THE FIRST BUBBLE

Silver mining in the Saxon Erzgebirge, c. 1470-1540

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Abstract

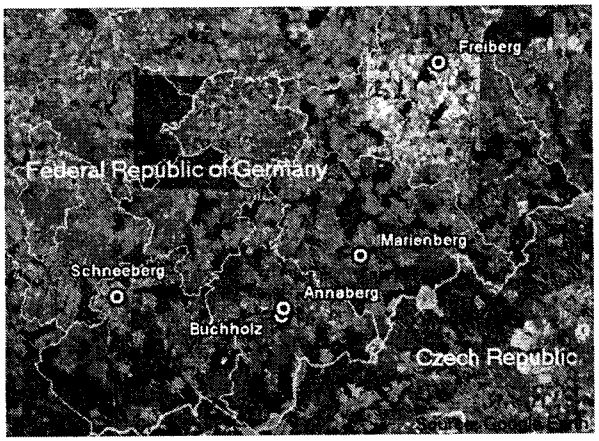
Since the trade in shares (*Kuxe*) in Saxon silver mines in Schneeberg, Annaberg and Marienberg from c. 1470 onwards shows essential characteristics of a speculative bubble, it can be designated as the first bubble whose existence can be demonstrated from the sources. The paper sketches the relevant structures of the Saxon mining industry at the cusp of the 15th century, sets out the criteria the literature regards as being crucial for demonstrating the existence of a speculative bubble and judges how well the trade in shares in Saxon silver mines fits the definition.

"The history of speculative bubbles begins roughly with the advent of newspapers ... Although the news media ... present themselves as detached observers of market events, they are themselves an integral part of those events" (Shiller (2005) 85)

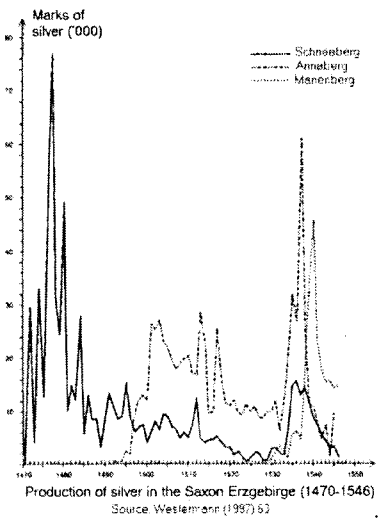
It is my contention that Shiller is wrong. Speculative bubbles occurred long before the advent of newspapers or published financial reporting, whose roots reach no farther back than the late 17th century (Neal (1988)). Since the trade in shares (*Kuxe*) in Saxon silver mines in Schneeberg, Annaberg and Marienberg from c. 1470 onwards shows essential characteristics of a speculative bubble, it can be designated as the first bubble whose existence can be demonstrated from the sources. In order to prove that this is so, I will first sketch the relevant structures of the Saxon mining industry at the cusp of the 15th century, then set out the criteria the literature regards as being crucial for demonstrating the existence of a speculative bubble[1] and (3) determine how well the trade in shares in Saxon silver mines fits the definition of a bubble.

THE SAXON MINING INDUSTRY

The history of silver mining in Saxony begins with the discovery of enormous deposits of silver ore in Freiberg in 1168 (Schirmer (2000) 7-8 with references to the older literature). Huge amounts of silver were extracted in the late 12th and 13th centuries, but by the 1390s the boom was over. However, Freiberg generated the legal framework for silver mining in Schneeberg, Annaberg-Buchholz and Marienberg, where massive silver deposits were discovered in 1470, 1492 and 1519 respectively (Laube (1974) 22-37). Over the next 80 years the amount of silver produced (Graph 1) constituted – together with the production of yet more silver by means of the saiger process (Graph 2) – the central cause of the Price Revolution at the beginning of the early modern era (Munro (2003)).

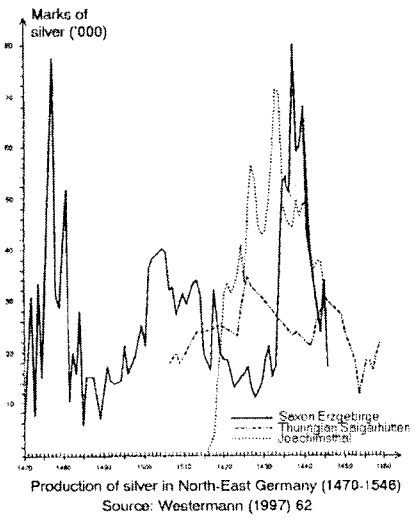


[1] I might as well state at the outset that I am not convinced by the Efficient Markets Hypothesis.



Production of silver in the Saxon Erzgebirge (1470-1546)
Source: Westermann (1997) 62

Graph 1



Production of silver in North-East Germany (1470-1546)
Source: Westermann (1997) 62

Graph 2

STRUCTURE OF THE SAXON MINING INDUSTRY

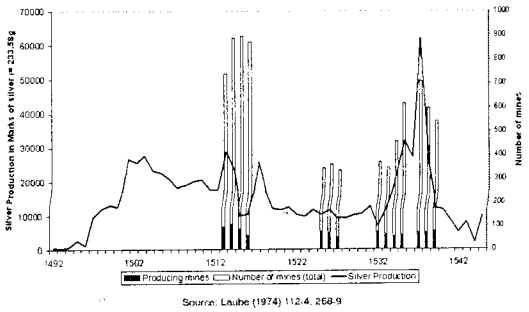
The structure of the Saxon mining industry was determined by two peculiarities. The first of these was geological. The geology of the Erzgebirge is extremely complex. As the result of volcanic eruptions and the cooling processes of magma, silver ore was found in individual pockets of varying size located in the cracks and pores of the bedrock (Laube (1974), 21-2 with references to the geological literature). Hence, no one could foresee where silver deposits might be found or estimate how large they might be once they had been found. Finding and extracting the ore thus depended upon a continuous stream of working capital. Worse yet, once the surface deposits (down to a depth of 50 meters) had been exhausted, water seepage became a serious problem. There were two solutions to this problem: the ground water was either lifted out in leather buckets attached to a paternoster chain driven by animal or water power (Ludwig, Schmidtchen (1997) 70-5, 219-24), or it was drained out by driving a tunnel into the mountain underneath the deepest pit. Both solutions, of course, required technical expertise and significant amounts of capital.

The solution the Saxon mining industry found to the problem of providing a continuous stream of working capital was one of the most wide-reaching financial innovations in European history. In dividing the ownership of each pit (which was an

independent corporation) into a number of shares, called *Kuxe*[2] – at first, there were four per pit, but the number quickly rose to 32 and finally 128 and fractions thereof as capital requirements exploded – the Saxon mining industry invented the public lending corporation. The owner of a *Kux* was entitled to 1/128th of all profits of the pit ('Ausbeute'), but was also liable for 1/128th of all running costs.[3] Since it was impossible to say in advance what costs might be incurred, *Kuxe* had no par value, but they could be bought and sold on the open market without informing the other investors or obtaining their approval (Dietrich (1958) 170). Moreover, since there was no limit on the number of pits whose *Kuxe* one could buy, an investor could spread his risks amongst a number of mines and continuously reconstitute his portfolio, dependent upon his own risk assessment and degree of risk aversion (Westermann (1997) 58). This capital structure had two important advantages for the Saxon mining industry as a whole. On the one hand, it provided a continuous stream of working capital for individual pits, as insolvent investors were replaced by those who could meet calls. On the other, it allowed investors to spread their risks and optimize their portfolios.

This is not to say that every investor got rich quick. In fact, most lost money, since the success of their investments depended upon the sheer good luck of discovering (large) deposits of silver ore. Most mines just chewed up working capital without producing any profits. The Nuremberg humanist Sebaldus Schreyer, for instance, invested 272 fl. in 15 shares in 11 pits in 1477, but had to meet calls for 85 to 95 fl. during the next eleven years, after which he sold all of his shares, which had not produced a single penny of profit (Werner (1970) 163 n. 215). Generally, only around 10-15% of all mines in a given area produced any silver at all. Graph 3, which shows the total number of (producing) mines and the total silver

Graph 3: Total Silver Production of Annaberg and Number of Mines



Source: Laube (1974) 112-4, 268-9

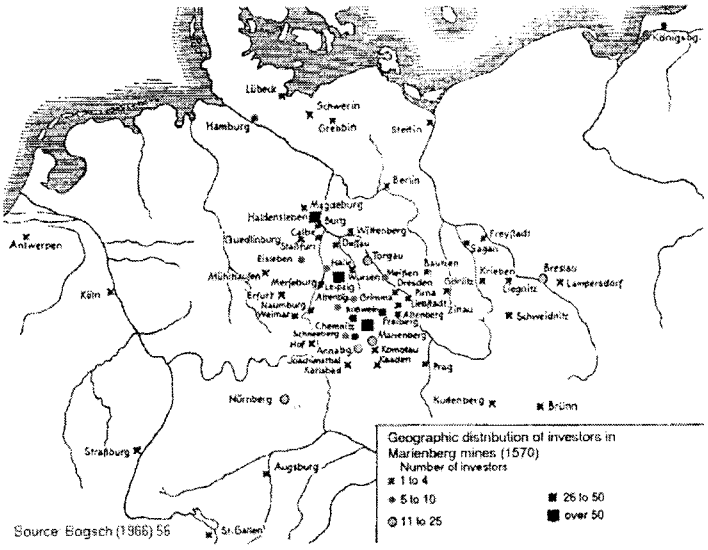
[2] *Kux* is derived from a Slavic word (*kukux* or *kus*), but there is no evidence whatsoever that it was used to mean 'share in a mining company' anywhere in the Slavic world. The *Kux* was unquestionably a financial innovation of the Saxon mining industry around 1450 (Westermann (1997) 57-8).

[3] Calls placed on investors were called 'Zubuße'. There was no limit on how many calls could be placed on investors in a given year or how much money could be demanded at any one time. If an investor could (or would) not pay, his shares reverted to the remaining owners who then could either decide to purchase them or sell them on to other investors (Dietrich (1958) 160, Hoppe (1908) 131-2, Helbig (1953) 88-9, Werner (1936) 133).

production of the mines in Annaberg, demonstrates this to a nicety. For the 14 years for which we have quarterly accounts in the early 16th century, an average of 16% of pits produced silver (median 14%; high 1525: 28%; low 1516: 7%). To put it in plain English: five of six investments failed to produce anything but calls.

Consequently, the market for *Kuxe* was extremely volatile, depending on the news emerging from the mining districts. Contemporaries were well aware that the market – centred on the international fairs of Frankfurt on the Main and Leipzig (Dietrich (1958), 171, Laube (1974), 106) – could go up or down in a matter of hours (Werner (1936) 134, Laube (1974) 84). Trading volume was considerable, to judge by the yearly turnover in investors in any given pit (Laube (1974) 88-91). Stockbrokers specializing in mining shares ('Kuxkrenzler') were active, some buying and selling on their own account (Werner (1936) 122), and at least one trading company was founded in Schneeberg sometime prior to 1478 with the sole purpose of buying and selling *Kuxe* (Hoppe (1908) 74-5, Werner (1936) 132). In this hothouse atmosphere, insider trading was rife (Werner (1936) 133). The market was awash with rumours, some true, others deceptive and specifically intended to manipulate prices (Werner (1936) 140-1, Dietrich (1958), 172-3).

One clear result of this activity was the broad geographic spread of investors. The map shows the origins of the investors in mines in Marienberg in 1570, but the spread of investors over most of Germany (even if Nuremberg, Augsburg and Leipzig led the pack) is a pattern typical of Saxon mining over the entire period (Werner (1969, 1970) passim). The second result of this intensive trading in mining shares was, it would seem, that new groups of investors entered the market. Not only merchants active in the metals trade, but also town councils (e.g. in Leipzig, Zwickau and Chemnitz), artisan guilds, journeymen, the clergy, the nobility (including the duke of Saxony himself) and even the philosophical



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faculty of the university of Leipzig were numbered amongst the owners of mining shares (Laube (1974) 125, 171-5, 181, Werner (1936) 123, Dietrich (1958) 161, Werner (1969) 217).

Suffice it to say that the capital structure of the Saxon mining industry – in combination with the uncertainty of profits and losses, itself a consequence of the complex geology of the mining districts – was conducive to the emergence of speculative bubbles.

The second factor which determined the structure of the Saxon mining industry was the heavy hand of the state. Alone amongst the seven electoral princes of the Empire, the duke of Saxony retained his regalian rights – guaranteed by the Golden Bull in 1356 (Fritz (1972) c. 8, 64-5) – to all precious metals found on his territories. Around 1440, these rights had evolved into the 'direction system',[4] which first of all meant that the duke of Saxony claimed 10% of all silver produced in the mining industry of the Erzgebirge, and exercised a monopoly right to purchase all silver at a price significantly below the going market rate.[5] No one was allowed to mine for precious metals in Saxony without having been enfiefed by the duke's officials, and ducal officials were responsible for all technical and managerial decisions regarding the mines as well as supervising all aspects of the smelting of the ores. Moreover, the duke promulgated all mining laws (*Bergrecht*), issued all regulations for the industry (*Bergordnungen*). His judges adjudicated all disputes involving mining claims and his officials (*Berggeschworene*) inspected the mines for maintenance of standards. The investors were thus limited to providing working capital for the day-to-day running of the mines.

How did the 'direction system' work in practice? The first principle was that anyone could prospect for precious metals ('Der Berg ist frei') without having to obtain the permission of the owner of the land in question.[6] However, miners had to apply to the *Bergmeister*[7] for permission to prospect ('Mutung'). After that was granted, the miners had 14 days to sink a shaft, whereupon the *Bergmeister* inspected the mine and

[4] For a detailed description see Laube (1974) 48-81, Schirmer (2000) 21-4.
[5] *Das silber gehort yn dy muncze czu Freiberg*, as the Freiberg mining law put it in the early 14th century (Ermisch (1886) 269).
[6] The landowner could, however, claim one *Kux* (which was exempt from calls) or four (the so-called 'Ackerteil') if he was prepared to meet the calls (Hoppe (1908) 56).
[7] In this section, the titles of all ducal officials are italicized.

measured the claim in order to make certain that it was not too close to other claims. On the following Wednesday, the miners were enfiefed with their claim by the *Bergmeister* in the presence of the duke's chief official in the district (*Hauptmann*) and their claim was entered in the 'Bergbuch' by the *Bergschreiber*. That was the signal for the miners to begin to scout around for capital. Normally, only very modest sums were required at this point, usually no more than 3 fl., since the initial payment did little more than demonstrate that the investors were in earnest. Once this working capital had been exhausted, the miners (the vassals) handed in a list of their investors (the 'Gewerke', known collectively as a 'Gewerkschaft') which was entered into the 'Gegenbuch' by the *Gegenschreiber*, which constituted proof of their collective ownership of the pit and their individual possession of *Kuxe*.[8] The investors elected two to four of their number as a steering committee and appointed a 'Schichtmeister' who was to supervise the work in no more than six pits (of which only two were allowed to be silver-producing). The 'Schichtmeister', whose appointment required the approval of the *Hauptmann* and the *Bergmeister*, was primarily a financial conduit between the investors and the mine workers. He was responsible for obtaining working capital from the investors in order to make all purchases necessary (wood for beams, lighting materials etc.) and to pay the wages of the mine workers. He was also required to account quarterly before the *Hauptmann*, the *Bergmeister* and other ducal officials, make calls on the investors as required and distribute the profits (if they amounted to more than 2 fl. per Kux, after deduction of enough working capital for three months). Since the investors were not usually resident anywhere near the mining districts, they also named a 'Verleger' – required to be resident in the mining district itself or in nearby Zwickau – to represent them and underwrite any calls[9] as well as distribute profits. Any silver the mine produced was smelted under the strict control of the duke's *Zehntner*, who was required to have all ores weighed at each stage of smelting, to calculate (together with the

[8] Originally, i.e. 1471-9, the *Gegenschreiber* was responsible for accounting for all ducal income from the Schneeberg mining district (parallel to the *Zehntner*), and it was the Schichtmeister – appointed by the investors to supervise four to six pits – who was responsible for maintaining the list of investors. However, since many of the Schichtmeister were unable to read and write, they hired schoolboys from Zwickau for the scribal work, which quickly proved unsatisfactory. From 1479 the *Gegenschreiber* was responsible for entering the names of the investors and keeping these lists up to date (Hoppe (1908) 52-3).

[9] Investors were notified of calls by the 'Verleger'. If they had not paid up within 14 days, the 'Schichtmeister' was required to inform the *Bergmeister*, who would contact them directly with an order to pay. If the investor still did not comply, his shares were said to be in 'Retardat'. The *Gegenschreiber* recorded this fact in his 'Gegenbuch' and the shares reverted to the 'Gewerkschaft'.

'Schichtmeister') the duke's tenth at the end of the process and credit the 'Schichtmeister' with the net proceeds (i.e. less the duke's tenth and the smelting fees). The actual payment of the investors in coin followed somewhat later, since the silver had to be minted. In practice, the investors (or their representative) were paid at one of the three Leipzig fairs, where public notice of profits was given.

Transferring shares was very simple and did not require the seller or the buyer to notify the other shareholders or obtain their permission. Either buyer and seller drew up a contract of sale (see Helbig (1953) 98-9 for a spot/forward contract) or the seller issued a simple receipt (Laube (1974) 106 quotes one). The transfer was completed by the cancellation of the name of the seller in the 'Gegenbuch' and the entry of the buyer's name,[10] at which point the *Gegenschreiber* issued a 'Gewährschein' certifying the name of the new owner which the purchaser presented to the 'Schichtmeister' for entry in his books. Once that had occurred, the purchaser was liable for all calls and entitled to his share of the profits.

Since each new mine (and each re-opening of a old mine which had been given up as worthless) represented an investment opportunity at least as enticing as the computer corporations floated in the dotcom bubble, investors were anxious to get in on the action. When, for instance, the Cologne merchant John Liblar sold two half-*Kuxe* in mines in the Schneeberg district to a group of punters from Cologne at the Frankfurt fair in the spring of 1477, they paid on the spot, but not in cash: payment was made in the form of 52 pieces of cloth of Arras and one ring valued at 12 fl., for a total of 260 fl. Delivery of the shares (presumably the 'Gewährschein') was to be made at the next Leipzig Easter fair or within the following six weeks 'without fail' (Helbig (1953) 98-9). Not only the form of payment suggests desperation on the part of the purchasers, but also the price: the same shares (Schächtlein, Hängende Kluft) were valued at a total of 150 fl. the same year (Hoppe (1908) 150), which meant that the purchasers overpaid by a considerable amount.

In short, fools and their money were soon parted. The kinds of fraud, chicanery and sharp practice which took place demonstrate how anxious purchasers were not to miss out on anything which might turn out to be profitable. They were enticed first of all by the augurative names given to the mines, which were worthy of the shadiest fly-by-night

real-estate developer in Boomtown USA after WWII: for instance, 'Hope' (Hoffnung), 'Certainty' (Gewißheit), 'Rich Mine' (Reiche Zeche), 'Rich Treasure' (Reicher Schatz) etc. in Schneeberg alone (Werner (1936) 136; see the list of pit names from 1477 in Hoppe (1908) 150-4). A host of other methods was used to take advantage of the desperation of prospective investors to get a piece of the action. Stockbrokers ('Kuxkrenzler') and existing investors spread misleading information about mines (Werner (1936) 140), showed ore samples to prospective buyers which were not taken from the mine whose shares were on offer (Dietrich (1958) 172) and sold shares in mines which either no longer were being worked or had never existed (Werner (1936) 141, Dietrich (1958) 173). Since share prices rose dramatically when ore was discovered and fell when the deposits were exhausted, the bedrock proved to be hard to work or large amounts of water seeped into the pits, share prices could also be manipulated to force existing investors to sell out. Consequently, insider trading was rife. If the 'Schichtmeister' was in cahoots with the insiders to separate the less solvent investors from their shares, the discovery of rich deposits would often enough be concealed from public knowledge, thus allowing the insiders to offer attractively high prices for shares in seemingly non-producing mines (Werner (1970) 155). If that didn't work, then the 'Schichtmeister' would issue a large call on the shareholders, forcing the less solvent to give up their shares, which the insiders then snapped up at bargain prices. The 'discovery' of rich deposits was then made public (Werner (1936) 141).[11]

There are some indications that prospective shareholders knew what was afoot and took measures to protect themselves against chicanery.[12] One contract, closed in 1479, allowed the purchaser to return the *Kuxe*, which he had purchased at 90 fl. apiece, to the seller if their value fell below 90 fl. during the following year (Hoppe (1908) 76). Another method of insuring oneself against fraudulent sellers was to stipulate that the seller had to meet all calls (for a contractually defined period of time) as long as the mine failed to turn a profit (Dietrich (1958) 161, Ermisch (1886) 370). Finally, sales

[10] In order to protect the rights of shareholders, no such entry was permitted to be made unless the seller or his accredited representative appeared before the *Gegenschreiber* (Ermisch (1886) 507 § 19).

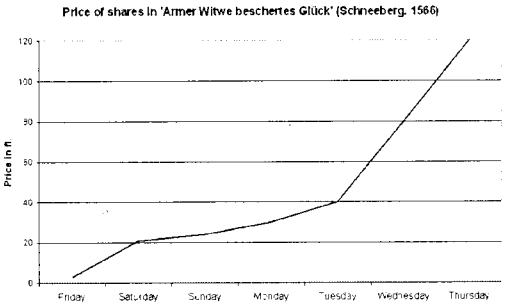
[11] Note that shares in *Retardat* had to be offered to existing shareholders before they could be sold on the open market (Werner (1936) 133).

[12] It is worth remarking in passing that these methods were intended to achieve the same aim as today's CDSs.

contracts could contain an escape clause which enabled the purchaser to void the contract but required him to pay the seller a modest fee (Helbig (1953) 96).[13]

While scholars are agreed that *Kuxe* were bought and sold speculatively (Laube (1974) 109, Werner (1936) 134), price information is not easy to come by. For some mining districts (and for a limited period of time), the chroniclers provide a rough-and-ready history of prices: In Schneeberg, for instance, share prices rose between 1471 and 1475 on the news of discoveries of silver ore, fell in 1476, only to rise again later in the year as new finds were announced. In the summer of 1479, water seepage led to a collapse of prices and a total of 3500 shares (out of a total of 30,216) were abandoned (11,58%) (Werner (1936) 137). Thereafter, however, prices rose and remained high until 1482 (Dietrich (1958) 170). We also have some reports of individual high prices. When, for instance, high-grade silver ore was found when a tunnel was driven into Mühlberg (Schneeberg), the *Kuxe* of the group around Martin Römer rose to a value of 1400 fl. (Werner (1936) 139). In 1478, Niklas Staude sold one *Kux* in the mine Überschar zu Unserer Lieben Frau (Schneeberg) to Nikolaus Töpfer of Nuremberg for 1150 fl. in cash (Laube (1974) 84).

We also have reports of dramatic rises in share prices. The town council of Leipzig bought *Kuxe* in the Alte Fundgrube (Schneeberg) in 1472 for 135½ fl. apiece. In 1478 these shares were valued (in order to raise a tax to build the church of St. Wolfgang: Werner (1936) 137) at 1600 fl. and were sold that year for 3000 fl. (Kroker (1909) 45). On 5 February 1546, one Paul Schmidt declined to buy a half *Kux* in Kaiser Heinrich (Marienberg) for 150 fl. because it seemed overpriced, but thought himself lucky to be able to buy it two weeks late for 163 fl. (Laube (1974) 106). The most dramatic documented price rise, however, involved the discovery of high-grade silver ore in the back garden of the widow of Lukas Schütz (in Schneeberg) in 1566. The price of the shares in the mine – appropriately named



[13] The fee in this case, which dated from 1477, was 100 fl. on a total purchase price of 1675 fl. The similarity to the *rouwkoop*, common at the time of the tulip mania in Holland in the 17th century (Goldgar (2007) 210), is striking, but no one seems to have undertaken a study to determine if the two phenomena are related.

'The poor widow's lucky strike' (Armer Witwe beschertes Glück) – rose forty-fold from 3 fl. to 120 fl. within a week (Laube (1974) 106).

Prices could – and did – fall as dramatically as they rose. Shares in St. Georg (Schneeberg) had been valued in 1477 at 2000 fl., but when the Leipzig town council bought some in 1486 they cost a mere 171 fl. (Kroker (1909) 46). Other shares in St. Georg were selling for 2000 fl. in 1480, but in the following year for no more than 200 fl., and shares in other pits found no buyers whatsoever (Dietrich (1958) 171).

Now, of course, it is normal for share prices to rise and fall. The fact that prices of shares in Saxon mining corporations rose and fell – sometimes dramatically – does not prove that their movements resulted from the build-up and bursting of a speculative bubble. Proponents of the Efficient Markets Hypothesis would be well within their rights to claim that purchasers of *Kuxe* – even the most desperate – were reacting to economic fundamentals, or at least thought they were doing so (Garber (2000)). There is nothing in the sources to disprove such a contention: the fact that things did not pan out does not, for adherents of the EMH, prove that punters were not reacting to fundamentals.

There are, however, one or two pieces of evidence which point in another direction. The Nuremberg humanist Sebald Schreyer – animated by pervasive rumours flying about everywhere (*ein groß mercklich geschrei und ruf, der weit und breit allenthalben erschollen*) – bought shares in eleven Schneeberg mines in 1477 against the advice of his parents and friends (Werner (1970) 163 n. 215). Irrational exuberance indeed, as Schreyer himself ruefully admitted later. The second piece of evidence that speculative bubbles developed in trading in Saxon mining corporation shares is the denunciation of the moralists.[14] No less an authority than the great reformer Martin Luther stated in no uncertain terms that ownership of mining shares was sure to beggar the wealthiest, and called out in 1544, 'I don't want to have anything to do with mining shares! They are play money, and play money does not increase in value' (Werner (1936) 134).[15]

SPECULATIVE BUBBLES IN ECONOMIC THEORY

[14] Indeed, I would claim that ex post denunciations of punters' greed constitute historical proof that a speculative bubble had burst. This certainly characterised the reaction to the South Sea Bubble in 1720 (Sperling (1962) 35, Chancellor (1999) 84-8), not to mention reactions in our own day.

[15] *Ich will kein kuks haben! Es ist spielgelt, und es will nicht wudeln* [gedeihen] *dasselbige gelt.*

It will not have escaped the attentive reader's notice that I am persuaded that speculative bubbles did develop during the Saxon mining boom (1470-1540). It is, however, time to test my conviction against current economic theory.

In the Minsky-Kindleberger synthesis, a bubble is a non-sustainable rise in the price of assets which is not explicable by economic fundamentals, in which purchases are often funded by credit and executed in order to capture short-term capital gains from rapid re-sale of the assets rather than long-term dividend income from holding them (Kindleberger (2005) 1, 9, 11, 21-32; see also Stiglitz (1990) 13, Shiller (2005) xviii, 32, Brown (2008) 3-5).[16]

This definition raises two problems: How is one to determine the fundamental value of an asset, and what mechanisms set off a speculative bubble?

The literature uses one of three measures to determine the fundamental value of an asset (usually the price of stock in a company)

- Equity q, calculated by dividing the total current market value of a stock by the net worth of the corporation at replacement cost. If the market is at fair value, this ratio should be 1 (Smithers (2009) 206, 67-79)
- Cyclically adjusted price-earnings ratio (CAPE), calculated by dividing the current value of a single stock by the average of dividends (earnings per stock) for the previous ten years. Dividing CAPE for any given year by its long-term average provides a measure of the ratio of stock market values to fair value (Smithers (2009) 203-4, 67-79)
- Present value of future dividends, calculated ex post on one of three assumptions: (a) a constant discount rate, (b) the individual yearly rates plus a constant risk premium and (c) an inferred discount rate based on aggregate per capita real consumption and an assumed risk aversion (Shiller (2005) 190-2, 263 n. 26)

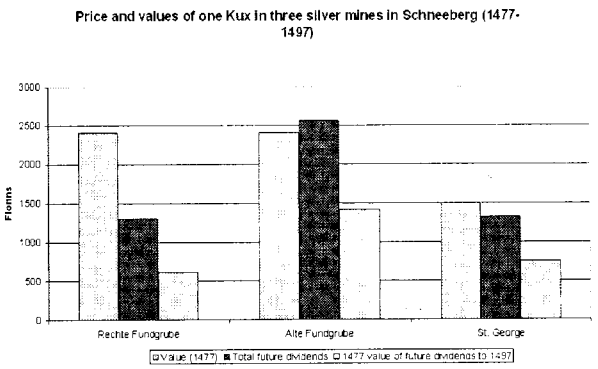
Are these models of any use in analyzing the price movements of shares in Saxon mines?

- Theoretically, one could calculate the original cost of an individual pit by summing the calls ('Zubußen') over time. However, since all our sources on calls stem from private or corporate investors, who tended to buy *Kuxe* in bundles,

[16] See also Dale (2005) 236-8 for a blessedly clear and succint taxonomy of speculative bubbles.

hold on to them for a period of years and then sell them on the open market (Kroker (1909) 45, Werner (1970) 163 n. 215), one would have to construct an interlocking series of records covering the entire operating life of the mine. No one has, to my knowledge, even attempted such a feat. Even if this were to be feasible, it would not yield the replacement value of the corporation,[17] even if one were to calculate the forward present-day value of the working capital sunk into the pit. Since price information is rare and replacement costs unknowable, calculating Equity q is impossible.

- While we do have some information on prices and considerably more on dividends, no one has yet produced yearly lists of prices and dividends for any given pit. Calculating CAPE is therefore not possible.
- Owing to the chance survival of accounts for the churches of St. Mary and St. Catharine in Zwickau (Hoppe (1908) 154-5)[18] we have a continuous dividend list for three Schneeberg pits (Rechte Fundgrube, Alte Fundgrube and St. Georg) during the period from 1476 to 1497. Since we furthermore have a list of the 'value' (not the market price) of all shares in Schneeberg mines in 1477 (Hoppe (1908) 150-4), we can roughly calculate the 1477 value of all dividends to 1497 (assuming a 5% discount rate) and compare that to the 'value' of the shares in 1477. As the graph shows, the 'value' of the shares in 1477 exceeded the 1477 present-day value of future dividends (to 1497) by 74.22%, 41.19% and 49.50% respectively. It seems reasonable to interpret this as a sign that the shares were over-valued in 1477.



[17] Among other things, the wood used to butress the shafts and tunnels had to be replaced every five or six years, implements like hammers wore out and had to be replaced and the tallow used for lighting was lost forever on use. Moreover, calls included labour costs. Hence, calculating the total working capital expended to a given date could not but diverge from the replacement cost of the pit at that date.

[18] These churches came into possession of shares since the 129th *Kux* in any pit was reserved to the local church (Werner (1936) 122).

What mechanisms set off a speculative bubble? The Minsky-Kindleberger synthesis observes first of all that speculative bubbles tend to emerge at the peak of the business and credit cycle, when lenders are most sanguine about the profitability of investments and entrepreneurs' risk aversion at its nadir. At this point, speculative displacement (the term was coined by Brown (2009) 7) can take place as the result of a shock – caused by new technology, financial innovation or political upheaval – and produce euphoria. If the shock is large enough, it obviates the prevailing world view – anticipated profit opportunities, level of risk aversion – and thus fundamentally alters expectations about the future of a particular sector or of the economy as a whole. As Brown points out (Brown (2009) 8-9) a learning process ensues, because the implications of the shock are initially unclear to lenders and borrowers alike. As they attempt to work out (by trial and error) just what the probabilities of income distribution and risk are in the new environment, some will inevitably be quicker off the mark than others and "begin to get excited about huge expected returns not yet perceived by their more conservative peers" (Brown (2009) 8). Since no one can be certain about the returns to be expected from any given asset and hence about its value, economic agents may overvalue fundamentals (thus initiating an intrinsic bubble) or impute asset-enhancing value to factors which in fact have no impact on fundamentals (thus initiating an extrinsic bubble) (Dale (2005) 236-7). If these agents find enough followers (who assume that these agents are making the right decisions on the basis of information not available to them), a stampede may result, in which the desire to capture short-term capital gains from the rapid re-sale of the assets begins to outweigh the desire for long-term dividend income from holding them. Outsiders begin to enter the market for these assets, enticed by the rapid rise in prices and – often enough – the low margin (i.e. low entry costs: cf. Zeira (1999) 251-2). Increasingly, they finance their acquisitions with credit and borrow yet more money for further purchases, using assets already purchased as collateral. The media contribute to the show by playing up prices and propagating 'New Era Thinking' (Shiller (2005) 90-3, 107-9).

How many of the characteristics of this model can we find in the market for Saxon mining shares?

- Business and credit cycle: The sources are so rare and disparate that we cannot begin to identify economic cycles.
- Speculative displacement by shock (new technology): This is a leading characteristic of Saxon mining. In particular, the technology employed to construct machines to extract ground water (Becherwerk, Bulgenkunst, Heinzenkunst) represented significant technological advances. Furthermore, the technology used to extract silver from ore (the saiger process, use of water power to drive bellows and crush ore) was first introduced on an industrial scale around 1461 (Westermann (1997)).
- Speculative displacement by shock (financial innovation): Also a leading characteristic of Saxon mining. Mining activities were financed by creating independent public lending corporations for each pit whose shares had a low initial price (3 fl.), were traded on the open market (e.g. on the Leipzig and Frankfurt fairs) and were easily transferable.
- Speculative displacement by shock (political upheaval): Political upheaval is so common during the period 1470 to 1540 (Reformation, Peasants' War etc.) and prices so rare that it is impossible to link the two.
- Overvaluation of fundamentals (intrinsic bubbles): The fundamentals were news of discovery of silver ore and dividend announcements (which drove prices up), news of manipulation of the purchase price of silver by the duke, exhaustion of silver ore in a pocket, hard bedrock and water seepage (which drove prices down). While the behaviour of shareholders in Saxon mines concords with Froot and Obstfeld's observation that prices tend to overreact to dividend announcements (Froot, Obstfeld (1991)), the argument that bubbles occur because fundamentals are overvalued begs the question, since a bubble is defined as the overvaluation of fundamentals by the market.
- Imputation of asset-enhancing value of irrelevant factors (extrinsic bubble): There is no evidence of this.
- Outsiders enter the market: This was characteristic of the market for Saxon mining shares: not only merchants invested, but also town councils, craft guilds, associations of journeymen, university faculties, members of the high nobility (including the duke himself) and the upper clergy. Among other things, investors

were enticed by low entry costs which occurred in two forms. On the one hand, the initial investment in a mine was modest (3 fl.), and on the other shares were sub-divided continuously, down to ¼ *Kux*. Moreover, most shares were not so expensive as to be beyond the reach of even modest investors.[19]

- Acquisition finance by credit: As far as I am aware, there is no evidence of purchase of Saxon mining shares on credit.
- Media (stories about prices, New Era Thinking): There were, of course, no newspapers in Germany at the cusp of the 15th century. Nor were they, in my view – pace Shiller – a necessary precondition for the development of speculative bubbles. Goldgar presents compelling evidence that speculative purchases of tulip bulbs in Holland (1636/7) were executed amongst friends and acquaintances, often enough fellow tradesmen or Mennonites, at dinner parties (Goldgar (2007) 131-9, 149, 171, 257), and Shiller himself points to the overarching importance of word of mouth – compared to all other forms of mass communication – in the context of present-day speculative bubbles (Shiller (2005) 162-3). The story of how Sebald Schreyer came to invest in mining shares in 1477 points in the same direction: he simply could not resist the *groß mercklich geschrei und ruf, der weit und breit allenthalben erschollen* (Werner (1970) 161 n. 215). The only difference the advent of newspapers and financial reporting made was to ease the historian's task of proving the existence of speculative bubbles.[20]

CONCLUSIONS AND CAVEATS

On the balance of the evidence, I am persuaded that speculative bubbles did develop in trading Saxon mining shares between 1470 and 1540, even if most of the details have not survived in the historical record.

It would, however, be intellectually dishonest not to point out the weaknesses of the evidence. In the absence of newspapers and other price currants, price series are

[19] In 1477, the average price of a *Kux* in a mine in the Schneeberg district was 26.14 fl. (calculated from Hoppe (1908) 150-4). At the same time, artisans were investing in rents sold by towns for many times this amount (Munro (2003a), Gabrielson (1971) 92).

[20] One might also point out that for a considerable period of time there was a large time lag between market events and the appearance of reports in newspapers (Neal (1988)). Anyone who wanted to know current price levels had to go to the relevant coffee-houses (England) or taverns (Holland).

difficult to construct.[21] Moreover, despite the work of Werner (1936, 1937, 1969, 1970, 1971), Dietrich (1958, 1959, 1961), Bogsch (1933, 1966) and Laube (1974), there is *much work to be done in identifying the investors whose names – and (rarely) place of* residence – appear in the lists of investors, which do not survive in any great number until around 1550. That, in turn, raises the danger that we may be tempted to read history backwards, imputing later, well-documented structures to earlier, less well-documented periods. Finally, it is anything but straightforward to isolate individual pits in the historical record,[22] but it goes without saying that a gazetteer of pits has to be drawn up before it makes any sense to attempt to establish price series for shares in individual mining corporations.

Consequently, the conclusions I have reached in this paper have to be treated as preliminary indications, which later, more exacting and systematic research might well disprove.

[21] However, my (necessarily limited) reading of the literature indicates that no one has really tried. Previous scholars' central questions revolved around (a) the total silver production of the Saxon mines, (b) the Saxon dukes' income, (c) the legal framework of mining activities and (d) identifying the investors. Not only Marxist authors (e.g. Laube (1974)) are content to tell a few horror stories about prices and leave it at that.

[22] For instance, most of the pits in the Schneeberg mining district in which the town council of Leipzig invested between 1472 and 1535 cannot be found in the list of Schneeberg pits drawn up in 1477 (Kroker (1909), Hoppe (1908)).

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