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The efficiency of the London Gold Fixing: from gold standard to hoarded commodity (1919–1968)

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This article presents the newly reconstructed daily gold price from 1919 to 1968 for the world's primary gold market during the London Gold Fixing auction, when gold was the cornerstone of the world's monetary system. We assess whether this market conformed to the Efficient Markets Hypothesis, which posits that prices are unpredictable, or the Adaptive Markets Hypothesis, which posits that a market efficiency will evolve based on changes in the market structure. We find that the Gold Fixing price was inefficient in periods when prices were market-based from 1919 to 1925 and again in the 1930s when private hoarders began to have a significant impact on the market. We find the Gold Fixing was also inefficient during gold standard periods when central bank interventions limited gold's ability to react to new information, despite two episodes where prices rose above the official ceiling.

Keywords: daily gold price, London market, market efficiency, Adaptive Markets Hypothesis, gold fixing, hoarding

JEL classification: F3, G1, G2, N2, Q3

I

At 11:00am on 12 September 1919, the first London Gold Fixing auction took place at N. M. Rothschild & Son bank in St Swithin's Lane in the City. London had already been the world's main gold market for two centuries, with most of the globe's newly mined gold sold there (Evitt 1938). The Gold Fixing price from this auction remained the world's *benchmark gold price* for financial contracts worldwide through world wars, depression and changes in the world's monetary regime (Harvey 2008). Over 100 years later, this auction still takes place. However, its name has changed to the London Bullion Market Association (LBMA) Gold Price.

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Despite the importance of gold in international monetary affairs in the twentieth century, data pre-1968 for the London Gold Fixing has been unavailable to researchers in discussions of monetary policy or financial markets during this period. The archive of investment bank N. M. Rothschild & Son, who administered the Gold Fixing from inception to 2004, said that a 'complete record of the daily … *Gold Fixing* (1919–2004) has proved surprisingly *elusive*' (Rothschilds n.d.). This article's first contribution is reconstructing and making this dataset freely available[1] and showing that the prices from the Gold Fixing represented the true tradable price for gold prices in Great British pounds in the periods examined here.

The quantitative financial economic aspects of the pre-1968 Gold Fixing is an underresearched topic in financial history due to the previous lack of daily data. Harvey (2008) provides a detailed discussion of the socioeconomic underpinning and development of the Gold Fixing from its inception using archival sources such as the Bank of England, while Blagg (2013) and Bott (2013) provide insights into the impact of the actions of refiners and gold miners on the gold market in the early twentieth century.

A fundamental question to be answered about any investible asset where a dataset of daily prices becomes available is whether it was weak-form efficient (Fama 1970), the most basic test of the Efficient Markets Hypothesis (EMH). This evaluates whether price movements are predictable using *only* past price data. Suppose markets are found to be weak-form efficient. In that case, they will react quickly to new information, which makes price movements unpredictable. Predictability would allow better-informed traders to profit from the patterns they find, over and above what would be justified by the risk of the market, at the expense of participants who did not have this knowledge but traded anyway, who are referred to as Noise Traders (Dow and Gorton 2006).

Analysing the weak form efficiency of each market phase will allow us to see whether the market became more efficient over time as participants' knowledge grew or if shocks to the market, such as coming and going from the Gold Standard, meant that the development of the market's efficiency suffered setbacks. A priori, it is unclear whether the greater influence of central banks before 1968 would increase or reduce market efficiency relative to the present-day free markets for gold. From a theoretical standpoint, Levich (1985) argues that as officially set prices cannot react to all available information, they are less likely to be efficient. A reply to this would be that during the pre-1968 period, central banks were a part of the information that drove price interventions as endogenous actors in the market and would have been well-informed professional participants in a good position to trade away market inefficiencies.

[1] The data is available at https://data.mendeley.com/datasets/ddcsmwkfxw/2 and is freely downloadable.

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If profits from trading, over and above justified by the risks undertaken, were available to informed traders on the Gold Fixing, this would increase the likelihood that gold would become a speculative asset rather than simply a monetary metal, becoming another '*mere commodity*' as the bullion bank Samuel Montagu & Co. feared it would in their discussion of the implications of the new Gold Fixing in their annual letter to clients of 1919. As discussed at the end of Section II, speculators' actions resulted in the gold pool's failure in 1968, which resulted in fundamental changes to the world's monetary system. But their prominence had started growing from the 1930s in what we will show was a persistently inefficient market.

Evidence on gold's efficiency pre-1968 is thin due to a lack of data at a frequency higher than monthly. A study of the clandestine gold market in Paris during World War II and the official market that came after it found that in both cases, the market was inefficient, concluding that the efficiency of the market was related to the type of asset traded rather than the legality of the market (Gallais-Hamonno, Hoang and Oosterlinck 2015). Outside of gold studies of market efficiency using daily data from the 1930s in the Japanese stock market, these markets failed to demonstrate efficiency (Bassino and Lagoarde-Segot 2015).

Officer (1986) discusses the efficiency of the dollar–sterling gold standard from 1890 to 1906 but in terms of the efficient allocation of gold stock across countries under the rules of the gold standard before World War I. He finds this system efficient in that arbitragers importing or exporting gold made generally profitable decisions as gold flows moved in the correct direction in months when the exchange rate allowed arbitrage profits to be made. This differs significantly from the idea of 'efficiency' under the EMH being tested here, where profits for traders would be evidence of inefficiency.

Economic historians have focused on analysing gold in the early twentieth century within the context of macroeconomics and exchange rate regimes (Irwin 2012), the restoration of the interwar gold standard (Eichengreen 1996), and the impact of gold on the recovery of economies post depressions (Eichengreen 2021). Other countries where gold prices were allowed to vary, such as the Netherlands from 1925, where import and export prices differed over time (Fliers and Colvin 2022), have been examined but again in the context of gold standard monetary policies rather than questions about the financial economics underpinning the prices. This data will allow questions surrounding the financial economics of gold during this period to be addressed for the first time.

An alternative hypothesis is the Adaptive Markets Hypothesis (AMH), which argues that markets evolve and can go from being inefficient to efficient, and possibly back again, as the characteristics and participants of a market change over time (Lo 2004). This theory is based on the ability of a market and its participants to learn over time and forget as new participants replace retirees and not immediately notice price patterns when they develop. The AMH allows for markets to be out of equilibrium, exhibiting periods of instability and irrationality, such as asset bubbles (Lucey and O'Connor 2013). In contrast, the EMH assumes that markets

are always in equilibrium, as prices are always based on the information at hand. Addressing which hypothesis better describes the London Gold Fixing auction is this article's second contribution.

London had been the centre of the world's gold market for over two centuries. One reason was Isaac Newton's choice of a gold-to-silver ratio that led to a large inflow of gold into England after 1696, allowing a gold standard to emerge; see Craig (1946) and Eichengreen (2008). Another came from its unique position of power within the British Empire. This gave London unique access to the world's largest gold-producing country, South Africa, whose gold flowed predominantly to London for sale. Together these factors allowed expertise in the auxiliary services necessary to develop a dominant market, such as insurance for shipping gold internationally, which created a difficult position for other markets to replicate.

Figure 1 indicates the UK's continued dominance in the global gold market during the period examined here,[2] showing the proportion of UK gold imports and exports to world gold production, taken from Samuel Montagu & Co.'s *Annual Bullion Letters*. This shows that imports or exports were sometimes larger than global annual production, as stocks in London vaults were either added to or depleted to satisfy international buyers or sellers. While we do not have a time series of daily turnover for the *Fixing* Montagu's 1934 letter says that the average daily turnover was £406,000 that year, which means that *c.* 65 per cent of annual global production was traded through the *Fixing* that year. In the nine months of 1939 before the market closed with the outbreak of World War I, the average volume traded was £480,000 per day.[3]

The focus of pre-1968 research on gold's monetary function seems to be based on an assumption that gold was not an investible asset during this period, serving only as an official monetary asset. We show that the demand for gold pre-1968 did not just come from official sources, such as central banks, but to a significant degree from 'hoarders', as private gold investors and speculators were referred to up to the 1970s. Eccles (1936) estimated that by this time, there was $2 billion worth of gold in international private 'hoards', two-thirds of which were held in London vaults, with only a minority-owned by English residents. Tamagna (1954) looked at private gold demand globally from 1931 to 1954 and found worldwide private demand for gold in this period was 'unprecedented', with western hoarders increasing their holdings by over 600 tonnes, worth £240 million in 1954.

As detailed below, this dataset covers four distinct periods of the London gold market, each with different characteristics, moving between officially set and market-based gold prices. While official sector organisations such as central banks were involved in all these phases, the market-based price phases were not controlled

[2] No data was present for 1932.

[3] These average hides wide variations, for example it was reported that only $41,580 worth of gold traded on 29 April 1939 (Samuel Montagu & Co. 1940).

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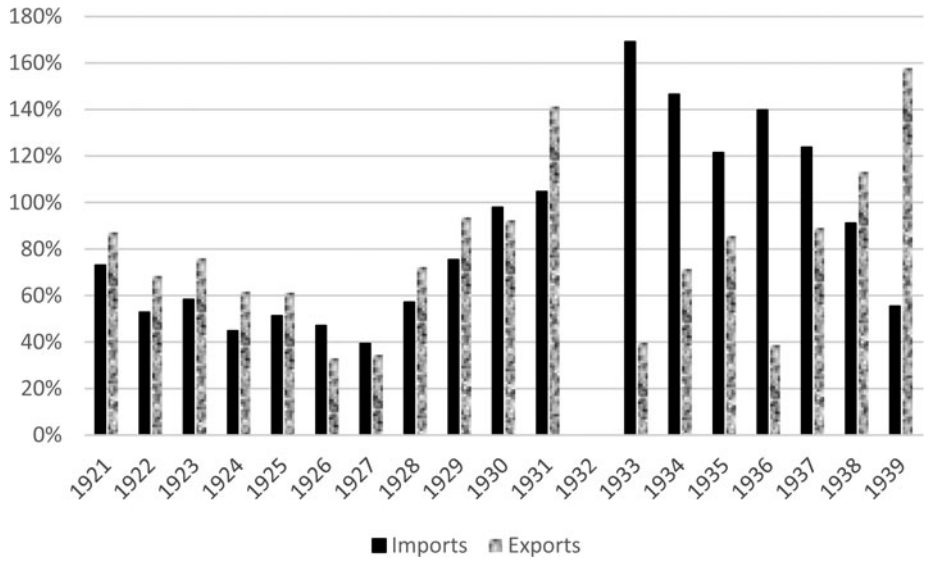

Figure 1. *UK gold imports exports as a ratio to world gold production*
Source: Samuel Montagu & Co., *Annual Bullion Letter* (1921–39).

through interventions to keep prices in a particular range. They were more like the modern gold market, where central banks remain important players.

As the functioning of this market is not widely discussed in the literature and is important in interpreting the data, we will develop a qualitative discussion of these phases. This is based on the published work of authors such as Harvey (2008) and Green (1978), who worked with archival sources at the bullion banks and Bank of England, as well as contemporary public sources gathered for this research. We use newspaper coverage from the *Financier and Bullionist*, the *Financial News* and the *Financial Times*, official sector publications such as Federal Reserve reports, as well as the annual letters of London bullion banks[4] written for their clients, which have not previously formed a core of this discussion to develop a portrait of each phase of the Gold Fixing.

Studies have found mixed results on the efficiency of the modern gold market. Early papers like Tschoegl (1980) found that the market did not present any inefficiencies after accounting for trading costs. Newer studies such as Bariviera *et al.* (2019) find three periods of waxing and waning efficiency, with the gold market

[4] The *Annual Bullion Letters* of Samuel Montagu were found and accessed at the Library of the London School of Economics.

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having a low level of efficiency up to 1980 but a higher level of efficiency from 1981 to 2002, with results that fit the AMH more closely than the EMH.[5]

We find that the first phase of this newly formed auction (1919–25) was not weak form efficient, a period when we show that the market was dominated by well-informed professional traders at the London bullion banks and central banks. However, the Gold Fixing prices were determined at the daily auction based on supply and demand. When gold prices were again determined by the market (1931–9) the market remains inefficient. However, this is the period when private hoarders began to significantly influence the market and liquidity was the highest across all periods discussed, based on the qualitative sources used below. The market is conclusively shown to be inefficient when the gold price varied marginally from day to day under a ceiling set by the Bank of England from 1925 to 1931. The next period of fixed gold prices (1954–68) is also found to be inefficient though the market did breach the official set ceiling on prices in both official price periods due to shocks.

II

Daily gold price data used here was reconstructed from three sources. The *56th Annual Report of the Deputy Master and Comptroller of the Royal Mint* contributed the data for the 1919–25 period. *Quin's Metals Handbook and Statistics*, published annually, provides data covering the period 1921–65, and the *Metal Bulletin*, a trade magazine published twice weekly, covers the remainder of the period up to April 1968 when the sterling-based Gold Fixing ended. This data is freely downloadable here.

Other sources of gold price data pre-1968 do exist. Measuringworth.com provide very accurate annual data for sterling gold prices back to 1257 (Officer and Williamson 2022). Monthly data for the London gold price is available from the Global Financial Database but this is not the Gold Fixing price for gold. It is the official US dollar gold price converted to pounds sterling at the market exchange rate for dollar–sterling. This is an imperfect measure when compared to the Gold Fixing price which was the market price for gold that traders could really buy and sell at on that day. The Fixing price was frequently, as will be discussed below, driven by factors other than the dollar–sterling exchange rate. Using data other than the Gold Fixing price data provided here means that there will be significant errors in the series in particular for the 1930s and 1960s, when other factors drove the Gold Fixing price away from its official level.

Daily data for the period 1961–8 does exist from Bordo, Monnet and Naef (2019) transcribed from Bank of England traders' files. These are US dollar prices rather than pounds sterling, the currency of the London Gold Fixing auction. As this data comes from traders' internal reports it is unclear whether these were the market price for that

[5] For a review of the literature on this issue see O'Connor *et al.* (2016).

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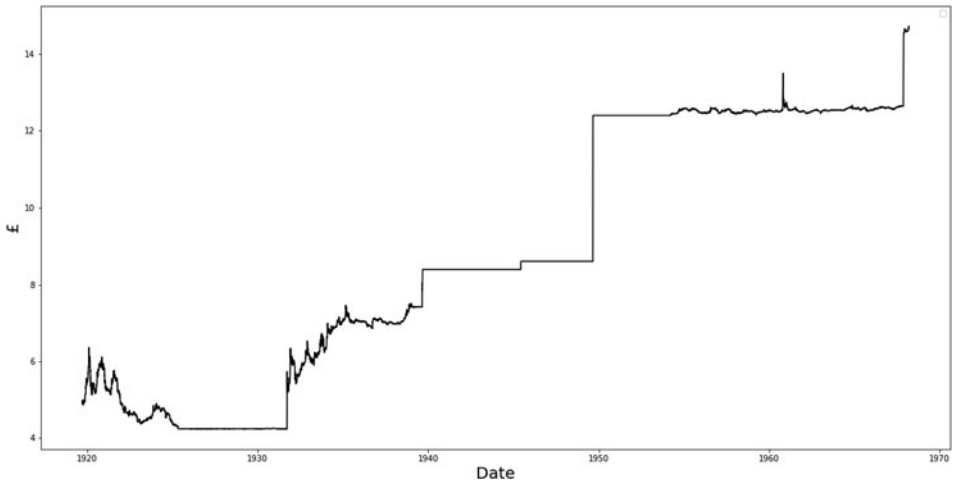

Figure 2. *Gold price in sterling (1919–68)*
Source: 56th Annual Report of the Deputy Master and Comptroller of the Royal Mint (1919–25), *Quin's Metals Handbook and Statistics* (1926–65), *Metal Bulletin* (1965–8).

day, or the price executed by the traders in the Bank of England on the OTC market that operated around the Gold Fixing during each day. Daily data from April 1968 is freely available to researchers from online sources such as the LBMA website.[6]

Figure 2 graphs the daily price of gold on the London market from 1919 to 1968. The periods of relatively fixed official gold prices are clearly visible with little or no volatility, as well as the more volatile periods' market-based prices. Extreme price movements can be seen due to large official revaluations, such as the large official revaluation in the price of gold in 1949.

The new Gold Fixing began to operate from 12 September 1919 and this was the first time gold prices in the Britain had been set by the market since the 1700s.[7] The members participating were the four major London bullion banks[8] and Rothschilds, representing the Bank of England. In the beginning Rothschilds were the sellers of all the gold that came in each week from the South African miners, giving them a near monopoly on new gold sales (Harvey 2014).[9] This is at least partly because the Gold

[6] www.lbma.org.uk/prices-and-data/precious-metal-prices#/prices-explained

[7] Harvey (2008) shows that Gold Fixing auction that began in September 1919 was formalisation of a meeting which had taken place daily at an undisclosed location in London since at least 1907 (WSJ 1907).

[8] They are: Mocatta and Goldsmid; Pixley and Abell; Sharps and Wilkins; and Samuel Montagu & Co. and Johnson Matthey & Co. joined the auction process in the early 1930s.

[9] Newspapers also reported an 'experimental sale' which was made some weeks about 10 per cent above the previous official price. See 'Money market: South African gold arrives', *The Financier and Bullionist*, 12 September 1919, p. 1.

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Fixing came to be through pressure from South African gold miners to secure a higher price post-World War I in London, or begin selling directly to America;[10] see Ally (1994) and Harvey (2008) for discussion of the British political and economic reasons for this, and Swanepoel and Fliers (2021) for the South African background.

The format at this auction was 'curiously informal', even to commentators of that time (Evitt 1938, p. 240), with no publicly discussed rules at its inception and a process which evolved over the following years. As the selling on the early Gold Fixing was mainly through Rothschilds, the four remaining bullion banks were merely setting the price that would clear the supply Rothschilds offered at each auction. Originally the daily auction allowed buying at or above an opening price set by the chair, using the official dollar gold price, or French if that was the reference parity that dominated at the time, and the dollar–sterling exchange rate as a starting point. In this way the official US dollar price did set a floor, but not a ceiling, for the gold price each day in the early fixing period (Harvey 2008). As the auction evolved there was no minimum price and, as will be seen below, the Gold Fixing could fix below its reference parity price when uncertainty dominated, and over time the chair of the auction began to revolve between the five participating banks.

The Gold Fixing auction process evolved to take place as follows. After the chair of the auction had stated the starting price, each bank then offered an amount of gold to either sell or buy at that price (Green 1978). This would represent the net orders of that bank from their clients, meaning that at a particular price a bank may offer zero ounces, but this could result from a large purchase and a large sale by two of their internal clients offsetting each other, referred to as a 'marriage'. The price was adjusted by the chair until balance was reached. In the 1930s market, once the price was *fixed* members declared the total 'marriages' so that the total traded on the fixing was known for that day (*Economist* 1937).

By 1935 a settled format had emerged. Where previously members could not communicate with their offices during the fixing, or indeed leave the room, by 1935 each had a telephone to communicate as the price moved around trying to balance supply and demand. With prices more volatile during the fixing, due to constant changes exchange rates, participants who wished to pause the fixing to talk with their own office now raised a Union Jack flag saying, 'Flag up'. If the market reached a balance between supply and demand then the price would be fixed for that day, or if the imbalance was small enough the price would be set at a point where the buyers outnumbered the sellers and the buyers would get only a proportion of their order (*Banker* 1935). The bullion banks fee agreed at the opening of the fixing in 1919 with the Bank of England was 1/8d per ounce (Harvey 2008, p. 61).

[10] The creation of the Federal Reserve in 1913 and large inflows of gold bullion during and after World War I meant that London's long-running and seemingly natural supremacy as the world's financial centre was under threat (Eichengreen 1996).

Some commentators have said that the Gold Fixing auction was similar to a Walrasian auction, where bidders submit the volume they are willing to buy at a range of prices, but there are differences (Lawrence 2006). Firstly, participants of the Gold Fixing auction can buy or sell, and not just buy as in a traditional Walrasian auction. Secondly, it is not a one-shot game. Participants submit buy or sell orders only at the price put forward by the chair at that stage. If supply does not equal demand at that price, they then revise their buy or sell order, but they do not need to present their buy or sell orders for all prices suggested by the chair in the first step.

Oddly, in Samuel Montagu & Co.'s *Annual Bullion Letter* for 1919 they do not mention the founding of the Gold Fixing, instead only the freeing of gold for import and export under licence from the government is discussed. This is also reflected in the fact that the bullion banks did not all attend every fixing meeting until the return of the gold standard in 1925 (Harvey 2008). Their weekly circular in the week before the opening of the Gold Fixing also did not mention the establishment of the Gold Fixing, though it did in passing the following week. This points to this market being dominated by the bullion banks, with little speculative activity to attract excitement. This is despite 1919–20 seeing an explosion in the value of transactions that were processed by the Bullion Banks (Arnold 2016).

The Gold Fixing's first price was set at 98s 6d[11] (£4.93); see Figure 3. The first large consignment of gold bullion (£1.75m) from South Africa come up for sale at the Gold Fixing on 16 September.[12] This was seen as bringing the free market for gold back into 'actual being' by the *Financial Times*, implying that a low level of liquidity had prevailed in the first days of the new Gold Fixing.[13] On the second day of the Gold Fixing, the rate of exchange between London and New York was £4 17s 5d, and the official US gold price was $20.67. Based on this, the London price would have been £4 19s, but the gold price was fixed at £4 18s 6d.[14] This difference of 6d, about 0.5 per cent, reflects transport, insurance, or brokerage costs and matches other estimates of 0.4 per cent (Dunbar and Sprague 1917) and 0.6–0.7 per cent (Officer 1989).

In the first years of the Gold Fixing, the only gold that could be auctioned came from African mines that had a licence for export from the Treasury.[15] For 1919 and

[11] Before World War I, the official gold price was 77s 9d on a 11/12ths fine basis (91% pure gold) and this had been the price since the early 1700s. This price was a constant for all of 1913, with only three days in 1912 where the price was 1/8d higher due to 'keen' demand from New York (Mocatta and Goldsmid 1913). When the Gold Fixing was founded, it operated on a pure basis (99.5% pure gold) to match the standard in America, meaning that the equivalent pre-price was just under 84s 10d.

[12] 'Money market: pressure for loans continues', *Financier and Bullionist*, 17 Sept. 1919, p. 1.

[13] 'The gold price', *Financial Times*, 16 Sept. 1919, p. 2

[14] 'Gold at a premium', *Financial Times*, 19 Sept. 1919, p. 3.

[15] A parallel market for domestic gold is mentioned in Samuel Montagu & Co. (1920), where gold that was not exportable was traded. Up to late 1920 its price mirrored the Gold Fixings price but towards

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Figure 3. *Gold fixing price, 1919–25, £'s*
Source: 56th Annual Report of the Deputy Master and Comptroller of the Royal Mint.

1920 about 50 per cent of the gold bought at the Gold Fixing was exported to the US, with 25 per cent going to India (Samuel Montagu & Co. 1920). Sales were mentioned as being to countries as opposed to individual investors, for example 'fresh supplies' would be reported to be secured by India or America,[16] underlining the monetary nature of the market at this time, with any speculation concentrated in the gold miners' stocks, rather than gold itself.

The liquidity of the market during this time is unclear. Two weeks into the Gold Fixing it was reported that about £1.5 million would be available in the market at the beginning of the next week. While there was a daily auction, Tuesday was reported the busiest day in this period as this was the day when new South African shipments were auctioned (Evitt 1938). Green (1979) states that based on the internal records of Mocatta and Goldsmid over the first five weeks of the Gold Fixing, 660,000 ounces were sold, the majority of which this was purchased for the India Office. October 1919 saw reports that 'a very small amount of gold' was transacted and that it went to 'the trade' rather than national buyers.[17] Buyers from trade, such as jewellers, were satisfied first at the Gold Fixing's price while the major buyers were arbitrageurs (Evitt 1938). By 1920, the bulk of the gold being sold was destined for either India or China (Samuel Montagu & Co. 1920).

The market-based sterling prices determined at the Gold Fixing in the 1919–25 and 1931–9 periods were still heavily influenced by the official prices being set in other countries. The most obvious is the official US dollar price for gold, which dominated

the end of 1920 the price on this market fell to 20 shillings or more below the exportable Gold Fixings price. It is not mentioned again in these annual letters.

[16] 'Silver steady: gold higher', *Financier and Bullionist*, 21 June 1922, p. 1.

[17] 'Money market: sales of Treasury bills', *Financier and Bullionist*, 16 Oct. 1919, p. 1.

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the starting point for the auction in most years. But it was not the only driving factor: prominent newspapers such as the *Financier and Bullionist* said that the relative price of the US dollar versus the Indian rupee was a primary determining factor during the 1919–25 period. The strength of each currency relative to sterling on any day determined where the gold sold was exported to. India was a consistent buyer and a good portion of the gold exported there was purchased on a speculative basis with demand from small speculators being about 7,500 ft/oz per day.[18] Grewe (2013) argues that the gold price was dominated by the dollar–sterling exchange rate with some deviations at different times during periods of high demand from India.

Aside from occasional mentions of gold shipment destinations, the Gold Fixing in this period seemed to warrant little discussion in newspapers which did discuss silver markets in more detail at least weekly. It was dominated by market professionals like the Bank of England, the bullion banks and Rothschilds, who had been trading gold in London even before the Gold Fixing existed. This would indicate a lack of *noise traders* participating in the market during this period and therefore a possible high degree of rationality in their trading.

It was six years before Great Britain returned to the gold standard on 28 April 1925. The announcement was made after the Gold Fixing had already taken place that day (Clough, Moodie and Moodie 1968). The price on that morning fixed at 86s, up from 85s 6d on the previous day. This might seem to suggest that the return caught the gold market off guard as the officially set price announced in the afternoon was set at 84s 11.5d – 1.2 per cent below the previous day's Fixing price. This is an example of a price marked as 'Nominal' in the source material, calculated based on the US dollar gold price and the exchange rate that day, as no trading had occurred that day and there was no traded price available. The lack of trading implies uncertainty on the part of the bullion banks and an unwillingness to trade before the announcement.

As more countries began re-entering the gold standard in the late 1920s, the London market had a lower level of liquidity than in the previous period (Harvey 2008), despite a growing number of significantly large gold purchases by 'Undisclosed buyers' (Samuel Montagu & Co. 1928). This gold was normally held in London until the transition to a gold standard for that country was confirmed, as London remained the financial centre for gold trading during the interwar gold standard period. This was done so that the central banks' gold could be traded quickly without the need to transport it to a market, to help support and maintain its exchange rate (Fliers and Colvin 2022). In 1928, supplies of newly mined gold from the USSR also started to arrive on the London market (Samuel Montagu & Co. 1929) but the newly formed South African central bank (the SARB) secured a monopoly to purchase all newly mined South African gold until 1930 (Swanepoel and Fliers 2021).

[18] 'Money market', *Financier and Bullionist*, 9 May 1922, p. 1.

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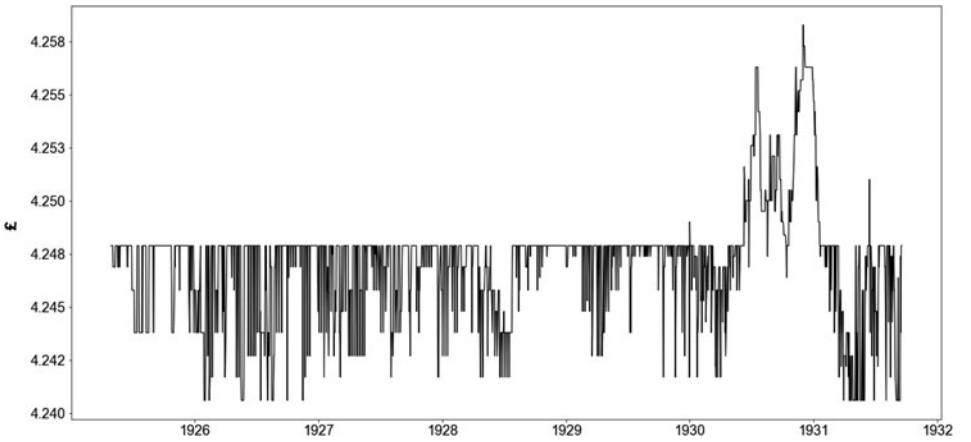

Figure 4. *Gold fixing price, 1925–31, £'s*
Source: Quin's Metals Handbook and Statistics (1925–33).

The sterling gold price has been assumed to have been relatively static in this period, held in a range by the official actions. New data shows this was not always the case and that prices did rise above the Bank of England threshold at times, as shown in Figure 4.

Until June 1930, gold had traded in a tight range around £4.24, but on 11 June the gold price rose above £4.25 – a significant upward deviation during this period of officially set prices. Large outflows of gold to France had lowered the Bank of England's stock of fine gold (99.5 per cent) and it began selling bar gold that was of the old standard fineness (91 per cent). Normally the price paid for a bar would simply have been adjusted to reflect the lower quantity of gold delivered, but the Bank of France refused to accept anything but fine gold bars. This created a bottleneck for the refiners who were already operating at full capacity converting London's standard-quality gold bars to fine-quality bars. The peak price recorded in 1930 was £4.46 on 2 December (Samuel Montagu & Co. 1931). This ended on 15 January 1930 when the Bank of France relented and accepted standard bars, resulting in the quantity of gold being shipped to France increasing with the refining capacity no longer being an issue (Samuel Montagu & Co.1932). This shows that even when prices were set officially, the Gold Fixing auction could still react to information.

The Netherlands gold market, while seemly more OTC in nature than the Gold Fixing, also showed signs of this stress. Fliers and Colvin (2022) show outflows of gold from the Netherlands in mid 1930 after a five-year period where net trade in gold was persistently close to zero. This coincides with a period where the implied price monthly difference between import and export prices stabilizes.

As this official price period was ending in June 1931, the London market saw a significant increase in activity from continental buyers. In September, the Bank of England began buying gold covertly at above the statutory price, with increases in

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Bank of England holdings later matching these purchases (Samuel Montagu & Co. 1932).

On 20 September 1931, the UK Treasury announced that it advised a departure from the gold standard (Government 1932).[19] A bill was debated on 21 September after the Gold Fixing had taken place for that day and prices started freely floating the following day. The *Financial Times* reported that 'a large number of people had an intuition of what was to happen' in advance.[20] However, the price data argues against this suggestion.

Firstly, the price on the morning before the vote occurred fell from 84s 11.5d to 84s 9.75d (0.2 per cent); the expected devaluation in sterling and thereby rise in the gold price should have encouraged buying and possibly a price increase as a result. Also, this price is marked as 'nominal' indicating another day when no trading took place on the Gold Fixing. As gold trading does not seem to have been barred, the lack of buying by the auction participants implies their 'intuition' was not strong enough to overcome their uncertainty about what would happen, to the gold standard or the gold price, and put their money at risk.

The gold price rose 17 per cent on the morning after the vote to leave the gold standard, rising to 99s 7d, but still the market displayed uncertainty as to what would happen and this was again a 'nominal' price. Gold finally began changing hands again at 100s on 23 September and by the end of the week the gold price was fixed at 114s 9d – up 27 per cent.

Though by 1931 the Gold Fixing had been in operation for 12 years, this phase of the Gold Fixing's development was agreed to be when gold as an asset began to attract more 'general interest' from investors.[21] Private hoarding demand meant that gold prices in the 1930s were frequently *fixed* above the American or French parity due to 'Foreign enquiry for hoarding' (Samuel Montagu & Co. 1933, p. 4).[22] Hoarding becomes increasingly prominent in discussions about the gold market from this time on, reflecting its new importance to the functioning of the market. In its review of 1936, the *Financial News* said one of the main features of this period was the 'enormous increase' in private demand for gold coupled with massive increases in the overall scale of dealings on the London gold market. Harvey (2008) also says that speculative forces became more prominent in the Gold Fixing during this period.

Figure 5 shows the volumes of gold bought each year by private investors, using data compiled by the Federal Reserve (Tamagna 1954). This excludes official buyers, jewellery and other non-financial uses such as dentistry. This data offers further evidence that post-1931 gold was used as a private financial asset by investors

[19] See Eichengreen (1996) for a discussion of the macroeconomic reasons for their departure.

[20] 'Effect of gold decision', *Financial Times*, 4 Sept. 1932, p. 4.

[21] 'The London gold market', *The Economist*, 4912 (1937), pp. 6–7.

[22] *The Economist* (1937) also reported that hoarding demand had been very prominent since 1934, while the *Financial News* reported in its review of 1933 that that was the year that a 'worldwide resumption' in hoarding.

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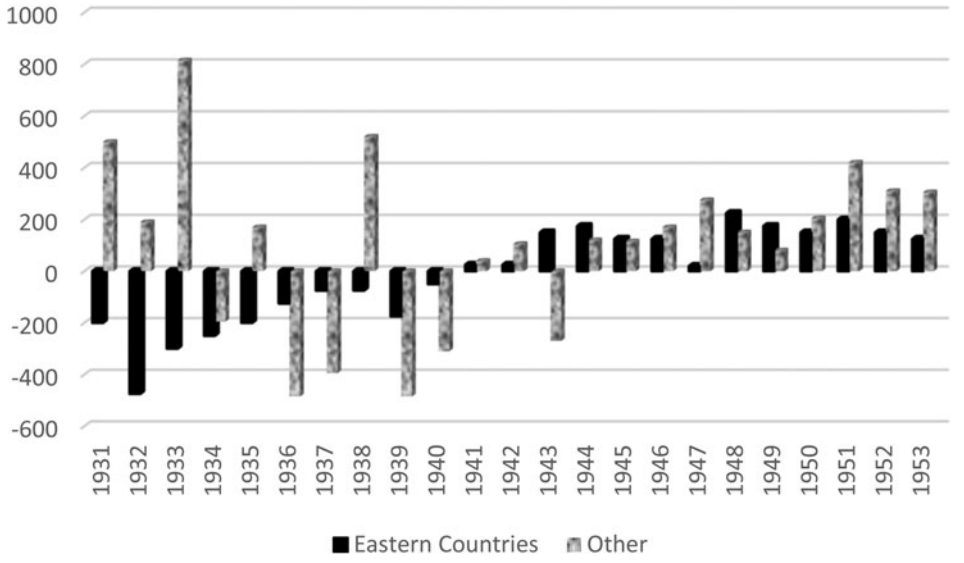

Figure 5. *Private gold purchases, $ millions*
Source: Tamagna (1954).

before 1968 and was not solely a monetary asset. Uncertainty in this period was unusually high for investors, as countries came and went from the gold standard regularly, so that by the end of 1936 gold was fulfilling what we would now describe as its role as a safe haven asset for investors (He, O'Connor and Thijssen 2018) and London was the most important venue to buy and store gold globally. As hoarders were frequently smaller investors for whom gold bars would be too large an investment, their demand was satisfied by gold coins, which in 1938 were commanding a premium of 7 per cent over their gold value (Samuel Montagu & Co. 1939).

The suspension of the US gold standard in April 1933 was another factor which increased uncertainty. By April it was illegal for US citizens to hoard gold, which led to increased buying by US citizens on the London market to avoid these restrictions (Samuel Montagu & Co. 1933). Following the suspension of the US gold standard the *Financial News* reported that most of the new gold being offered on the Gold Fixing was being taken up for *hoarding* with London serving hoarders from 'every part of the Earth'. From 1934 to 1940 official gold holdings in the US went from $4bn to over $18bn, and $10bn of this rise came from gold imports which primarily came through the Gold Fixing.[23]

A new source of supply in the 1930s was dishoarding from Middle and Far Eastern markets, where there was a very large buildup of gold from long-term historical buying, attracted to sell due to the new all-time high prices available (Tamagna

[23] 'America faces gold avalanche', *Financial News*, 22 April 1940.

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1954). Where India had normally imported gold from the UK, in 1931 it exported £65mn, and was the largest source of supply to the London market in 1932 (Samuel Montagu & Co. 1933).[24] When gold prices rose above its exchange rate determined parity, gold being was sold by small UK investors was drawn out into the market as in 1934.[25]

Following the ending of the gold standard, newly mined South African gold did continue to come to London but Samuel Montagu & Co. (1931) say it was 'not made available to buyers as heretofore'. Now all new mine production shipped to England was sold directly to the Bank of England, who could sell it on the Gold Fixing if they wished; West African and Rhodesian gold was still sold directly through the Gold Fixing. From 1938 the South African mine production stopped being shipped to London, as the government began a policy to hold some of its gold reserves abroad.[26]

Eichengreen (2021) argues that South African supply was not important in the short term to price formation in London, though price increases in this period had an impact on South Africa's recovery from depression (Swanepoel and Fliers 2021). Demand was rising much faster than new supply, evidenced by increases in the inflation-adjusted price of gold particularly in the United States. O'Connor *et al.* (2016) also point to gold's unique position among commodities with a large and ever-growing stock meaning that previous supply, whether held in vaults or as potentially recycled jewellery, is always available to come onto the market if prices are rising fast enough with gold miners left as price takers.

Up to 1933, about one-third of gold trading took place outside the Gold Fixing in the OTC market, but the Gold Fixing price was used as their reference price (Harvey 2008). By 1938 the Gold Fixing had begun to monopolise gold trading, with double the volume traded of the previous year, and the Bank of England began encouraging some trading to take place throughout the day in the OTC market, rather than all in the roughly 20-minute window in which the Gold Fixing occurred (Harvey 2008).

From 1935 countries were cooperating to reduce the volatility of the Gold Fixing's price, thereby making the Exchange Equalization Fund (EEF) in Great Britain the most important buyer on the market by 1936. This limited the ability of private individuals to trade profitably in gold (Samuel Montagu & Co. 1936) and though the Gold Fixing price was still a market price, the authorities were actively discouraging *hoarding*.

Exchange rate parities with a country operating a fixed gold price were still a common driver of gold prices in the Gold Fixing, through arbitrage activities.

[24] The late 1930s saw large flows of supply onto the fixings from 'continental sellers', as noted frequently in the *Financial News*.

[25] Recycled gold jewellery also came onto the market during these high price periods (Samuel Montagu & Co. 1933), so much so that gold for trade purposes was no longer a source of demand on the Gold Fixing.

[26] 'The money market', *Financial News*, 7 Feb. 1939, p. 4.

However, in the short term, political uncertainty frequently caused prices to trade above or below the US parity unexpectedly. The reference price for the Gold Fixing in 1933 switched to the French franc parity, though the London gold price traded frequently above this parity as well.[27] For example, the 1932 high of 134s 8d was 5d higher than the simple French parity price. With the suspension of the gold standard in the US, the London gold price followed the sterling–franc rate within a 1s margin of error for the rest of that year.

An example of uncertainty specific to the gold market was the Gold Clause Cases (Dawson 1935), which heightened uncertainty as the legality of the ban on US citizens owning gold was challenged. In the end it was ruled the ban was lawful, but in the run up to the decision the price was 7d below the shipping parity as arbitragers were unwilling to maintain the dollar–sterling gold price parity.[28] When the US resumed quoting a daily price for gold it did not reassert its importance as the Federal Reserve did not buy at that price regularly enough.

As the gold bloc broke up in 1936, the price went well above the American parity again due to *hoarding*. In 1937, rumors of a reduction in the price at which the US would buy gold, due to the vast quantities of gold that the US Government had bought in the previous years, resulted in a period where gold traded significantly below its US parity.

The Montagu *Annual Bullion Letters* become increasingly occupied with the growing tensions in Europe from 1938, with the absorption of Austria by Germany, and the effects of this uncertainty on sterling gold prices. In the nine months of 1939 before the London gold market closed with the outbreak of World War II, the market traded seven times more gold than the previous year, about £480,000 per day on average. This hides wide variations; for example, it was reported that only $41,580 worth of gold was traded on 29 April 1939 (Samuel Montagu & Co. 1940), but a daily dataset on the liquidity of the market does not exist.

Gold prices surged in August 1939 following the relative stability of the previous year; see Figure 6. Prices peaked at 161s on 28 August, up 8.5 per cent in one week. The threat of war had been felt throughout 1939, with unease about the value of sterling leading to much of the 565,000 ft/oz of gold exchanged at the first Gold Fixing of 1939 being purchased for *hoarding* purposes rather than on official government accounts.[29]

The Gold Fixing did not operate on the 2 September as war began and it would stayed closed. Gold dealings from Tuesday were prohibited except through official channels – marking the end of a market price for gold in London. This contrasts with the stock market which reopened on 7 September and the silver market where the price continued to float freely.[30]

[27] 'Lombard Street, gold in 1933: prospects for 1934', *Financial News*, 2 Jan. 1934, p. 4.
[28] 'The money market', *Financial News*, 7 Feb. 1935, p. 7.
[29] 'Money market', *Financial News*, 2 Jan. 1939, p. 2.
[30] 'City and the war: new measures', 5 Sept. 1939, p. 1.

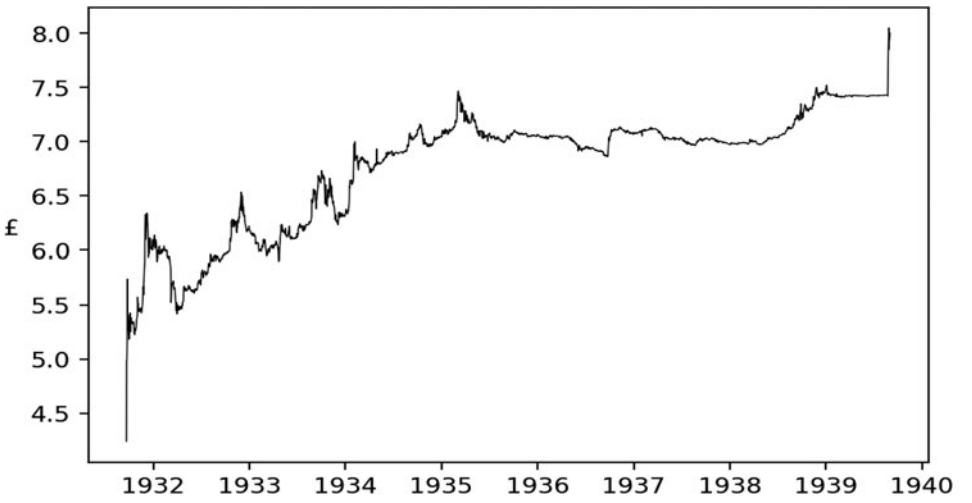

Figure 6. *Gold fixing price, 1931–9, £'s*
Source: Quin's Metals Handbook and Statistics (1933–40).

The official gold price was increased from 160s to 168s (5 per cent) by the Bank of England, remaining at that price until 11 June 1945. On 4 September the government had ordered that UK citizens sell their gold coin and bars to the Treasury, then the Bank of England took control of the bullion market in London at the fixed price of 168s. Privately held gold was flowing into the Bank of England at a 'moderate scale' by 7 September while gold held in the UK by foreign individuals was exempt from this forced sale.

The Gold Fixing did not reopen again until 1954. This was a period when the gold trade moved off to other markets where the price was not officially controlled, such as Hong Kong, Beirut, Paris, Tangier and the most notably Zurich, which remains a market of importance to this day (Lombard 1954), though a significant proportion of South African gold was still sold in London to official buyers. Other markets prices were well above the London price in 1945 but the London brokers were barred in 1947 from being involved in these premium transactions (Bott 2013). By 1953, an equilibrium had been restored, with all these markets trading at roughly the same price as London (Tamagna 1954).

Reopening the London gold market in 1954 was a central part of the Bank of England's plan to resuscitate London as an international financial centre (Harvey 2008). This, however, was not going to be the Gold Fixing of the 1930s with prices set by the market. Sterling area residents were allowed to sell through the Gold Fixing but only buy for industrial use; only non-residents had unrestricted access (Bott 2013). This market would be best characterised as dull; as seen in Figure 7, the price was generally set through the official US dollar gold price and a stable exchange rate, bar intermittent revaluations in sterling.

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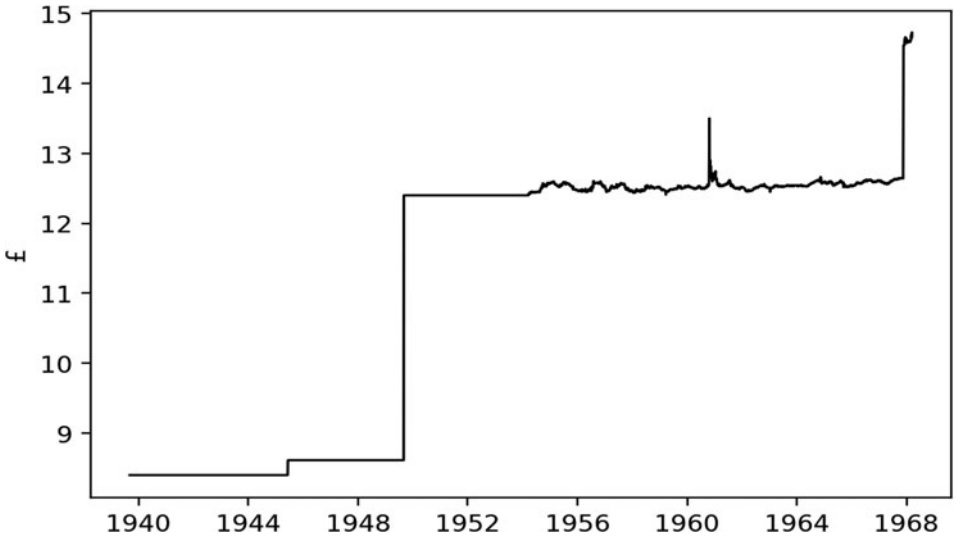

Figure 7. *Gold price, 1939–68, £'s*
Source: Quin's Metals Handbook and Statistics (1940–65), *Metal Bulletin* (1965–8).

The exception was October 1960 when prices moved substantially above their official level for several reasons. There was a burst of buying interest as the market began to worry that the US would soon have to increase its official price. There was also a growing pool of 'hot money' in Europe looking for profitable speculative opportunities. Lastly central banks, including the Bank of England, did not want to use their reserves to intervene in the London market even as price pressures started to build, though the US treasury seem to be unconcerned about the price action in London. Following record prices on 18 October the US Treasury finally stepped in and calmed the market (Samuel Montagu & Co. 1961). Episodes such as this, and the breach of the official price ceiling in the 1930s discussed above, give strong evidence for our assertion that the Gold Fixing gave us the true traded prices for gold in Great British pounds for these periods. We do not make the same assertion for 1939–54 prices, when the market never breached its price ceilings, nor vary in any way from day to day due to supply and demand, which is why we do not assess the market efficiency of that period here.

While this market pressure did not end Bretton Woods, it was a sign of a serious crack in the gold standard's architecture. The inaction of central banks to maintain the official gold price allowed the thought that gold prices could substantially increase above the set price to seem more plausible. 1967 saw the London markets' largest-ever turnover since reopening in 1954, as pressure from hoarders started to build (Samuel Montagu & Co. 1967). The brewing international monetary crisis led to sterling revaluing in November, with the gold pricing rising 15 per cent to £14.55. The liquidation of the Gold Pool in March 1968 spelt the end of the sterling-denominated

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Gold Fixing. The London market was closed on 14 March 1968 with the final price fixed at £14.73, but London dealers continued to execute orders for foreign principals (Samuel Montagu & Co. 1968).

Although it took 50 years from the inception of the Gold Fixing for gold to be removed as the anchor of the monetary system, there is some truth to the idea that allowing gold's price in its primary market to be driven by the laws of supply and demand, like any other 'mere' commodity, represented an early crack in the system. By the 1960s their fears were coming to pass, as surging demand from hoarders at the Gold Fixing forced central banks to sell so much gold that the floor of the gold-weighing room in the Bank of England collapsed while trying to process the transactions (Green 2007), foreshadowing the imminent fate of the gold exchange standard itself.

The London Gold Fixing auction began its modern practice of running twice daily on 1 April 1968, the AM and PM fixings, and prices were quoted in US dollars from then on – in an effort to better attract participants in the US dollar-dominated financial system. Further discussion of the market post-1954 can also be found in Naef (2022) and the operation of the modern gold market is discussed in Green (2007).

III

Table 1 shows descriptive statistics for each of the subperiods examined below, broken into periods when gold prices were officially set or market determined.[31] Gold returns post-1968 are notable for being consistently, positively skewed, unlike many other financial assets, a characteristic that significantly adds to gold's ability to diversify investors' portfolios in research on modern markets (Lucey, Poti and Tully 2006). This characteristic of gold returns persists in all subperiods when the gold price floats freely and is only negative during the gold standard period from 1925 to 1931 when the Bank of England intervened in the market regularly.

Gold's returns are notably non-normal with very large and significant Jarque-Bera statistics in all subperiods, reaching more than 1 billion. This means that the size of the one-day changes in the gold price, which occur when prices are revalued unilaterally by the government, are frequently much more positive or negative than would be expected from a standard normal distribution. There are a good number of daily price changes of more than 10 per cent – where under a standard normal distribution we would expect to see returns between +/-3 per cent around 99 per cent of the time over the full sample.

Gold returns post-1968 are notable for being consistently, positively skewed, unlike many other financial assets, a characteristic that significantly adds to gold's ability to diversify investors' portfolios in research on modern markets (Lucey, Poti and Tully 2006). This characteristic of gold returns persists in all subperiods when the gold

[31] The Gold Fixing did not operate from the outbreak of World War II to 1954.

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Table 1. *Descriptive statistics for daily gold returns*

Daily gold return's	Full sample	1919–25	1925–31	1931–9	1954–68
Mean	0.0002	−0.0001	−0.0000	0.0003	0.0001
Min	−0.1273	−0.0410	−0.0121	−0.0580	−0.0370
Max	0.4397	0.0458	0.0121	0.1770	0.1497
Standard deviation	0.0092	0.0056	0.0003	0.0068	0.0024
Skewness	5.0642	0.2531	−3.3111	10.593	47.888
Kurtosis (excess)	215.7	12.58	207.1	254.4	2,860
Jarque-Bera [P-value]	52,208,899 [0.000]	9,390 [0.000]	3,333,600 [0.000]	5,706,204 [0.000]	1,486,636,649 [0.000]
Obs.	27,340	1,420	1,863	2,101	4,357

price floats freely and is only negative during the gold standard period from 1925 to 1931 when the Bank of England intervened in the market regularly.

The general meaning of the EMH per Fama (1970) is that markets are efficient if they incorporate information quickly and accurately. There are a wide range of methods to test this such as semi-strong-form tests, including event studies which assess whether particular events cause assets to have returns which are above what would be expected by empirical models; see Brown (1978), who looked at the impact of earnings announcements. In general, they are assessing whether it is possible to achieve returns above that justified by the risk being undertaken by traders, referred to as abnormal returns.

This article focuses on weak-form efficiency tests which use only past price or volume data to test whether past data can be used to predict future price movements. In an efficient market current price changes are independent of past price changes as they are caused only by *news* which is by definition unpredictable, meaning that price changes are random. We will employ two types of tests for randomness below. We present only the results of parametric tests here as the data distribution is highly non-normal. These tests use the sign or rank of the returns and ignore the magnitude of each return, allowing the issue of non-normality to be mitigated.

A runs test is a non-parametric test of whether past price changes influence current and future price change. A run is defined as 'a sequence of price changes of the same type preceded and followed by price changes of the other types' (Solt and Swanson 1981, p. 471).

The expected number of runs for a sample ($E(r)$) is shown in (1) below, where a positive return is symbolised by P, and a negative return by N,

$$E(r) = \frac{2PN}{(P+N)} + 1 \tag{1}$$

and r is the actual number of runs. The formulae for the variance of the runs is shown in (2) below.

$$\sigma_r^2 = \frac{2PN(2PN - P - N)}{(P+N)^2(P+N+1)} \tag{2}$$

$$Z - stat = \frac{(r - E(r))}{\sigma_r^2} \tag{3}$$

The null hypothesis of the test is H_o: r = E(r) against an alternative that they are not equal. If the z-stat calculated is greater in (3) than the critical value the null of independence is rejected, and the market is characterised as inefficient – as a gold price rise is more likely to be followed by another day of positive returns than is be expected. If

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returns lack independence this might allow market operators to predict the direction of movement in gold prices profitably by looking at past price changes.

Another way to assess if a financial market is efficient is whether the returns on an asset are mean reverting. If they are, they will follow a random walk, where future prices are unpredictable, and the market can be characterised as efficient. Lo and MacKinlay (1988) provide the most common parametric test of market efficiency from this perspective, if the price of an asset follows a random walk, then the variance of the k-period return is equal to k times the variance of the single period return. They show that if an asset's returns (r_t) are independent and identically distributed (iid) then the Variance Ratio can be calculated as:

$$VR(k) = \frac{\sigma_k^2}{k\sigma^2} \tag{5}$$

Where σ_k^2 is equal to the variance of the k period return. This can be rewritten in terms of the autocorrelation of r_t:

$$VR(k) = 1 + 2\sum_{j=1}^{k-1}\left(1 - \frac{j}{k}\right)\rho_j \tag{6}$$

where ρ_j is the j^{th} autocorrelation of the asset's returns. In an efficient market, all VR(k)'s will equal one. A finding that VR(k)'s are greater than 1 points to positive autocorrelation in the data and values of less than 1 show that negative autocorrelation is present in the return's series (mean reversion).

Wright (2000) developed three non-parametric alternatives to the above Variance Ratio tests. According to Hoque, Kim and Pyun (2007), a major advantage of these tests is increased power when the data's distribution is highly non-normal, as is the case in all subperiods for gold returns; these are the appropriate tests to examine gold's weak-form efficiency. Wright (2000) also shows that the R1, R2 and S1 statistics developed do not suffer significantly if the data is heteroscedastic, as gold's returns are in all periods. Critical values for these tests are bootstrapped.

IV

Table 2 assesses the efficiency of the Gold Fixing using runs tests during the different periods detailed above. An oddity of this data relative to modern financial markets is the frequent days on which there is no price change: 14 per cent of days show a return of zero, with the vast majority of these coming in the pre-World War II period.[32] To deal with this issue we run this test in two ways, with all the data used in panel A and removing all zero return days from the sample for the tests in panel B. In panel B a

[32] This is unrelated to the issue of Nominal prices mentioned above.

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Table 2. *Runs tests of market efficiency*

	Panel A: All data			Panel B: No zeros		
	Observed	Expected	Z-stat	Observed	Expected	Z-stat
1919–25	676	690	−0.750	578	609	−1.705
1925–31	603	591	0.913	502	335	12.95***
1931–9	1,212	1,192	0.821	1,086	1,024	2.742**
1954–68	1,863	2,003	−4.628***	1,474	1,519	−1.648*

Note: ***, **, * denote significance at the 1%, 5% and 10% level, H_o: r = E(r).

positive return followed by a zero-return day and then another positive day is treated as a positive run of two days. This assumes that traders would view a zero-return day as there being no change to the direction of the price.

Panel A only finds the 1954–68 period to be inefficient with less runs than would be expected. This means that positive days are more likely to be followed by positive days and vice versa. The other periods have the number of runs we would expect based on chance. Results where zeros are removed in panel B show three periods as inefficient. The earliest periods are still found to be efficient while the final period, 1954–68, is also seen as inefficient. The two formulations of the test disagree on the two middle periods.

This implies that the dominance of the bullion banks and Bank of England in the 1919–25 period did keep the market more rational and harder to find patterns in returns that traders could profit from. The second period of officially determined prices is found to be inefficient as would be expected based on these price's inability to react to information as policymakers try to keep prices at their desired level, as predicted by Levich (1985).

Table 3 shows the results of Wright's (2000) non-parametric Rank Variance Ratio tests using daily returns, weekly average returns and Tuesday returns, to assess whether the frequency will impact the robustness of our results. Tuesday returns are investigated as many sources point to this as the busiest day on the Gold Fixing in the earlier periods. Bootstrapped critical values for the daily tests based on 10,000 repetitions are presented in Tables A1 and A2 in the Appendix. Critical values for Tuesday and weekly returns are available on request.[33]

The daily tests give strong evidence again that the market was efficient in the first subperiod as the null hypothesis of a Random Walk is not rejected in six of the nine tests carried out. Only the sign-based version of the test (S1) finds evidence of

[33] Parametric versions of the variance ratio tests, M2 and Automatic Variance ratio tests, were also carried out but are not discussed here due to the non-normality issue. The M2 finds most periods to be efficient while the Automatic Variance Ratio test fin inefficient in the 1925–31 and 1931–9 periods.

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Table 3. *Wright's non-parametric variance ratio tests*

		K=2			K=5			K=8		
		R1	R2	S1	R1	R2	S1	R1	R2	S1
1919–25	Daily	0.623	0.244	2.114 **	0.065	0.225	2.171 **	0.599	1.052	3.037 ***
	Tuesday	2.186 **	1.567 *	1.705 *	2.72 ***	2.576 ***	0.988	2.362 **	2.323 **	0.576
	Weekly	3.149 ***	3.426 ***	2.092 **	3.668 ***	4.331 ***	2.398 **	2.624 ***	3.257 ***	1.689 *
1925–31	Daily	−11.09 ***	−12.33 ***	16.80 ***	−10.30 ***	−11.44 ***	30.23 ***	−8.384 **	−9.630 ***	40.61 ***
	Tuesday	5.503 ***	5.329 ***	12.03 ***	6.375 ***	6.033 ***	21.47 ***	6.728 ***	5.999 ***	27.24 ***
	Weekly	−5.454 ***	−5.841 ***	4.338 ***	−3.818 ***	−4.431 **	10.356 ***	−3.336 ***	−3.826 ***	13.823 ***
1931–9	Daily	−2.054 **	−1.878 *	−0.203	−2.728 ***	−2.463 **	0.304	−1.941 **	−1.838 *	1.925 *
	Tuesday	1.692 *	1.339	3.366 ***	0.961	0.48	5.115 ***	0.335	0.007	6.133 ***
	Weekly	1.972 **	1.742 *	1.565 *	1.826 **	1.536 *	1.982 **	1.656 *	1.544 *	1.636 *
1954–68	Daily	5.014 ***	4.572 ***	9.575 ***	−1.157	−1.52	6.71 ***	0.009	−0.175	11.28 ***
	Tuesday	3.488 ***	3.283 ***	3.444 ***	5.629 ***	5.620 ***	5.950 ***	6.395 ***	6.639 ***	7.024 ***
	Weekly	1.989 **	2.321 **	0.809	1.853*	2.013 **	0.174	1.584 *	1.321	0.522

inefficiency. These results seem to point to an efficient market where professional traders prevented easy returns being made by looking at daily returns price patterns.

However, if we instead look at the results of Tuesday and weekly returns a different picture emerges. These imply that at these frequencies the returns were trending, as the statistical values calculated are all positive, so that positive Tuesdays were more likely to be followed by positive Tuesdays, and vice versa with the same finding for weekly average returns. This shows that while those who were unaware of the importance of Tuesdays would have been unable to earn abnormally high returns, traders who were better informed, such as those in the bullion banks, would have been would have been able to profit from the market's inefficiency. While the choice of lag lengths is arbitrary, including too long a lag length can reduce the test's power as it includes a number of individually insignificant autocorrelations, meaning that on balance the results of shorter lags should be given more weight (Campbell, Lo and MacKinlay 1997). As two-thirds of the tests undertaken for this period show an inefficient market with the majority of this at shorter lag lengths, profitable opportunities did exist for better-informed participants of the Gold Fixing.

In the second market price period (1931–9) there is again strong evidence of inefficiency, at all three frequencies and tests, and again at shorter lags. Even though we saw that this market showed a significantly increased interest from private hoarders, this provides evidence that they did not manage to trade away the inefficiencies that had existed in the previous market price period. They appear to fit the role of noise traders not reacting rationally to news as it emerged and instead following patterns in the historical data.

The official price-based phases of the Gold Fixing (1925–31 and 1954–68) are both found to be inefficient regardless of the lag chosen or frequency of returns examined. All tests in the earlier period agree, and though about 30 per cent of the tests for 1954–68 do find the market to be efficient, these are mostly at longer lag lengths. We can confidently say this period was inefficient, as was also found using the runs tests above. This finding of inefficiency during periods where the Gold Fixing's price changes were constrained by official policy matches the prediction of Levich (1985), who posited that the constraints imposed on the market by official actions would prevent prices from reacting to information as they should under the EMH.

V

This article presents the newly reconstructed daily gold prices that were traded at the London Gold Fixing auction from 1919 to 1968, the world's reference price for gold during this period when gold was still central to the worlds monetary system. Gold price data used to study this period has, up to now, assumed the price for gold on the London market was equal to the official US gold price converted at that day's exchange rate. While this is normally a fair approximation of prices on the Gold Fixing, this data allows researchers a more accurate examination of the fluctuations of the gold price. This data and market discussions of the time show that gold

prices could, and indeed did, deviate significantly from the official set prices due to shocks, such as the French demands for 99 per cent pure bars in the 1930s and the extraordinary level of demand for gold *hoarding* in 1961.

Annual London Bullion Bank letters, newspaper articles and official research from organisations such as the IMF helped this article to develop a picture of the gold market during this period showing that there was significant private demand from hoarders for gold beginning in the 1930s, which contemporary authors argue had significant effects on the price. While all sources should be treated with scepticism, these public accounts do align with the archival research on the market that has been undertaken by Harvey (2008) and Green (1978).

The results of the empirical tests of the EMH show clearly that the Gold Fixing was an inefficient auction throughout its existence. It failed to evolve over time to become more efficient, as might be expected under the Adaptive Markets Hypothesis (Lo 2004) and based on the results shown in this article, it is possible that those who participated in the daily auction were able to earn abnormal returns, greater than those justified by the risk being undertaken, through analysing price patterns. While modern markets have been shown to evolve and become more efficient over time (Urquhart and McGroarty 2016) this and studies of other financial markets prior to 1968 have shown a general failure of pre-Bretton Woods markets to meet the conditions of even weak-form efficiency (Bassino and Lagoarde-Segot 2015).

The gold price's inability to fully react to news during periods where prices on the Gold Fixing were officially set seem to be a primary reason that these periods are also being found to be inefficient. However, even in these periods of official prices they did sometimes manage to react to news despite the efforts of official actors in the gold market, breaching the official price ceilings twice for extended periods of time due to market forces, as discussed above. The evidence of these episodes is why we argue that the Gold Fixing prices reflect the true price of purchasing gold in Great British pounds during this period, while if we look at London prices from 1939 to 1954 these do not reflect true tradable prices as they never experience a breach of the official price.

Though the market did change over time, starting with a very narrow set of participants in 1919 mostly focused on purchases for official purposes and broadening out to include significant levels of private hoarding from the 1930s, these new actors did not help trade away these inefficiencies. Instead, they appear to have acted as uninformed noise traders for the most part, while some informed traders probably did recognise the patterns and benefit from them. Whether the inefficiency is caused by an inability to recognise the patterns or collusion on the part of the traders is unclear from historical sources, though as the modern gold market has seen cases of collusion in the current millennium (Schäfer, Hume and Rice 2014) it cannot be discounted as the source of the inefficiency.

The availability of this data to researchers will allow the question of the London Gold Fixing auctions' efficiency to be addressed through further statistical methods. Coupled with other data outside the gold price the question of whether the

market was semi-strong-form efficient could be addressed, and event study methodologies could be used to look for collusion around important events. We have established its growing importance as a financial asset to hoarders in the 1930s and this data will allow questions of its place in an investor's portfolio to be examined in terms of whether it offered diversification benefits as has been established for modern markets and whether it offered a safe-haven could also be addressed if other asset prices at the same frequency can be paired with it. Finally, studies following the work of Fliers and Colvin (2022) investigating issues surrounding the gold standard will now be able to access market prices for their work, rather than calculated prices from the American parity which we show was not the only determinant of the London Gold Fixing's price.

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Appendix

Table A1. *Wright's R1 and R2 bootstrapped critical values: daily data*

		K=2		K=5		K=8	
		R1	R2	R1	R2	R1	R2
1919–25	0.5%	−2.6155	−2.6928	−2.4868	−2.5330	−2.5488	−2.5499
	2.5%	−2.0066	−2.0218	−1.9890	−1.9565	−1.9692	−1.9624
	5%	−1.7078	−1.6855	−1.6783	−1.6626	−1.6972	−1.6962
	95%	1.5937	1.5868	1.5742	1.5239	1.5498	1.5239
	97.5	1.9440	1.9010	1.8914	1.8528	1.8634	1.8349
	99.5%	2.5441	2.5870	2.5150	2.5078	2.6320	2.5772
1925–31	0.5%	−2.6148	−2.5640	−2.5645	−2.5126	−2.5237	−2.4791
	2.5%	−2.0334	−2.0097	−1.9977	−1.9813	−1.9904	−1.9631
	5%	−1.7082	−1.6741	−1.6997	−1.7077	−1.7191	−1.7054
	95%	1.6131	1.6228	1.6051	1.5996	1.5784	1.5569
	97.5	1.9645	1.9305	1.9501	1.9236	1.9280	1.8955
	99.5%	2.6293	2.5991	2.6529	2.6798	2.6487	2.6997
1931–9	0.5%	−2.6606	−2.5711	−2.4996	−2.5194	−2.4675	−2.4471
	2.5%	−2.0365	−2.0262	−1.9535	−1.9469	−1.9487	−1.9643
	5%	−1.6961	−1.7101	−1.6645	−1.6643	−1.6649	−1.6960
	95%	1.5911	1.6039	1.5894	1.5905	1.5505	1.5419
	97.5	1.9450	1.9010	1.8938	1.8886	1.8789	1.8858
	99.5%	2.5389	2.5114	2.5416	2.5141	2.5642	2.5345
1954–68	0.5%	−2.5638	−2.5492	−2.5668	−2.5766	−2.5617	−2.5472
	2.5%	−2.0158	−2.0093	−1.9925	−1.9915	−1.9371	−1.9762
	5%	−1.6952	−1.6946	−1.6885	−1.6829	−1.6949	−1.6796
	95%	1.6092	1.5980	1.6075	1.6058	1.5917	1.5627
	97.5	1.9173	1.9358	1.9195	1.9333	1.8968	1.8920
	99.5%	2.5310	2.5796	2.5804	2.5157	2.5866	2.58047
1919–39	0.5%	−2.6511	−2.6474	−2.5135	−2.5323	−2.5201	−2.5278
	2.5%	−1.9991	−2.0137	−1.9916	−1.9846	−1.9595	−1.9604
	5%	−1.6734	−1.7069	−1.6906	−1.6889	−1.6721	−1.6621
	95%	1.5818	1.5987	1.5556	1.5686	1.5674	1.5705
	97.5	1.9228	1.9612	1.8862	1.8822	1.9078	1.9306
	99.5%	2.4898	2.5195	2.5403	2.5427	2.5602	2.5688

Note: Bootstrapped critical values estimated based on 10,000 repetitions.

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Table A2. *Wright's S1 bootstrapped critical values: daily data*

Sample period		K=2	K=5	K=8
1919–25	0.5%	−2.520	−2.499	−2.487
	2.5%	−1.989	−1.956	−1.884
	5%	−1.6712	−1.646	−1.648
	95%	1.618	1.666	1.651
	97.5	1.936	2.014	2.034
	99.5%	2.679	2.770	2.760
1925–31	0.5%	−2.564	−2.527	−2.446
	2.5%	−1.967	−1.927	−1.918
	5%	−1.668	−1.654	−1.659
	95%	1.618	1.618	1.632
	97.5	1.917	1.982	2.001
	99.5%	2.564	2.600	2.709
1931–9	0.5%	−2.552	−2.533	−2.482
	2.5%	−1.985	−1.975	−1.955
	5%	−1.636	−1.641	−1.647
	95%	1.636	1.625	1.624
	97.5	1.941	1.943	1.994
	99.5%	2.596	2.644	2.671
1954–68	0.5%	−2.530	−2.489	−2.486
	2.5%	−2.014	−1.947	−1.907
	5%	−1.681	−1.659	−1.652
	95%	1.621	1.615	1.637
	97.5	1.893	1.936	1.959
	99.5%	2.560	2.710	2.703
1919–39	0.5%	−2.548	−2.547	−2.498
	2.5%	−2.003	−1.950	−1.959
	5%	−1.648	−1.671	−1.655
	95%	1.621	1.622	1.601
	97.5	1.921	1.960	1.928
	99.5%	2.602	2.627	2.608

Note: Bootstrapped critical values estimated based on 10,000 repetitions.