis of 2008*, New York: Norton & Co, 2008).

NZZ, „Kein Ende des globalen Kapitalismus“, Neue Zürcher Zeitung, Zürich, Donnerstag, 9. April 2009, p. 13.

Obstfeld, M. „Rational and self-fulfilling balance of payments crises“, *The American Economic Review*, Vol. 76, 1986, 72-81.

Obstfeld, M. “Destabilizing effects of exchange rate escape clauses”, NBER Working Paper 3603, 1991.

Obstfeld, M., „Models of currency crises with self-fulfilling features“, *European Economic Review*, Vol. 40, 1996, 1037-1047.

Obstfeld, M., Rogoff, K., *Foundations of International Macroeconomics*, Cambridge, Mass.-London: The MIT Press, 1996, 558-566.
OECD, *Economic Outlook*, Paris, No. 2, Vol. 84, December 2008.
OECD (2009A), *Economic Outlook: Interim Report*, Paris, March 2009.
OECD (2009B), "Fiscal Packages across OECD countries: Overview and country details", Paris, 31 March 2009.
Rancière, R., Tornell, A., Westermann, "Systemic Crises and Growth", *The Quarterly Journal of Economics*, Vol. 123, Issue 1, February 2008, 359-406.
Reinhart, C.M., Rogoff, K.S., "This Time is Different: A Panoramic View of Eight Centuries of Financial Crises", University of Maryland and NBER, March 30, 2008.
Reinhart, C.M., Rogoff, K.S., "The Aftermath of Financial Crises", Paper presented at the American Economic Association meetings in San Francisco, Saturday, January 3, 2009.
Schulmeister, St., *Trading Practices and Price Dynamics in Commodity Markets and the Stabilising Effects of a Transaction Tax*, Vienna: Wifo Study, January 2009.
Taylor, J.B., "The Financial Crisis and the Policy Reponses: An empirical analysis of what went wrong", NBER, Working Paper, No. 14631, January 2009.
The Economist, Economic focus: "Diagnosing Depression", January 3rd, 2009.
Thom, R., *Stabilité structurelle et morphogénèse*, New York: Benjamin, 1972.
Tornell, A., Westermann, F., "Boom-Bust Cycles: Facts and Explanations", *International Monetary Fund Staff Papers*, 49, 2002, 111-155.
Von Neumann, J., „ A Model of General Economic Equilibrium", *The Review of Economic Studies*, Vol. 13, No. 1, 1945-1946, 1-9 (first published in Germen under the title "Über ein Ökonomisches Gleichungssystem und eine Verallgemeinerung des Brouwerschen Fixpunktsatzes", in: Ergebnisse eines Mathematischen Seminars, edited by Karl Menger, Wien, 1938).
Zeeman, E.C., „On the unstable behaviour of stock exchanges", *Journal of Mathematical Economics*, Vol. 1, Issue 1, March 1974, 39-49.

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