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Speculative bubbles in precious metal markets – a suggestive model inspired by the 1986 platinum price development

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The standard rational expectations speculative bubble model is combined with a special technical feature of the New York Mercantile Exchange in order to account for some aspects of the highly irregular platinum price movements during the third quarter of 1986.

1. Introduction

In the third quarter of 1986, gold and platinum markets showed a high degree of irregularity which was very difficult, if not impossible, to explain by shifts in demand and supply schedules alone. Such developments are not uncommon in precious metal markets. The usual explanation, at least in some business journal's columns, is a shift in expected future supply or demand, the so-called 'market fundamentals'[1]. Let's have a closer look at the 1986 upsurge in the platinum market where the price for, e.g., October delivery on the New York Mercantile Exchange has soared from around $ 440 an ounce during most of July to well over $ 670 an ounce in September.

If there really was a shift in market fundamentals, at least its geographical source was, according to the Financial Times, unequivocal: "The only reason behind the increase – the highest since the metal markets boom of 1980 - 81 – is concern about the political factor of South Africa, the dominant supplier" (9. 8. 86). Nevertheless, while there was definitely no civil unrest giving rise to fears of a closure of platinum mines, there was no good reason either to expect a voluntary export cut. To quote again: "South Africa has responded to the external sanctions threat with hints of sanctions of its own ... the trouble is ... if, for example, platinum exports were stopped South Africa would lose over $ 1 bn in export revenues this year, equivalent to about two fifths of the postulated current account surplus" (Financial Times, 7. 8. 86). So, if there were no genuine fundamental news, what was the reason behind those price increases?

At first sight a general non-zero martingale solution, a kind of Cinderella in economic theory, of a forward looking rational expectations model seems

[1] For this terminology see, e.g., *Flood / Garber* (1980).

to provide the answer[2]. However, the price bubbles arising from such models suffer from a serious flaw: the typical theoretical bubble may survive for extented periods while real bubbles, if they are rational at all, tend to be rather short-lived. It is here where a crucial feature of the New York Mercantile Exchange comes in. Once the model is modified, as will be done below, to reflect the maximum daily fluctuation margin for platinum futures its solution turns out to parallel the basic aspects of real price movements in August and September 1986 remarkably well.

2. The basic model

Demand and supply of a precious metal (e.g. platinum), denoted by x_t^d and x_t^s respectively, are linear functions of today's price p_t, with supply additionally dependent on the mathematical expectation of tomorrow's price, $E_t(p_{t+1})$. Assuming normal reactions we obtain

$$x_t^d = a - b \cdot p_t \tag{1}$$

$$x_t^s = c + d \cdot p_t - e \cdot E_t(p_{t+1}),$$

with all coefficients being positive and $a > c$ in order to have a meaningful solution. For simplification we omit any error terms. As there are no time-dependent terms other than price and expected price the possibility of an exogenous shift in either the demand or the supply schedule is excluded.

Computing equilibrium gives the reduced form

$$p_t = \alpha \cdot E_t(p_{t+1}) + z \tag{2}$$

$$\text{with } \alpha = \frac{e}{b+d} \text{ and } z = \frac{a-c}{b+d}.$$

We assume $\alpha < 1$ as this is equivalent to a normal reaction of excess demand with respect to an equal change in both the price and expected price.

The general solution of (2) is given by

$$p_t = \frac{z}{1-\alpha} + \left(\frac{1}{\alpha}\right)^t \cdot M_t, \tag{3}$$

where M_t is an arbitrary martingale, i.e. for any $s > t$ we have $E_t(M_s) = M_t$[3]. Due to the bubble term this is supercountable. Remember that, e.g., any constant sequence of real numbers already is a martingale.

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[2] For a first example in asset market models see *Blanchard* (1979).

[3] For an interpretation of this solution in terms of first-order difference equations see *Gourieroux / Laffont / Monfort* (1982).

Usually, especially in macroeconomic applications, all non-zero martingales, the so-called 'speculative bubbles' or 'sunspots', are ruled out, practically by definition. This happens for several reasons. First, non-uniqueness of the solution set is generally, at least in economic theory, regarded as a rather unpleasant thing. Second, in the case of $\alpha < 1$ which is given here non-zero martingales lead to explosive behaviour of the (expected) solution. And third, by admitting non-zero martingales the solution of the reduced form (2) includes a variable not contained in the structural form (1).

This last point, however, does by no means imply any misspecification of (1). It simply opens the possibility of self-fulfilling expectations within a perfectly rational model. To quote Brian Nathan, managing director of the London platinum marketing company Ayrton Metals: "But there's an element of hype in all this" (Financial Times, 23. 8. 86). It is exactly this non-market fundamentals aspect which is modelled by the martingale solution.

Refering to the second point, once M_t takes a positive value the price can be expected to jump beyond any bound at some point in time. Yet, it did not happen. Why?

3. The daily upper limit

A special feature of the New York platinum market is the existence of an daily upper limit for price movements in relation to the previous day's closing price. Usually this is set at \$ 25 per ounce, though it can be altered in extraordinary circumstances. This happened, e.g., on September 11 and September 12, 1986, when the limit was extended to \$ 37.50 and \$ 50, respectively, to ease some pressure off the fourth consecutive limit-down movement that week.

Adding this restriction to the model, we have to distinguish between the unchecked (but not necessarily observable) equilibrium price p_t, given by (3), and the actual price p_t^*. They differ if and only if the movement is checked by the daily upper limit. They relate as follows

$$p_t^* = \operatorname{med}(p_{t-1}^* - s, p_t, p_{t-1}^* + s), \tag{4}$$

where med $(\cdot, \cdot, \cdot)$ denotes the median value of any three numbers and s is the upper limit. This implies a modified general solution

$$p_t^* = \operatorname{med}\left(p_{t-1}^* - s,\ \frac{z}{1-\alpha} + \left(\frac{1}{\alpha}\right)^t \cdot M_t,\ p_{t-1}^* + s\right). \tag{5}$$

A typical speculative price bubble not related to any change in market fundamentals then might look as follows: After a period of constant prices given by the first term in (3) – remember that for simplicity we have excluded stochastic error terms and assumed constant market fundamentals – prices will accelerate upwards once the martingale takes a positive value. Provided there is just this one change of the martingale's value for some time, the growth will be exponential until the daily upper limit of s is reached. After that the daily price increase will be equal to s. Assuming the probability of the bubble to burst to be an increasing function of the difference between equilibrium and actual price, the martingale will eventually return to zero. Moreover, the necessity of some larger values becoming more probable in order to satisfy the martingale property $E_t(M_{t+1}) = M_t$ will shorten the bubble's life even further, as any larger realization of the martingale is going to widen the gap between the then valid equilibrium price and the actual price. The latter's movement is restricted by the daily limit anyway. Once the martingale returns to zero the same daily limit prevents the prices from collapsing from one day to the other with a loud bang. In fact, the downward movement is only allowed to take place in consecutive steps equal to s until the market fundamentals solution will finally be reached again. This theoretical movement is shown in figure 1. The corresponding parameter values used for this illustrative exposition are $z = 47$, $\alpha = 0.5$, $M_t = 1/64$, $6 \leq t \leq 12$, and 0 otherwise. The binding daily upper limit of $s = 25$ is indicated by the horizontal grid lines.

We now compare this to the actual price movement during August and September 1986 which is depicted in figure 2. In fact, we consider daily clos-

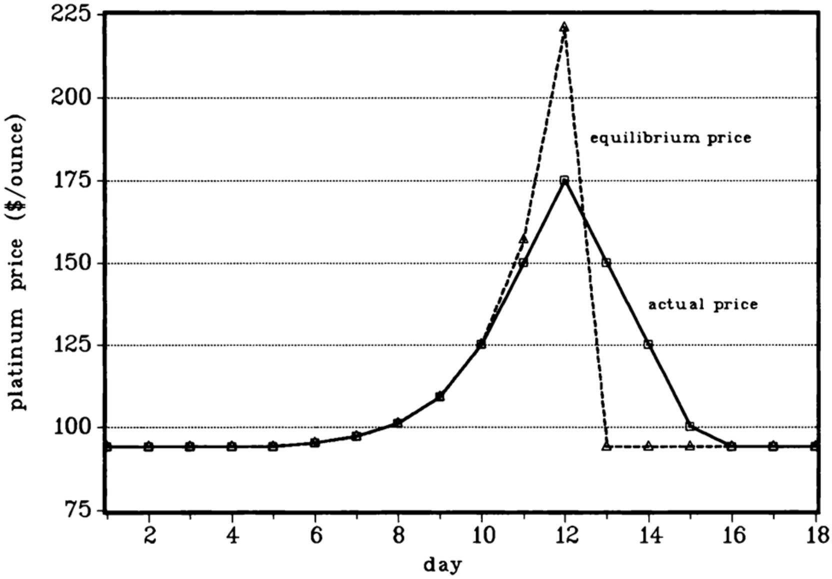

Figure 1

ing prices per ounce for October delivery on the New York Mercantile Exchange.

The steady upward trend lasting since the beginning of July gained real momentum during the first week in August to reach the daily upper limit of \$ 25 on friday, August 8, and monday, August 11. After hovering around the \$ 535 – \$ 545 range for some days the price accelerated on August 20 to reach the limit as early as next day and, following some minor ups and downs including several five-years highs, again on September 2. It peaked on friday, September 5, closing at \$ 677.70, to reverse completely on the following week, when, as already mentioned above, the platinum price rallied down reaching the corresponding downward limit on four consecutive days, even though this was raised twice that week. The hype had almost disappeared. Despite one final surge on September 19 and 22, the overall downward trend couldn't be reserved. At the end of the month platinum finished some 20 per cent below its peak, almost exactly where it traded seven weeks ago.

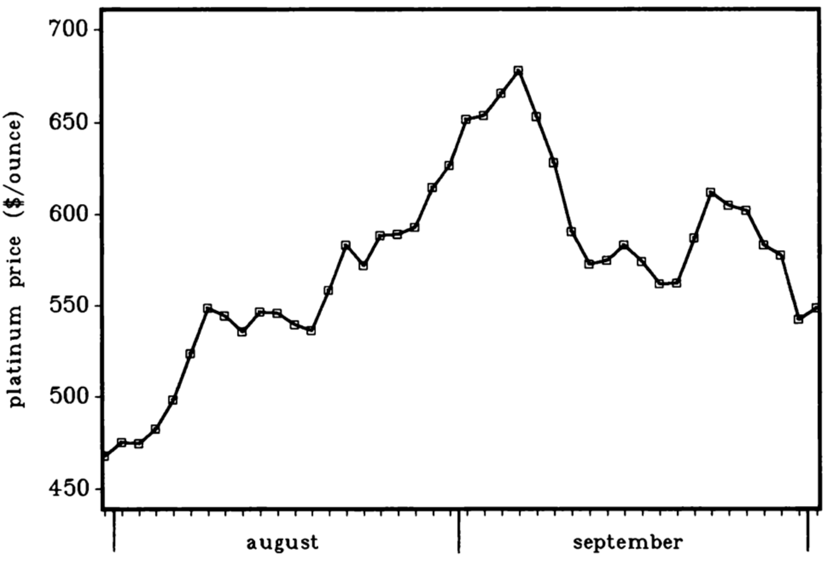

Figure 2

4. Correcting and concluding remarks

Of course this is far too simple to make up the whole story. The realization of the martingale we considered in section 3 has further implications. Should the daily limit have been reached once, it should be reached on each consecutive day as long as the increase continues. It was not. Once the hype has disappeared the reverse should be true: on each day the price should finish at the corresponding downward limits. Neither did that happen. There are several possible reasons. First, we excluded stochastic error terms. Second, there are some markets, e.g. the London Metal Exchange, without such technical upper limits. Consequently, arbitrage at least seems to be possible. Third, the realization of the martingale we considered is a rather simple one. Thus, only a rather simple price movement could be expected, as well. Finally, admitting the possibility of any shift in market fundamentals other than the one discussed in the introduction would have implied a far more complicated solution path than the one in figure 1.

Nevertheless, there are some conclusions to be drawn. Martingales, which are the very origin for non-uniqueness in rational expectations models anyway and therefore are usually excluded in many economic applications, prove to be the only way to incorporate the element of hype not contained in the structural form, i.e. the market fundamentals side of the model, into a nevertheless perfectly rational solution. When confronted with the actual movement of platinum prices they are able to account for some of its rather strange characteristics and provide an intentionally simple but fairly illustrative overall view.

To complete the picture, much empirical work remains to be done. This includes analysing market fundamentals as well as testing for the existence of martingales. The rather general form of martingales, however, still poses the most difficult problem. After all, who can claim to know the specific mathematical form of a 'hype'?

Nonetheless, a lot of empirical studies have been conducted in different fields of applications. These include hyperinflation bubbles (*Flood / Garber* 1980; *Burmeister / Wall* 1982; *Flood / Garber / Scott* 1984), exchange rate bubbles (*Woo* 1984; *Okina* 1985; *Meese* 1986) and stock price bubbles (*West* 1987). The two basic problems remain the same. The intrinsic values determining the market fundamentals can usually not be observed by the econometrician and could, thus, falsely indicate the presence of a bubble which, in reality, is a temporary shift in market fundamentals. Second, the particular form of the bubble has to be specified in advance with no theory whatsoever available to justify this very specification, or the researcher, including the author of the present paper, runs some risk of exposing himself to the accusation of 'data mining'. Diagnostic tests of the type proposed by *Blanchard / Watson* (1982) and *Evans* (1986) are far from being an effective remedy as their power is rather limited. Even longer running bubbles may quite often remain undetected resulting in a rather high probability of Type II errors. Short-lived bubbles are practically unobservable.

Finally, despite the explanatory power of martingale solutions, we should keep in mind that hypes make markets look quite irrational. Maybe rightly so. Maybe they are irrational.

Summary

Allowing for stochastic martingale solutions within rational expectations models implies temporary rises and falls in prices without any change in market fundamentals. This is combined with a special feature of the New York Mercantile Exchange precious metal futures, the upper limit for daily price changes, to give an illustrative view of the rather irregular and seemingly irrational platinum price movements in the third quarter of 1986.

Zusammenfassung

Auf Edelmetallmärkten werden gelegentlich Preisentwicklungen beobachtet, die unter der Annahme rationaler Erwartungen in keinem Zusammenhang zu den zugrundeliegenden ökonomischen Fundamentaldaten stehen. Als Ausweg bieten sich stochastische Martingallösungen an. Dieser Ansatz wird in der vorliegenden Arbeit zur Erklärung der recht irregulären und scheinbar irrationalen Bewegungen des Platinpreises im dritten Quartal des Jahres 1986 herangezogen. Das Modell berücksichtigt insbesondere die maximal zulässige Schwankungsbreite für tägliche Preisänderungen, wie sie beispielsweise für Edelmetall-Termingeschäfte an der New York Mercantile Exchange vorgeschrieben ist.

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