Metals and mining

SHADES OF THE 1970S

Gold: September 1979 revisited

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Shades of the 1970s

Gold: September 1979 revisited

'If there ever was an area in which to do the exact opposite of that which the government and the media urge you to do that area is the purchasing of gold. Start buying gold now, regardless of price. By acting now, you will not have to react when it is too late…too late will be when the majority of the public finally figures out what is happening (to paper assets) and frantically tries to get aboard. Remember, if you are one of the ones holding paper in the end, you will have given away your products and services for nothing.' – Robert Ringer, US author

Analysing gold with respect to real interest rates

Since the end of 2022, the US Federal Reserve has reduced the size of the total US monetary base by US$896bn, or 14.0%. However, recent data suggest that this form of monetary tightening has now been brought to a close in favour of another type – namely interest rate rises. In common with past reports, this report continues to predict future gold prices based upon the gold price's historically statistically significant relationships with 1) inflation, 2) the US monetary base and 3) US currency in circulation. In this case however, we have also added two further analyses: one that looks at gold in the context of the absolute level of the US Consumer Price Index (CPI) and one that looks at the gold price in the context of real US interest rates.

June 2023 directly analogous to October 1979

As has been well documented, since March 2022, the Fed has raised interest rates 11 times to result in real interest rates that have become meaningfully positive for the first time since late 2007 and, arguably, since early 2001. In so doing however, it has created a real interest rate profile that is almost directly analogous to the last time real interest rates became meaningfully positive for the first time in a long time, in October 1979.

History shows US$3,000/oz a realistic possibility

We believe that three features of the general, western economic crisis of the 1970s are relevant to current conditions both in the gold market and in the wider US economy. First, it heralded a period of significant volatility in real interest rates that lasted until December 1981. During this time, the gold price materially re-based itself from US$315/oz in August 1979 (when real interest rates were -0.438%) via US$382/oz in October 1979 (when real interest rates were 3.428%) to US$653/oz in January 1980 (when real interest rates were 0.091%). Second, the gold price did not peak until real interest rates attained a level of 4% on a sustainable basis in November 1980. This level of real interest rates not having remotely been reached and the Fed now seemingly pausing its tightening cycle, we believe that the gold bull market remains intact and that, while it is possible to predict a lower gold price in the next few years (down to US$1,126/oz if latent inflationary forces fail to come through and 2029 becomes the analogue of 1985), in the shorter term a number of our analyses demonstrate that a price in excess of US$3,000/oz is a realistic possibility and that one of US$4,500/oz is an outside possibility. Our updated gold price forecasts are shown in Exhibit 13 on page 8 of this report.

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Gold price executive summary

In common with past methodology, in this report, Edison has updated its gold price forecasts, derived with respect to the gold price's historical correlation with the total US monetary base, inflation and currency in circulation. We have also added two further analyses: one that looks at gold in the context of the absolute level of the US CPI and one that looks at the gold price in the context of real US interest rates (for these purposes, defined as the Fed funds rate minus the rate of US CPI inflation). Finally, we have brought the process all together with a series of multiple regression analyses that look at the price of gold in the context of these variables simultaneously.

What has changed

At the time of our last gold report, in June 2020, the world was in the early stages of the COVID-19 pandemic. Having effectively abandoned its balance sheet tapering plan the previous autumn in response to stress in the repo market, when COVID-19 hit, the Federal Reserve returned to bond buying with a vengeance. After cutting interest rates to (effectively) zero and initially saying it would buy US$700bn in bonds, on 23 March 2020 it took off all the brakes and made the programme open-ended saying that it would 'purchase Treasury securities and agency mortgage-backed securities in the amounts needed to support smooth market functioning and effective transmission of monetary policy to broader financial conditions and the economy'. Where before we had expected the total US monetary base to stabilise at US$3,240bn, at the time of our last note, it had already expanded to US$5,069bn and would increase further to US$6,413bn by the end of 2021. It has since fallen back to US$5,517bn. However, the Fed's plan, since the beginning of May 2022, to reduce its bond holdings by US$95bn per month appears to have run its course.

**Exhibit 1: Total US monetary base, December 2021 to July 2023 (US$bn)**
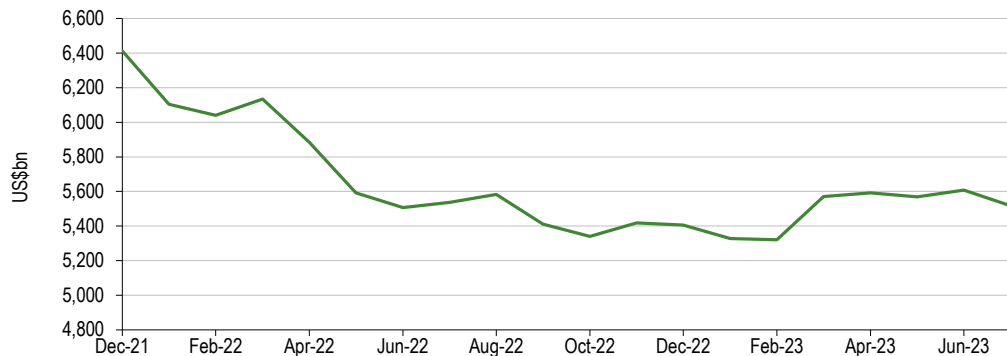
Source: US Federal Reserve

While it is possible that the Fed is still reducing its bond holdings by US$95bn/month, the implication of the largely static total US monetary base since October 2022 (arguably May 2022) is that the Fed must be reinvesting the proceeds of bond sales into other assets, rather than cancelling them and reducing the overall size of its balance sheet. As a result, the current level of the total US monetary base is:

1. US$3,399.0bn (or 160.5%) higher than it would have been had quantitative easing never taken place.

2. US$2,959.2bn (or 53.6%) higher than it would have been had tapering been executed according to plan (denoted 'Previous estimate (November 2017)' in Exhibit 2, below.

3. US$2,277.3bn (or 42.3%) higher than our estimate after tapering was brought to a premature end in 2019 (denoted 'Previous estimate (August 2019)' in Exhibit 2, below.

Exhibit 2: Total US monetary base (US$bn), 1959–2030e
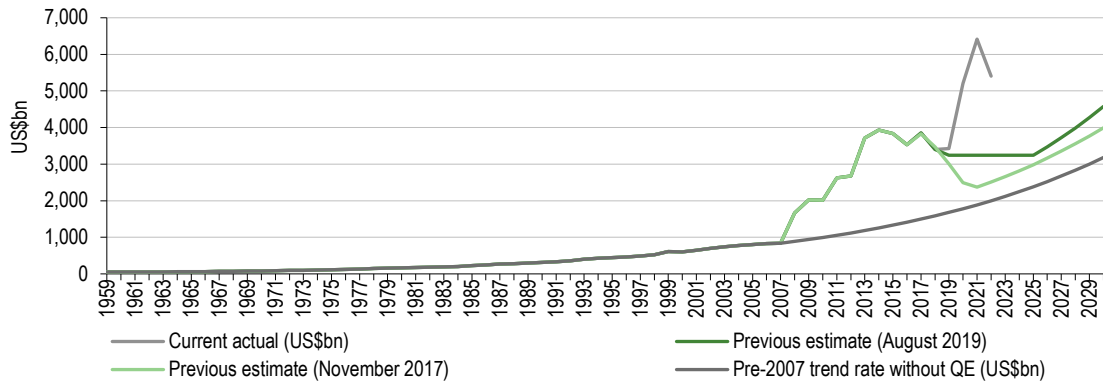
Source: US Federal Reserve, Edison Investment Research

However, while the Fed appears to have abandoned one form of tightening, as is by now well known, it has taken up another in the form of a series of interest rises since March 2022 that have resulted in a 5.25 percentage point increase in the Fed funds rate and real interest rates becoming meaningfully positive for the first time since late 2007 and, arguably, since early 2001:

Exhibit 3: US real interest rates* 2000–23

Source: Edison Investment Research (underlying data Bloomberg). Note: *Defined as the effective Fed funds rate minus US CPI inflation.

Why is this relevant to gold?

All of the above is relevant to gold for two reasons:

- Historically the price of gold has had statistically significant relationships with the total US monetary base, currency in circulation and the absolute level of the CPI.
- It also has a statistically significant – albeit slightly more complex – relationship with real interest rates.

In addition, we have analysed the price of gold in the context of its indexed price since January 1934, when it was first set at US$35/oz by the Roosevelt administration via the Gold Reserve Act.

Key findings

Given the level of the total US monetary base, currency in circulation and the absolute level of the CPI plus how we would expect them to evolve over time – largely based on long-term trend rates – our gold price scenarios for the rest of the decade (on the basis of their long-term correlations alone) are as follows:

Exhibit 4: Gold price scenarios (US$/oz) based on three different methodologies (nominal values)

Basis	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
CPI	1,514	1,585	1,659	1,736	1,815	1,898	1,985	2,075
Total US monetary base	1,898	1,998	2,104	2,216	2,335	2,461	2,594	2,736
Currency in circulation	1,969	2,104	2,248	2,402	2,567	2,744	2,934	3,137
Average	**1,794**	**1,896**	**2,004**	**2,118**	**2,239**	**2,368**	**2,504**	**2,649**

Source: Edison Investment Research

One obvious conclusion at this juncture is that, while gold appears to be relatively expensive with respect to the absolute level of the CPI, it is at about the correct level given the size of the total US monetary base and currency in circulation. Among other things, this could point to latent inflationary pressures still within the US economy. In this context, it is worth noting that the US experienced what might be described as enhanced inflation for more than a decade after Paul Volcker attempted to control it from late 1979.

At the same time, there are striking similarities between what may be regarded as the general economic crisis of 2004–23 and the one from 1971–81, with the emergence of the US into an environment of meaningfully positive real interest rates in May 2023 conspicuously analogous to October 1979:

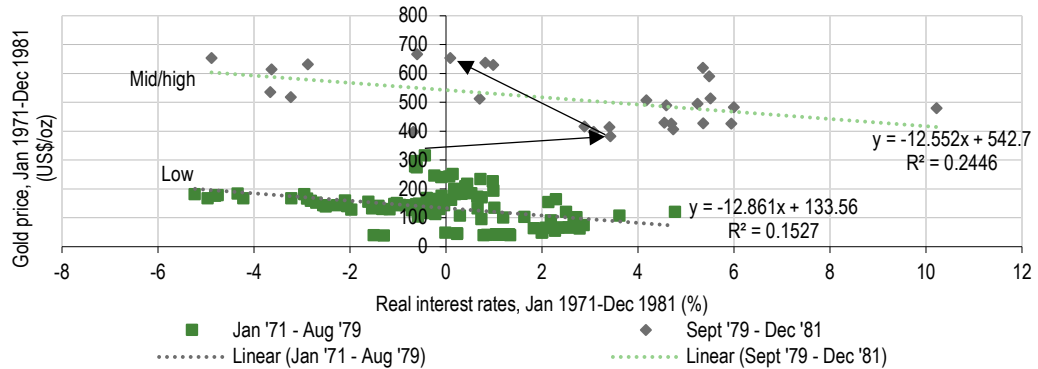**Exhibit 5: US real interest rates (%) vs the gold price (US$/oz), 1970–81 and 2004–23**
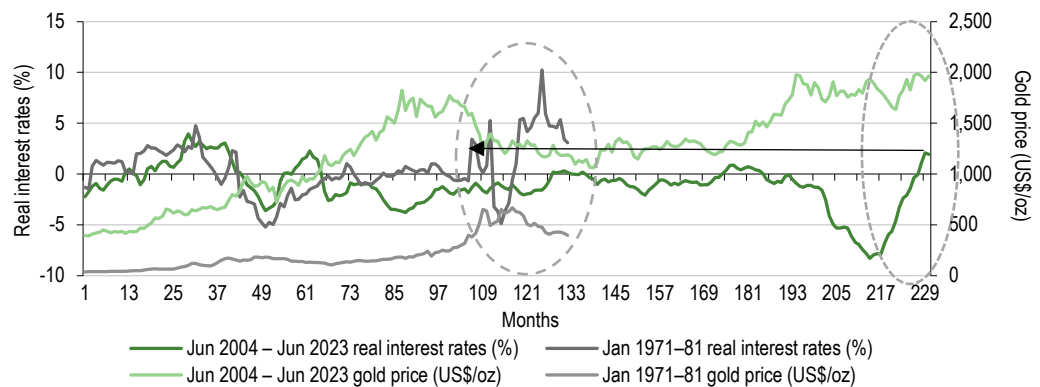
Source: Edison Investment Research (underlying data: Bloomberg, monthly)

The arrow demonstrates the last time that real interest rates in the US became similarly, meaningfully positive for the first time after a long period of being either negative or near zero (in October 1979). The earlier crisis being seen as a good analogue for the current condition of the US economy, it is not unreasonable to assume the following:

- A period of material volatility in real interest rates; this may take the form of volatility in either nominal interest rates or inflation or both simultaneously.
- That the gold price will not peak until real interest rates can be seen to reasonably exceed at least 4% for a sustained period of time.

In addition, the gold price materially re-based itself from US$315/oz in August 1979 (when real interest rates were -0.438%) via US$382/oz in October 1979 (when real interest rates were 3.428%) to US$653/oz in January 1980 (when real interest rates were 0.091%), as shown by the arrows in the graph below:

Exhibit 6: US real interest rates (%) versus gold price (US$/oz), January 1971 to August 1979 and September 1979 to December 1981

Source: Edison Investment Research (underlying data: Bloomberg, monthly)

Depending on the interpretation of the mathematics, a similar re-basing now would see the gold price trading around either the 'mid' (which is US$409.14/oz above the 'low' line – ie the difference between the two lines in Exhibit 6: 542.7 minus 133.56) or the 'high' (which is 4.06x the low line – ie the multiple between the constants of the two lines in Exhibit 6: 542.7 divided by 133.56) lines in the following graph (the 'low' line being the line that it has traded around in the crisis, to date):

Exhibit 7: US real interest rates (%) versus gold price (US$/oz), 2004–23 plus potential second phase indicators (the 'mid' and 'high' lines)
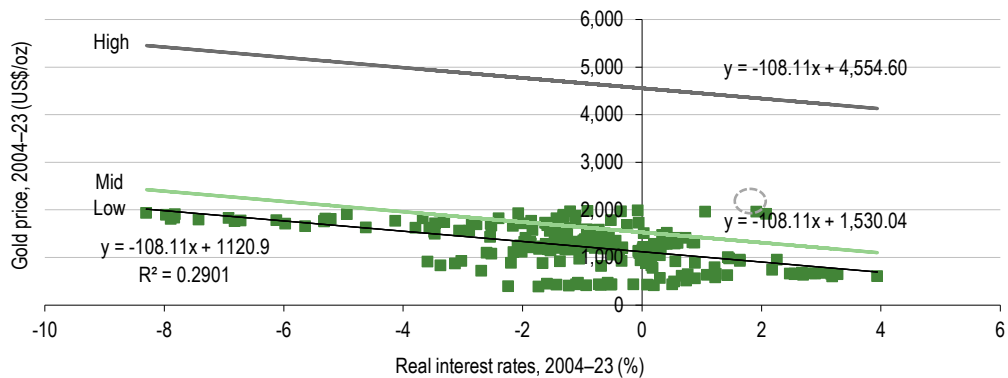
Source: Edison Investment Research (underlying data: Bloomberg, monthly)

Readers are reminded that the 'mid' and the 'high' lines in Exhibit 7 bear the same relationship to the 'low' line as the 'mid/high' line does to the 'low' line in Exhibit 6. In the event of real interest rates from August 2023 onwards following the path of October 1979 onwards, our gold price forecasts for the remainder of the decade would then be as follows (based on the three different correlations):

Exhibit 8: Gold price scenarios (US$/oz) based on three different correlations

Basis	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Real interest rates (%)*	0.8	4.6	7.2	5.0	5.0	5.0	4.8	4.0
Low	1,525	1,058	530	479	484	485	635	594
Mid	1,696	1,467	939	888	894	894	1,044	1,003
High	**2,956**	**4,492**	**3,964**	**3,913**	**3,918**	**3,919**	**4,069**	**4,027**

Source: Edison Investment Research. Note: *December.

Given the level of miners' costs (average all-in sustain cost (AISC) in Q123 US$1,358/oz: source World Gold Council and Metals Focus), we would regard the gold prices implied by even the 'mid' level correlation in the above table as being unsustainable from FY25. As a result, we therefore favour the outputs of the 'high' level correlation in formulating our gold price forecasts on the basis of real US interest rates.

Summary conclusions

A summary of our gold price scenarios, derived according to the methods set out heretofore, is as follows:

Exhibit 9: Gold price scenarios (US$/oz) based on five different methodologies

Basis	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Non-cycle adjusted								
CPI	1,514	1,585	1,659	1,736	1,815	1,898	1,985	2,075
Total US monetary base	1,898	1,998	2,104	2,216	2,335	2,461	2,594	2,736
Currency in circulation	1,969	2,104	2,248	2,402	2,567	2,744	2,934	3,137
Average	**1,794**	**1,896**	**2,004**	**2,118**	**2,239**	**2,368**	**2,504**	**2,649**
Cycle adjusted								
Inflation	2,178	2,266	1,617	1,324	1,498	1,277	1,126	1,343
Real interest rates	2,956	4,492	3,964	3,913	3,918	3,919	4,069	4,027
Average	**2,567**	**3,379**	**2,791**	**2,619**	**2,708**	**2,598**	**2,598**	**2,685**
Average	**2,103**	**2,489**	**2,318**	**2,318**	**2,427**	**2,460**	**2,542**	**2,664**

Source: Edison Investment Research

Superimposing the cycle onto our forecasts

Notwithstanding our prior analysis, one of the key unknowns in the arc of future gold price movements is the position of the US economy within its cycle. Exhibit 10 – demonstrating the divergence of the gold price from the value implied by its correlation – illustrates the point.

Exhibit 10: Variation of actual gold price versus that predicted by currency in circulation correlation, 1968–2022
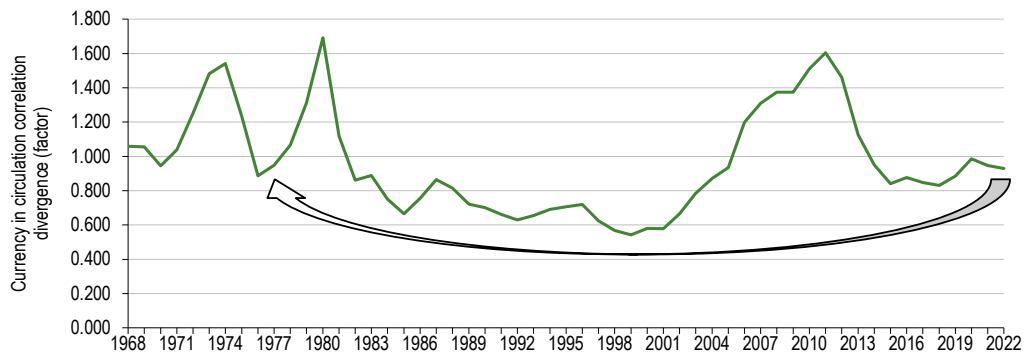
Source: Edison Investment Research (underlying data: US Federal Reserve, South African Chamber of Mines, Bloomberg, dollardaze.org)

The chart may be interpreted as measuring the amount of speculative pressure incorporated into the price of gold. In this case, it shows the divergence from the price implied by gold's correlation with US currency in circulation. However, the broad pattern of three peaks is also common to its correlation with the US CPI and the total US monetary base. Of note is the almost exact repetition of a 60% price premium in each of the obvious three prior gold price bull markets, in 2011, 1980 and 1974. Also of note is the similarity between current market conditions and those in 1976 (as measured by the variance between actual and predicted prices in Exhibit 10), opening up the possibility that, if 2011 was an analogue for 1974 and 2022 is an analogue for 1976, then there may be another peak in the near future equating to 'another' 1980. In this case, the past level of divergence from balanced conditions suggests that the gold price could trade anywhere in a range up to US$3,278/oz (equivalent to the 69.2% premium experienced in 1980).

Increasingly however – and particularly on the basis of the arc of recent real interest rate rises – we believe that the current circumstances of the US economy are analogous to those in September

1979 (±one month). In that case, given historical divergence from their respective correlations (Exhibits 10, 24, 36 and 49), we would anticipate gold prices to evolve as follows:

Exhibit 11: Predicted gold price (US$/oz) based on five different methodologies*

Basis	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Inflation	2,178	2,266	1,617	1,324	1,498	1,277	1,126	1,343
CPI	3,117	3,263	1,643	1,334	1,592	1,382	1,282	1,642
Total US monetary base	3,077	3,257	2,294	1,885	2,094	1,850	1,689	1,989
Currency in circulation	3,333	3,560	2,514	2,067	2,281	2,061	1,950	2,371
Real interest rates	2,956	4,492	3,964	3,913	3,918	3,919	4,069	4,027
Average	**2,932**	**3,368**	**2,406**	**2,105**	**2,277**	**2,098**	**2,023**	**2,274**

Source: Edison Investment Research. Note: *Assuming the price of gold and the US economy evolve from July 2023 onwards in the same way that they did from September 1979 onwards.

Bringing it all together

In the previous examples, we have analysed the gold price individually with respect to US CPI inflation, the total US monetary base, the absolute level of the Consumer Price Index and real interest rates. However, it is also possible to analyse it with respect to any or all of these variables simultaneously. If we do, then a summary of the results, depending on the regressors, is as follows (compared with the results of the previous analyses in Exhibits 9 and 11):

Exhibit 12: Predicted gold price, 2023–30e, based three multiple regression analyses (US$/oz)

Year	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Average of non-cycle adjusted (Exhibit 9)	1,794	1,896	2,004	2,118	2,239	2,368	2,504	2,649
Average of cyclically adjusted (Exhibit 11)	2,932	3,368	2,406	2,105	2,277	2,098	2,023	2,274
Predicted gold price (CPI, CiC, TUSMB & RiR)	1,866	1,982	2,092	2,167	2,264	2,366	2,470	2,574
Predicted gold price (CPI & TUSMB)	1,883	1,982	2,086	2,196	2,312	2,434	2,564	2,700
Predicted gold price (TUSMB & RiR)	1,939	2,091	2,234	2,319	2,440	2,569	2,701	2,835
Average of multiple regression analyses	**1,896**	**2,018**	**2,137**	**2,227**	**2,339**	**2,456**	**2,578**	**2,703**

Source: Edison Investment Research. Note: Grey highlights are the lowest predicted gold price for the year.

In the table above:
- CPI is the absolute level of the US CPI.
- CiC is US currency in circulation in US$bn.
- TUSMB is the total US monetary base in US$bn.
- RiR is real US interest rates (for these purposes, defined as the effective Fed funds rate minus CPI inflation) expressed in percent.

While we recognise that there is significant scope for upside in the price of gold relative to our scenarios, in deference to the principle of conservatism, for the purposes of our gold equity valuations, we have decided to make our formal gold price forecasts the lowest number from each year shown above (highlighted in grey). Nevertheless, this remains a considerable increase relative to our prior forecasts (see A Golden Future published in June 2020), as shown below.

Exhibit 13: Edison gold price forecasts, nominal and real (US$/oz), current cf prior

Year	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Current forecast (nominal US$/oz)	**1,896**	**2,004**	**2,105**	**2,239**	**2,098**	**2,023**	**2,274**
Current forecast (real, 2023 US$)	**1,822**	**1,851**	**1,869**	**1,912**	**1,722**	**1,596**	**1,725**
Prior (nominal US$/oz)*	1,892	1,892	1,892	1,892	1,892	1,892	1,892
Prior (real, 2023 US$)	1,819	1,749	1,681	1,617	1,555	1,495	1,437
Increase (nominal, US$/oz)	**4**	**112**	**213**	**347**	**206**	**131**	**382**
Increase (nominal, %)	**0.2**	**5.9**	**11.2**	**18.3**	**10.9**	**6.9**	**20.2**
Increase (real, US$/oz)	**3**	**102**	**188**	**295**	**167**	**101**	**288**
Increase (real, %)	**0.2**	**5.9**	**11.2**	**18.2**	**10.7**	**6.8**	**20.0**

Source: Edison Investment Research. Note: *See A Golden Future published in June 2020.

Graphically, the same forecasts (plus the contingent scenarios in Exhibit 12) may be depicted as follows:

Exhibit 14: Edison gold price forecasts plus contingent scenarios (US$/oz), 2024–30e
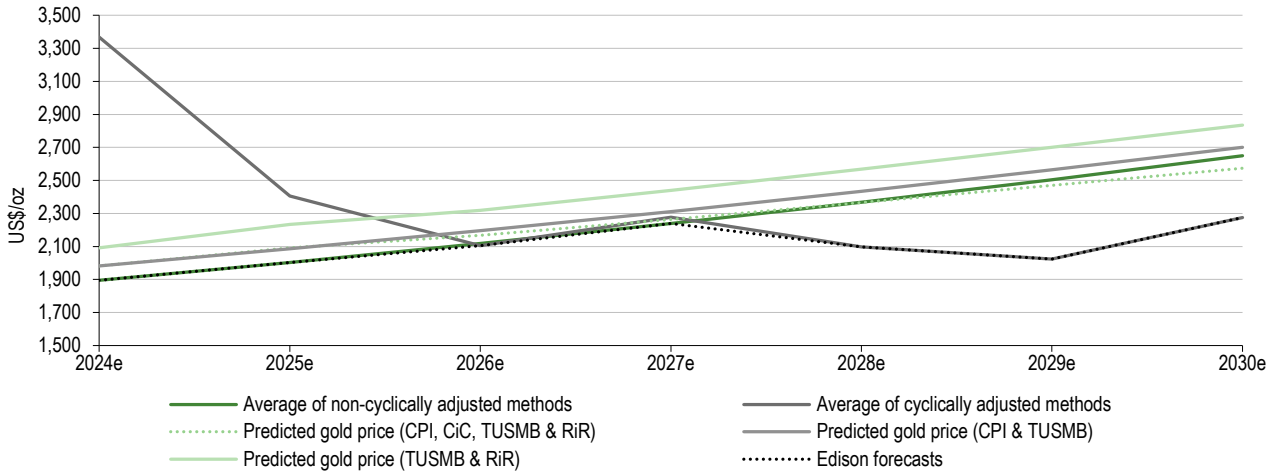
Source: Edison Investment Research. Note: CPI = the absolute level of the US CPI; CiC = US currency in circulation; TUSMB = total US monetary base; RiR = real US interest rates.

Gold price

Edison's long-term gold price forecasts have traditionally been based on the gold price's historical relationships with 1) inflation, 2) the US monetary base and 3) US currency in circulation. In this report, we have added two further analyses: one that looks at gold in the context of the absolute level of the US CPI and one that looks at the gold price in the context of real US interest rates (for these purposes, defined as the Fed funds rate minus the rate of US CPI inflation).

The gold price's relationship with US inflation

Since 1945, gold can be seen to have undergone at least two completed bull and three completed bear markets:

- In real terms, a bear market between 1945 and 1967 (a period that was characterised by inflation and positive real interest rates, while the price of gold was fixed at US$35/oz).
- A bull market between 1968 and 1980 (a period of financial crisis, negative real interest rates and/or unconventional monetary policy).
- A bear market from 1980 to 2001 (an environment of positive real interest rates).
- A bull market again from 2001 to 2012 (again characterised by political and/or financial crises, negative real interest rates and unconventional monetary policy).
- A short bear market from 2012 until 2015 (or perhaps early 2019) in an environment of anticipated and actual Fed balance sheet contraction and the expectation of a resumption of positive real interest rates. Note that this short bear market could also be interpreted as a bear phase within a longer lasting bull market from 2001 to 2023, approximately analogous to 1976–77.
- A bull market once again, from early 2019, as Fed tapering was reversed in the face of the perceived weakening of the US economy in March 2019 and the reinflation of the Fed's balance sheet both before and in response to the COVID-19 crisis at the same time that interest rates were reduced to (effectively) zero and real interest rates went materially negative.

Exhibit 15, below, shows gold's bull and bear markets since 1945. It also shows the level of the US$35/oz gold price from 30 January 1934 inflated with official US CPI inflation.

Exhibit 15: Nominal gold price (1913–2022) and indexed from US$35/oz in January 1934 (US$/oz)
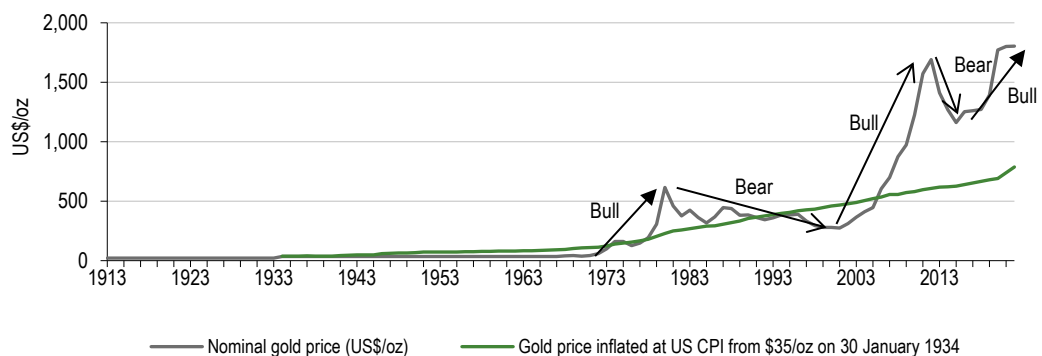
Source: Edison Investment Research, South African Chamber of Mines, Bloomberg (underlying data: US Department of Labor). Note: Prices are annual averages.

Between 1945 and 1971, the gold price was formally linked to the US dollar. Towards the end of this period, however, the US began both to run twin deficits and to expand the money supply. As a result, international creditors (particularly France) began to convert dollar foreign exchange reserves into gold, which put upward pressure on the price of gold and downward pressure on the

value of the dollar. After a series of initiatives aimed at preserving the Bretton Woods world order, President Nixon finally abandoned the link in August 1971. The subsequent devaluation of the dollar had the effect, among other things, of importing inflation into the United States, which jumped from a containable 3.4% in 1972 to a virtually unprecedented 8.7% in 1973. The Federal Reserve reacted conventionally by tightening monetary policy, which comprehensively burst the internal US credit bubble and started to suck markets into a debilitating debt-deflation spiral. In 1973–74, the Dow Jones Industrials average lost 45% of its value, while the US economy slowed from 7.2% real GDP growth in 1972 to a 2.1% contraction in 1974. Facing the prospect of a depression, the Fed reacted to the new threat by reducing interest rates to the minimum possible and by expanding the US monetary base. Inevitably, this put downward pressure on the value of the dollar in the foreign exchange markets and imported price rises, leading to a second peak in inflation later in 1979, which was only brought under control after Fed Chair Paul Volcker's eventual decision to raise interest rates to defend the dollar, albeit at the expense of a further debilitating recession in the early 1980s. Positive interest rates having once again been re-established, international markets returned to something approaching normality, albeit with the dollar (and sterling) at permanently lower levels compared to the currencies of resurgent international creditor nations such as Germany, France and Japan.

As positive real interest rates reasserted themselves in 1980, so currency markets stabilised and gold returned to a bear market phase that lasted until 2001 (analogous to the period of 1945–68). Hence, whereas the German mark appreciated by 66% against the US dollar during the 1970s, in 1999 the DEM/US$ rate was recognisably similar to that in 1980.

However, as the new millennium dawned (and after a period of relative economic stability) the US once again began to run twin deficits as a result of a combination of the 'war on terror' and the rise of a new economic competitor and international creditor in the form of China, which resulted in:

1. The return of negative real interest rates in 2001.

2. Inflation and a subsequent rise in interest rates in 2007.

3. The bursting of the credit bubble, subsequent banking failures (Bear Stearns, Lehman Brothers, etc) and the beginnings of a debt-deflation spiral in 2007–09.

4. The adoption of unconventional monetary policy in the form of record low nominal interest rates and three rounds of quantitative easing (QE1, QE2 and QE3) from 2008 until 2014.

5. The attempted partial reversal of a portion of quantitative easing from late 2017 until early 2019 in the form of tapering and the deliberate contraction of the Fed's balance sheet.

6. The effective end of tapering in mid-2019 in response to signs of stress in the repo market and a return, by the Fed, to its bond buying programme in late autumn 2019, buying US$60bn in Treasury bills per month until April 2020.

7. The reinflation of the Fed's balance sheet in response to the COVID-19 pandemic. After cutting interest rates (effectively) to zero and initially saying it would buy US$700bn in bonds, on 23 March 2020, the Fed took off all the brakes and made the programme open-ended saying that it would 'purchase Treasury securities and agency mortgage-backed securities in the amounts needed to support smooth market functioning and effective transmission of monetary policy to broader financial conditions and the economy'.

The waves of consumer price inflation inherent in these cycles in the US domestic economy may be seen in the following chart:

Exhibit 16: US consumer price inflation, 1965–2022
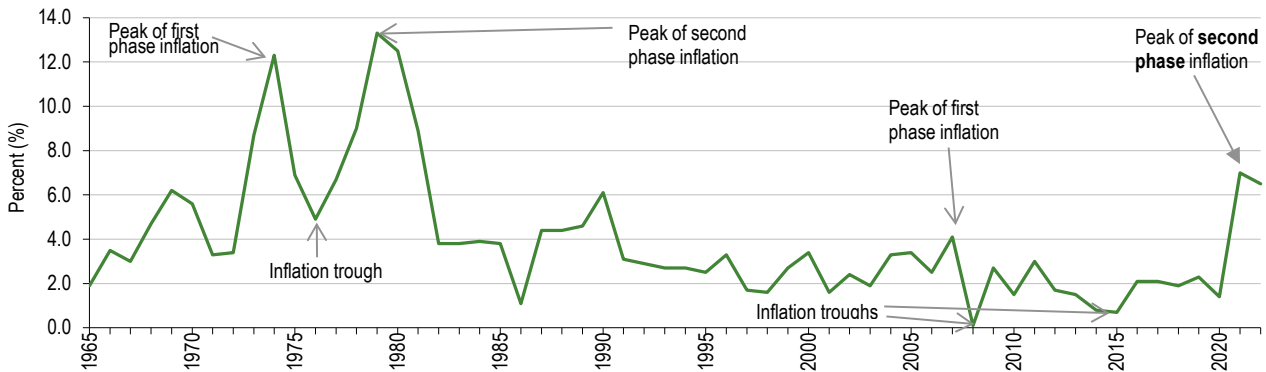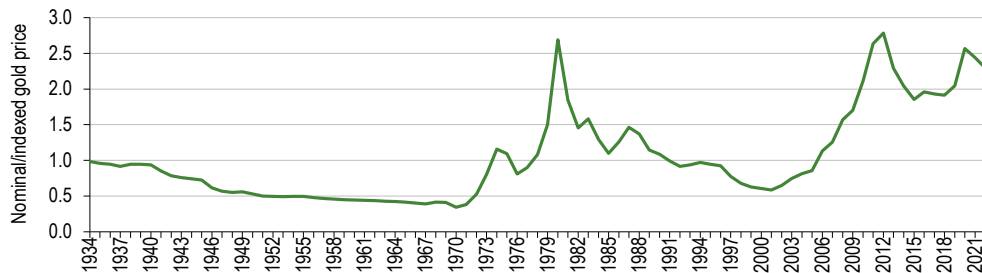

Source: US Department of Labor, Bureau of Labor Statistics (BLS)

One of the features of this analysis is the palpable extension of the 2004–22 inflation cycle relative to the 1970–80 cycle.

With respect to the gold price, the two completed bull and three bear markets may easily be seen by comparing the actual price of gold relative to its indexed price from US$35/oz in January 1934 (see Exhibit 15) using the US CPI, below:

Exhibit 17: Nominal gold price relative to indexed gold price,* 1934–2022

Source: Edison Investment Research (underlying data: Bloomberg, South African Chamber of Mines, US Department of Labor). Note: *See Exhibit 15, above.

Observing Exhibit 17, it is easy for gold bears to conclude that the peak in 2012 was analogous to that in 1980. However, it remains to be seen whether the 'second peak' in 2020 represents 'another 1980' or a temporary reprieve in an otherwise bear market analogous to either 1983 and/or 1987 in the earlier cycle. While it is tempting to see the 'second peak' in 2020 as a COVID-related aberration however, it is worth remembering that the initial uptick in the price of gold relative to its 1934 indexed level occurred in 2019 in response to stress in the repo markets and the reinflation of the Fed's balance sheet some months before the coronavirus outbreak in China became known to western markets. In fact, it was not until 31 December 2019 that the World Health Organization (WHO) was informed of a cluster of cases of pneumonia of unknown cause detected in Wuhan City, Hubei Province, China. Moreover, the level of the gold price (an average year to date price of US$1,931/oz and a 12-month US CPI inflation rate, as at August, of 3.7%) in 2023 can be seen to be similar to that in 1980 in real terms:
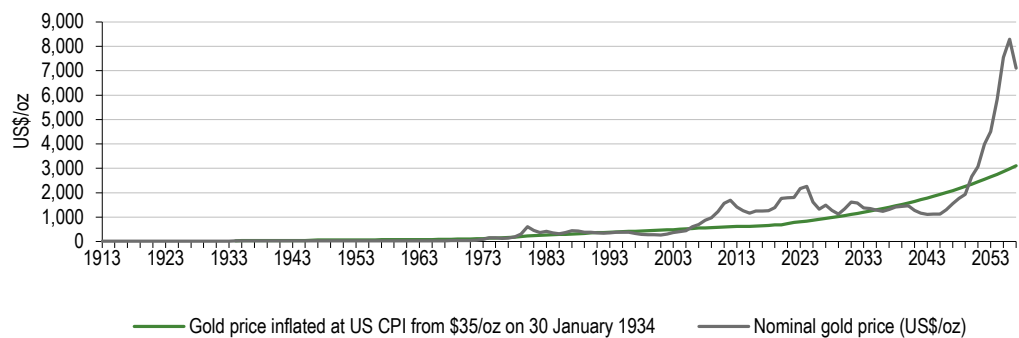
Exhibit 18: Gold price, 1913 to the present (real 2022 US$/oz and nominal)
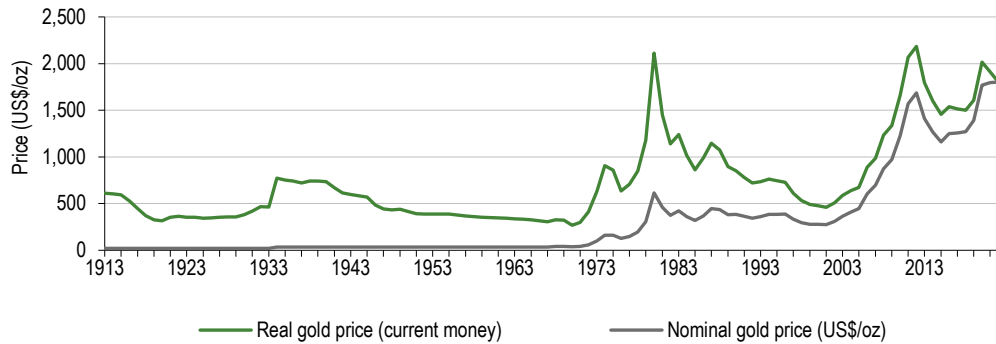
Source: Edison Investment Research, South African Chamber of Mines, Bloomberg (underlying data: US Department of Labor). Note: Prices are annual averages.

Assuming that the current time (September 2023) equates to late 1979 or early 1980 and projecting the indexed level of gold into the future at the same average historical rate of US CPI inflation between 1972 and 2022 of 4.0% and then applying the same cyclical discount or premium to it (depicted in Exhibit 18, above) allows us to generate the following future gold price profile:

Exhibit 19: Gold price, historical and forecast with respect to 1934 price (indexed), 1913–2057

Source: Edison Investment Research, South African Chamber of Mines, Bloomberg (underlying data: US Department of Labor). Note: Prices are annual averages.

In this case, we would expect the gold price to peak at US$2,266/oz in 2024, before starting a protracted 21-year bear market (analogous to 1981–2002) until 2045.

Tabulated for the near term, our gold price scenario, on this basis, is as shown below:

Exhibit 20: Gold price scenario, 2023–30e, based on indexed price since January 1934

Year	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Forecast gold price (US$/oz)	2,178	2,266	1,617	1,324	1,498	1,277	1,126	1,343

Source: Edison Investment Research

Correlation with US CPI

As well as considering the cycles of the actual gold price around its index-linked price, we can also consider gold's correlation with the absolute level of the CPI. In this case, we can see that the correlation between the two is good (with a Pearson product moment (correlation) coefficient, or PPMC) of 0.872 and that this correlation has been consistently statistically significant at the 5% level since at least 1968:

Exhibit 21: Gold price versus US CPI, regression analysis, 1959–2022
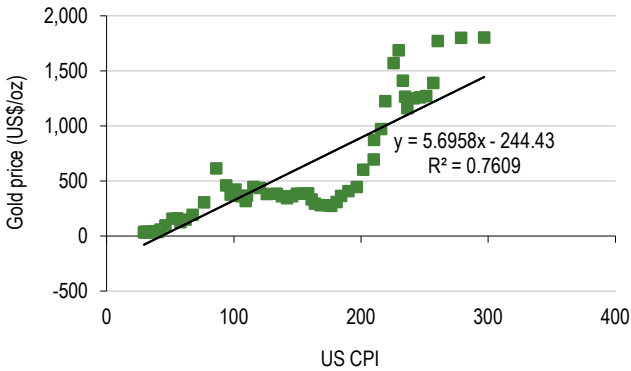
$y = 5.6958x - 244.43$
$R^2 = 0.7609$

Source: Edison Investment Research (underlying data: South African Chamber of Mines, Bloomberg, US Department of Labor).

**Exhibit 22: Gold price and US CPI correlation, 1968–2022**
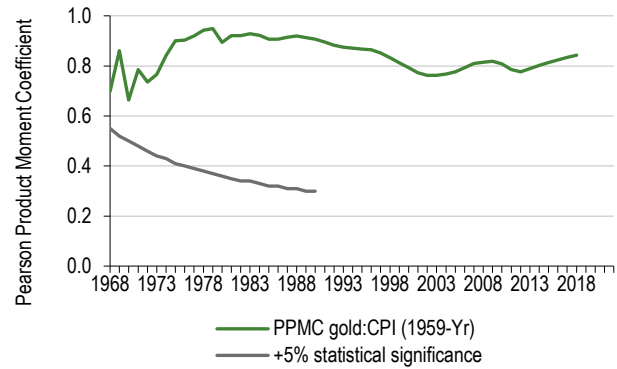
PPMC gold:CPI (1959-Yr)
+5% statistical significance

Source: Edison Investment Research (underlying data: South African Chamber of Mines, Bloomberg, US Department of Labor).

Exhibit 23 graphs the gold price and the US CPI index since 1959 and also the price of gold that would have been predicted by the correlation between the two as it would have been perceived at that time:

Exhibit 23: Gold price, US CPI and predicted gold price, 1959–2022
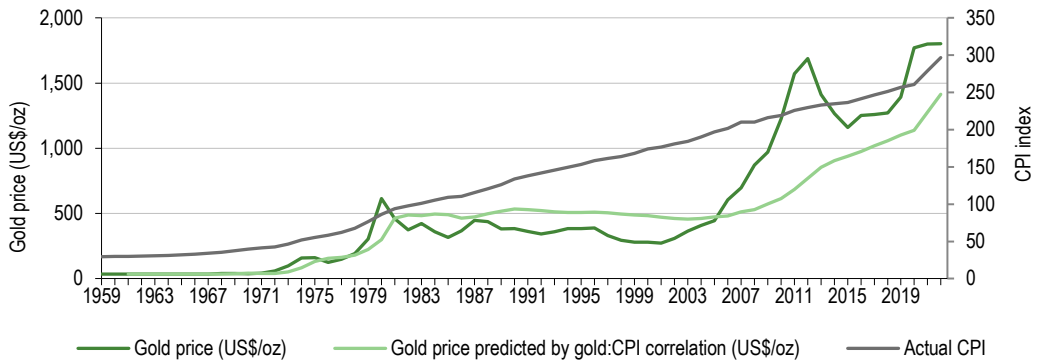
Gold price (US$/oz)   Gold price predicted by gold:CPI correlation (US$/oz)   Actual CPI

Source: Edison Investment Research, South African Chamber of Mines, Bloomberg, US Department of Labor

From this chart, and the chart below, it can be seen that the price of gold has ranged from a 129.6% premium to its predicted price (in 2011 – just above the peaks of 1980, 1974 and 1973) to a 43.0% discount (in 1999). On average however, it has traded at a 10.4% premium to its predicted price. In 2022, the actual price of gold was at a 27.4% premium to that predicted for the year by its correlation since 1959, albeit on a declining trend as inflation has picked up in the past two years:

Exhibit 24: Variation of actual gold price from that predicted by US CPI correlation, 1961–2022
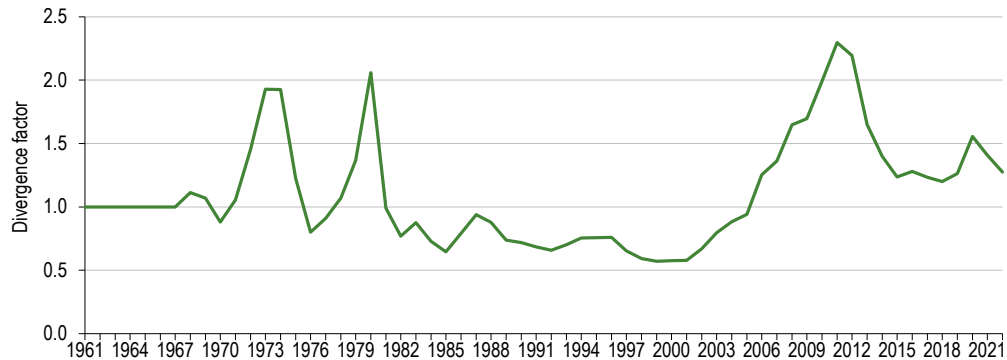
Source: Edison Investment Research (underlying data South African Chamber of Mines, Bloomberg, US Department of Labor).

If the US CPI should continue to advance in future years at its compound average rate since 1971 (of 4.0% per year), our gold price scenario – excluding any cyclical effect and based strictly on its most recently observed correlation – would be as follows:

Exhibit 25: Gold price scenario, 2023–30e, based on US CPI correlation

Year	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Forecast gold price (US$/oz)	1,514	1,585	1,659	1,736	1,815	1,898	1,985	2,075

Source: Edison Investment Research

Gold's relationship with the total US monetary base

In addition to its relationship with inflation and consumer prices, the gold price also exhibits a very close, statistically significant relationship with the US total monetary base. Since 1967, the relationship between the two elicits a PPMC of 0.934, which is statistically significant at the 5% level (ie there is less than a 5% chance that the relationship occurred by chance). This may be rationalised as the value of US gold holdings having a very close correlation with the total US monetary base (with a PPMC of 0.934 since 1967), which reduces to the gold price having a very close correlation with the total US monetary base, given that the US gold reserve by weight (ie in tonnes or ounces) has remained effectively unchanged since 1979 (and, to all intents and purposes, since 1972). The correlation between the two has also been strengthening in recent years (Exhibit 27). Stated alternatively, the more dollars that either are, or could be, in circulation, the higher the gold price should be expected to be, as shown in Exhibit 26:

Exhibit 26: Gold price versus US total monetary base, regression analysis, 1959–2022	Exhibit 27: Gold price and US total monetary base correlation, 1968–2022
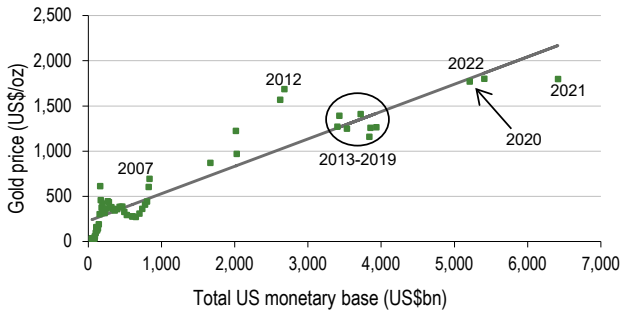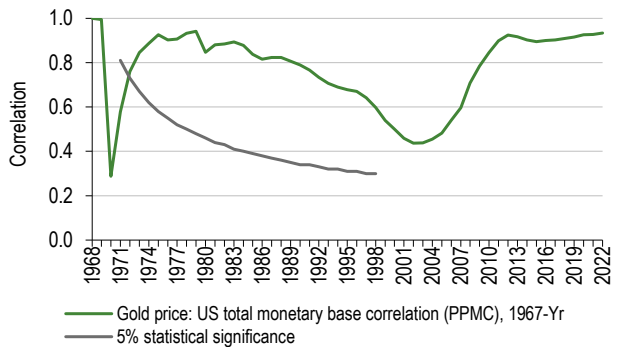
Source: Edison Investment Research, Bloomberg, South African Chamber of Mines, US Federal Reserve, dollardaze.org	Source: Edison Investment Research (underlying data: Bloomberg, South African Chamber of Mines, US Federal Reserve, dollardaze.org)

Recent history

Expansion

To put recent changes in monetary policy into context, in the seven years between 2007 and 2014, the Federal Reserve increased the US total monetary base by 4.7 times, or US$3.1tn, from US$0.8tn to US$3.9tn under the influence of QE1, QE2 and QE3 in response to the onset of the global financial crisis in 2007.

Exhibit 28: Total US monetary base, by decade, 1960–2010

Year	1960	1970	1980	1990	2000	2010	2020
Total US monetary base (US$bn)	49.8	81.0	163.0	313.6	596.9	2,017.0	5,206.6
Ratio cf prior decade (factor)		1.63	2.01	1.92	1.90	3.38	2.58

Source: US Federal Reserve, Edison Investment Research

Of note is the tendency for the total US monetary base to increase more in times of economic crisis (eg 1970–80 and 2000–20) and less in times of economic calm (eg 1960–70 and 1990–2000).

Stabilisation and attempted normalisation

When Janet Yellen announced the end of the Fed's bond buying programme in October 2014, the Federal Reserve's balance sheet had expanded to US$4.5tn (including US$2.5tn of Treasuries and US$1.8tn in mortgage-backed securities, or MBS) and the total US monetary base to US$3.9tn.

Up to that point, the Federal Reserve was believed to favour a relatively large balance sheet and therefore a relatively big presence in money markets. Until the election of Donald Trump as US president, the possibility that the Fed would actively sell securities to reduce its balance sheet was regarded as remote owing to the effect that such a policy could have on market interest rates and, potentially, volatility and the Fed was able to maintain a large balance sheet by reinvesting principal payments and maturing securities, such that the total monetary base remained at about the same US$3.9tn by the end of 2017 that it had been at the end of 2014. Over approximately the same timeframe, between December 2015 and December 2018, the Federal Reserve increased the Fed funds rate by 2.25 percentage points in nine hikes of 25bp each.

Prior to his election in 2016, however, Mr Trump had been highly critical of the Federal Reserve, while many Republican economists had actively criticised QE, with the result that, after he was elected, the Fed put in place a plan to actively reduce the size of its balance sheet.

Contraction/tapering

To soften the potentially deflationary impact of a shrinking balance sheet, at the Federal Reserve meeting in June 2017, committee members agreed that, rather than outright asset sales, they would start by letting US$6bn a month in maturing Treasuries run off, which would then increase to US$30bn a month, while MBS would run off at a rate of US$4bn a month, rising to US$20bn. Note that this total of US$50bn per month compared with the ultimate level of bond buying during QE3 of US$85bn per month. Moreover, while the rate of amortisation of MBS was estimated to be c 1% per month (such that the US$20bn maximum cap for MBS allowed for essentially unrestricted roll off), Treasury amortisation was uneven from month to month with the result that the US$30bn maximum monthly cap was anticipated to force the Fed to continue to purchase Treasury bonds in some months. Nevertheless, under the Federal Open Market Committee's then plan for Treasury roll off, the Federal Reserve's holdings of Treasury securities should have declined at a rate of c 11% per year. Any reduction in demand because of its shrinking balance sheet was to be mitigated by lowering the anticipated path of interest rate increases.

In November 2017, the Fed began its programme to reduce its balance sheet by US$1.48tn, or 33%, from US$4.5tn to US$3.0tn in a process that was essentially designed to at least partly reverse the quantitative easing of 2008–14 over a period of five years from 2017 to 2021 (but effectively three years, from 2018 to 2020).

Exhibit 29: Projected reduction of Federal Reserve's assets, by year (as at November 2017)

Year	Reduction (US$bn)	Percentage of total (%)
2017	20	1.4
2018	360	24.3
2019	463	31.3
2020	515	34.8
2021	122	8.2
Total	**1,480**	**100.0**

Source: Edison Investment Research

As a consequence, in the two years after the start of the asset reduction programme (namely 2017 and 2018), the Fed's progress (as reflected in the total US monetary base – ie the liabilities side of its balance sheet) declined almost exactly in line with Edison's prior forecasts:

Exhibit 30: Variation of actual total US monetary base versus Edison prior forecast, years 2017 and 2018

Year	Edison forecast of total US monetary base* (US$bn)	Actual year-end total US monetary base (US$bn)	Variance (actual vs forecast) (US$bn)	Variance (actual vs forecast) %
2017	3,827	3,851	+24	+0.6
2018	3,467	3,400	-66	-1.9

Source: US Federal Reserve, Edison Investment Research. Note: *See our report, Mining overview: Unlocking the price to NPV discount, published in November 2017.

In the long term, the Fed stated that it planned to keep its balance sheet 'appreciably below that seen in recent years but larger than before the financial crisis'. Once it fell below US$3.0tn, however, there was to be a further discussion as to how big the Fed's balance sheet should be once tapering was over.

Indications from the Fed chairman Jerome Powell, as late as November 2018, were that it would be some time before the Fed stopped raising rates and reducing its balance sheet as the asset reduction programme was deemed to be on 'auto-pilot'.

Under these circumstances, the earliest that the Federal Reserve could reasonably have started to expand its balance sheet once again was mid-2020.

Volte-face

However, as fears of a US slowdown mounted in early 2019 and the US yield curve flattened, the Fed materially altered its stance, saying it would begin to taper the amount of proceeds that it was allowing to roll off in May 2019 and would begin to reinvest the proceeds from the MBS's roll off in September – thus effectively keeping the total US monetary base on a flat – rather than declining – trajectory. Under the revised plan, the amount for allowable Treasury roll-off reduced to US$15bn per month in May (cf US$30bn previously). Moreover, beyond September, while technically still allowing the proceeds from MBS to roll off, in reality the Fed was to revert to something close to its former policy of reinvesting the proceeds into Treasury bonds.

Then, on 31 July 2019, the Fed brought forward the date of the end of the asset reduction programme to July from September. Simultaneously, it started a programme of rate reductions that saw the Fed funds rate cut for the first time in over a decade in August 2019 and declining by 75bp over three meetings between August and October.

At that point, the Federal Reserve stated that the average level of reserves would probably 'still be somewhat above the level of reserves necessary to efficiently and effectively implement monetary policy.' In that case, the committee anticipated that it would hold the size of the System Open Market Account (SOMA) portfolio roughly constant for a time. During this period, persistent gradual increases in currency and other non-reserve liabilities would be accompanied by corresponding gradual declines in reserve balances to a level consistent with efficient and effective implementation of monetary policy. When the committee judged that reserve balances had declined to that level, the SOMA portfolio was to hold no more securities than necessary for efficient and effective policy implementation. Once that point was reached, the committee would begin increasing its securities holdings to keep pace with trend growth of the Federal Reserve's non-reserve liabilities and maintain an appropriate level of reserves in the system.

At the time, Edison's forecasts for the total US monetary base for the remainder of the programme were adjusted to those shown in Exhibit 31, below (and compared with 2007 – the year immediately before quantitative easing):

Exhibit 31: Currency in circulation, reserve bank cash and total US monetary base, 2019–22 (US$bn), actual cf forecast

Year	2007	2019	2020	2021	2022
Forecast					
Currency in circulation	764	1,831	1,962	2,102	2,252
Reserve bank cash	73	1,408	1,278	1,138	988
Total US monetary base	**836**	**3,240**	**3,240**	**3,240**	**3,240**
Actual	**836**	**3,426**	**5,207**	**6,412**	**5,405**
Variance* (units)	N/A	+186	+1,967	+3,172	+2,165
Variance* (%)	N/A	+5.7	+60.7	+97.9	+66.8

Source: Edison Investment Research. Note: *Actuals cf forecast. See our report, Portents of economic weakness, published in August 2019. Totals may not add up owing to rounding.

According to this analysis, 2026 was the latest date by which the Fed would have needed to start expanding the total monetary base once again. In the event, while our 2019 forecast for the total US monetary base was tolerably close to the actual outcome, the emergence of the coronavirus pandemic in early 2020 – and the Fed's response to it – rapidly rendered our forecasts for all subsequent years obsolete (see below).

COVID-19

Then came the unexpected. In response to signs of stress in the repo market, in late autumn 2019 the Fed returned to its bond buying programme, buying US$60bn in Treasury bills per month until April 2020. At a stroke, this left the total US monetary base c 17%, or US$490bn, larger than had

originally been expected at the end of 2019. To put that in context, in 2007, immediately before the global financial crisis, the total US monetary base stood at just US$836bn. More importantly, it drew a line in the sand whereby thereafter Federal Reserve balance sheet expansions were once again on the cards. Then, when the COVID-19 crisis hit, the Federal Reserve returned to bond buying with a vengeance. After cutting interest rates to (effectively) zero and initially saying it would buy US$700bn in bonds, on 23 March it took off all the brakes and made the programme open-ended saying that it would 'purchase Treasury securities and agency mortgage-backed securities in the amounts needed to support smooth market functioning and effective transmission of monetary policy to broader financial conditions and the economy'.

Post-COVID-19

After almost 15 years of accommodative monetary policy, in December 2020, price pressures began to build in the economy, initially attributed to pandemic-related distortions to the global supply chain system and exacerbated by the container ship Ever Given becoming stuck in the Suez Canal for six days in March 2021 (NB despite contemporary reporting, ships blocking the Suez Canal are actually not such an uncommon occurrence). As a consequence, US consumer price inflation reached 7.0% (year-on-year) in December 2021, before being given additional momentum higher by Russia's invasion of Ukraine in February 2022. As the epidemiological effects of the COVID-19 crisis began to wane In March 2022, the US Federal Reserve approved its first interest rate increase in more than three years. In addition, at the beginning of May, it announced plans to reduce its bond holdings by US$95bn per month.

Since March 2022, it has continued with its programme of interest rate hikes, raising the Fed funds rate by a further 5 percentage points over the course of 10 meetings.

Exhibit 32: Post-COVID path of US interest rate increases (%)

FOMC meeting date	Rate change (bp)	Fed Funds rate (%)
26 July 2023	+25	5.25–5.50
3 May 2023	+25	5.00–5.25
22 March 2023	+25	4.75–5.00
1 February 2023	+25	4.50–4.75
14 December 2022	+50	4.25–4.50
2 November 2022	+75	3.75–4.00
21 September 2022	+75	3.00–3.25
27 July 2022	+75	2.25–2.50
16 June 2022	+75	1.50–1.75
5 May 2022	+50	0.75–1.00
17 March 2022	+25	0.25–0.50
Total	**+525**	

Source: US Federal Reserve

At the same time, however, while the pace of interest rate hikes may have been considered aggressive, the pace of Fed balance sheet reductions appears to have stagnated since at least February 2023 and, arguably, since May 2022 (albeit after an aggressive start):

Exhibit 33: Total US monetary base, December 2021 to July 2023 (US$bn)
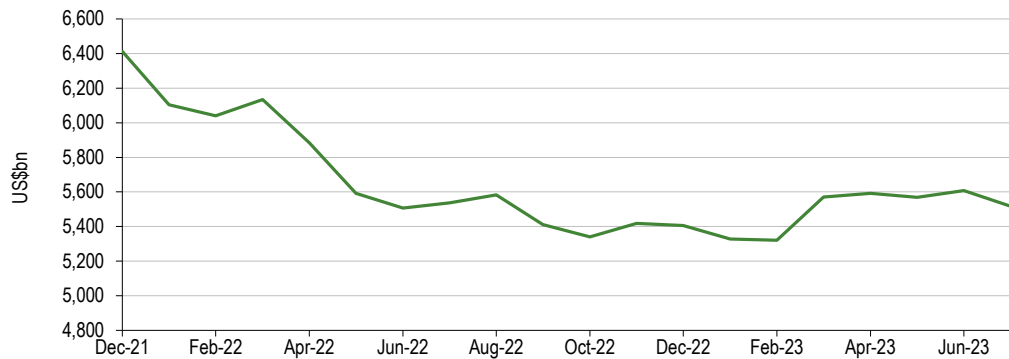
In the light of these changes to monetary policy – albeit often brought about by external circumstances – our forecasts for the size of the total US monetary base have changed substantially. Exhibit 34, below, shows:

1. The trend rate of growth of the total US monetary base since 2007 assuming that no QE had taken place nor subsequent tapering. In this case, we estimate that the total US monetary base at end-2023 would be US$2,118.2bn, rather than the US$5,517.2bn currently.

2. Edison's estimate of the level of the total US monetary base if the Fed's 2017 plan for tapering in the wake of QE had been pursued as originally intended. In this case, we estimated that the total US monetary base at end-2023 would have been US$2,558.0bn.

3. Edison's estimate of the level of the total US monetary base after tapering was brought to a premature conclusion in July 2019. In this case, we estimated that it would have been US$3,239.9bn as at end-2023.

4. The actual level of the total US monetary base in the wake of the COVID-19 reinflation and subsequent, albeit apparently truncated, balance sheet reduction (US$5,517.2bn).

Exhibit 34: Total US monetary base (US$bn), 1959–2030e
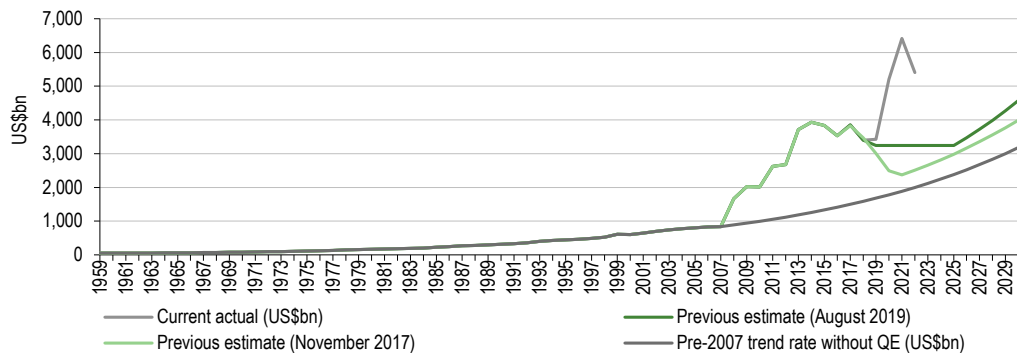
As such, the current level of the total US monetary base is:

- US$3,399.0bn (or 160.5%) higher than it would have been had QE never taken place.
- US$2,959.2bn (or 53.6%) higher than it would have been had tapering been executed according to plan (denoted 'Previous estimate (November 2017)' in Exhibit 34, above.
- US$2,277.3bn (or 42.3%) higher than our estimate after tapering was brought to a premature end (denoted 'Previous estimate (August 2019)' in Exhibit 34, above.

Historical gold price correlation with total US monetary base

Given the close statistical correlation between the gold price and the total US monetary base, these variances are significant. Exhibit 35 depicts the gold price and the US total monetary base since 1959, as well as a forecast estimate of the level of the gold price had it been predicted solely on the basis of its relationship with the US total monetary base as it would have been perceived at the time:

Exhibit 35: Gold price, US total monetary base and predicted gold price, 1959–2022
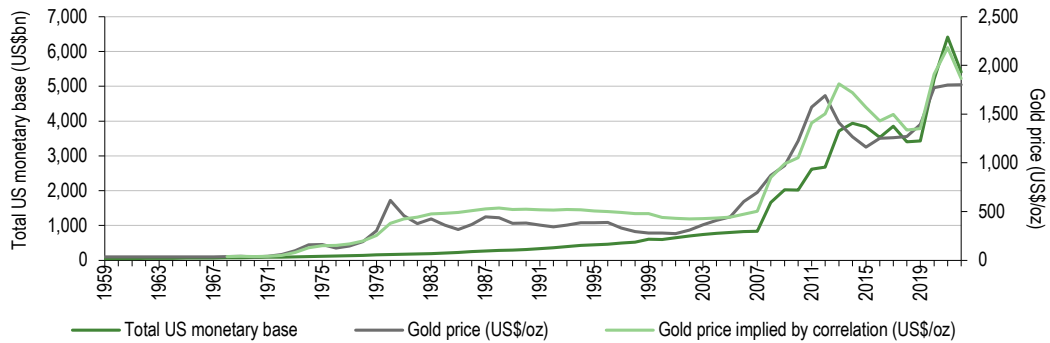
Source: Edison Investment Research, US Federal Reserve, South African Chamber of Mines, Bloomberg, dollardaze.org

Applying the strict mathematical historical relationship between the two, a total US monetary base of US$5,517bn at the end of July 2023 implies a gold price of US$1,898/oz – ie almost exactly where it is. Note that, statistically, the error of estimation of the regression analysis is ±US$188/oz, or 9.7% of the average price of gold to date in 2023 of US$1,931/oz.

As with inflation and the CPI, however, the gold price has diverged from the price implied by its correlation to the total US monetary base in the past to the following extent:

Exhibit 36: Variation of actual gold price from predicted, 1968–2022
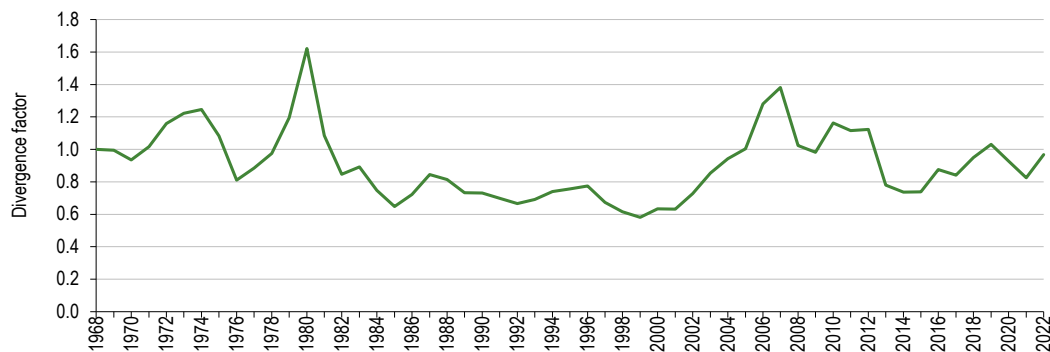
Source: Edison Investment Research (underlying historical data: US Federal Reserve, South African Chamber of Mines, Bloomberg, dollardaze.org)

Relative to the total US monetary base, the gold price can be seen to have reverted rapidly from the premiums that were typical of bull market conditions in 2005–12 to those that are typical of bear market conditions in 2013–17, but since recovered to something close to balanced market conditions.

While the current market appears balanced however, the past level of divergence from balanced conditions suggests that the gold price could trade anywhere in a range from US$3,076/oz (equivalent to the 62.1% premium experienced in 1980) to US$1,102/oz (equivalent to the 41.9% discount experienced in 1999). Future moves will, to a large extent, depend upon whether the Fed expands its balance sheet once again, contracts it or keeps it largely unchanged. Exhibit 33

certainly suggests that the Fed's May 2022 balance sheet contraction plan has run its course (in terms of reducing the Fed's balance sheet), while Exhibit 34 suggests that genuine, long-term contraction of its balance sheet is extremely hard to achieve. However, assuming that the total US monetary base remains flat for the remainder of 2023 and then begins to expand at its long-term trend rate from 1959 to 2007 of 6.0% per year, our gold price scenario (based on the strict mathematical correlation between the two) is:

Exhibit 37: Gold price scenario, 2023–30e based on total US monetary base correlation

Year	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Forecast gold price (US$/oz)	1,898	1,998	2,104	2,216	2,335	2,461	2,594	2,736

Source: Edison Investment Research

Reflecting a monetary paradox

From Edison's two analyses above, it can be concluded that the gold price is expensive with respect to indexed prices (or, stated alternatively, it has more than acquitted itself as a store of value and a hedge against inflation), but about right relative to the current level of the monetary base. At first glance this appears to be a paradox, especially since the relationship between prices in general and the total US monetary base has been extremely close in historical terms (eg a PPMC of 0.957 between 1959 and 2007):

Exhibit 38: Correlation (PPMC), total monetary base to US CPI index level, 1959–2022
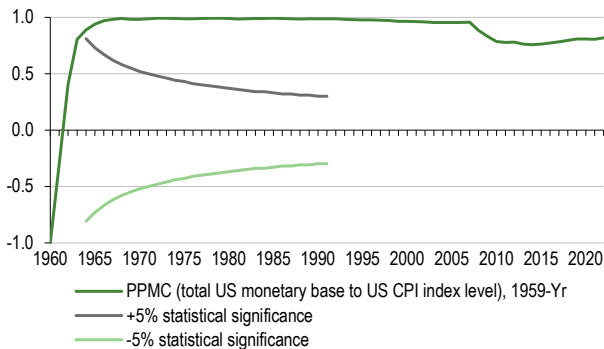
Source: Edison Investment Research (underlying data: US Department of Labor, US Federal Reserve, dollardaze.org)

Exhibit 39: Scattergram, total monetary base versus consumer price levels, 1959–2007
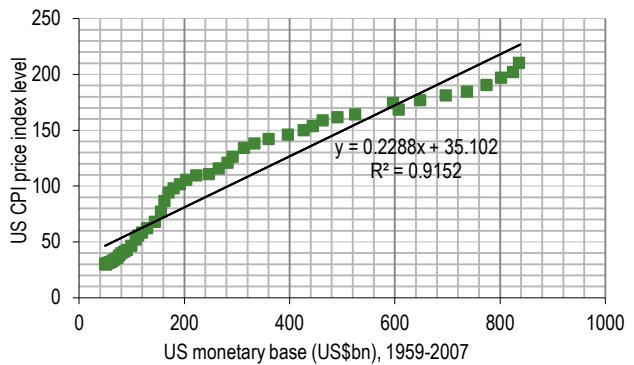
$y = 0.2288x + 35.102$
$R^2 = 0.9152$

Source: Edison Investment Research, US Department of Labor, US Federal Reserve, dollardaze.org

Since 2007, however, the relationship between the two appears to have broken down almost completely, with the US total monetary base having increased by 546.2% (until the end of 2022) at the same time as the US CPI has risen only 41.3% (or an average of 2.3% pa). Exhibit 40 demonstrates the degree of this divergence (cf Exhibit 39):

Exhibit 40: Scattergram, total monetary base vs US CPI level, 1959–2022
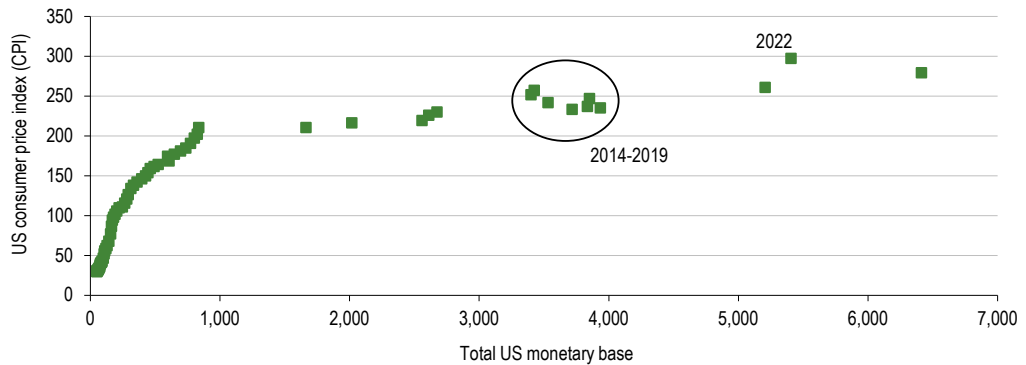
Source: Edison Investment Research, US Department of Labor, US Federal Reserve, dollardaze.org

This is all the more striking when the historical relationship between inflation and changes in the monetary base is considered. Traditionally (ie from 1959 until 2007), the total monetary base has increased at a rate of 6.0% per year (geometric mean), while inflation averaged 4.2% pa (geometric) over the same timeframe, with an increased risk of enhanced inflation if the total US monetary base increased by more than 4% in any one year. As shown below however, while inflation and the change in the monetary base can be shown to have been on the cusp of a statistically significant relationship at the 5% level between 1960 and 1972 and to have had one between 1994 and 2007 (ie indicating that there is less than a 5% chance that this relationship occurred by random chance), between 1973 and 1993, in what might have been regarded as a period of economic dislocation, the relationship was a) almost random and b) negative (ie a greater increase in the monetary base corresponded to lower, rather than higher, inflation):

Exhibit 41: Scattergram, US CPI inflation cf change in total US monetary base, 1960–2007
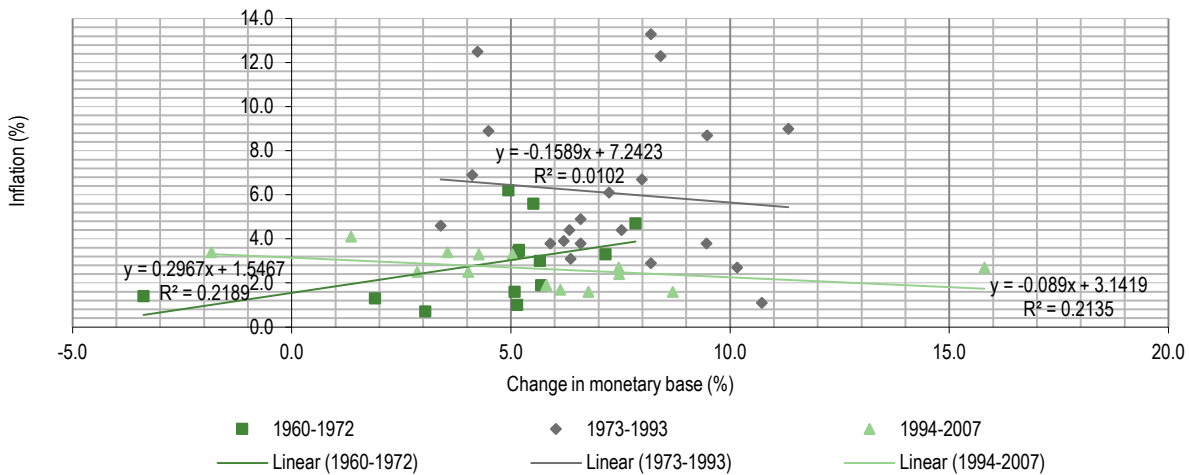
Source: Edison Investment Research, US Department of Labor, US Federal Reserve, dollardaze.org

This pattern of a coupled, decoupled, recoupled relationship between the monetary base and inflation could add nuance to conventional monetarist doctrine:

- Between 1960 and 1972 changes in the monetary base and inflation were, indeed, positively correlated and on the cusp of statistical significance at the 5% level (a PPMC of 0.468 being only fractionally less than the limit for a directional hypothesis for 13 data points of 0.48).
- Between 1973 and 1993 – a period of crisis and immediate post crisis characterised by increased inflation – there was effectively no discernible relationship between changes in the monetary base and inflation.

- Between 1994 and 2007, a reconnection in the relationship between changes in the monetary base and inflation, which is (just) statistically significant at the 5% level (a PPMC of 0.462 cf a 'directional' limit for 15 data points of 0.44), albeit apparently negative in the sense that greater changes in the monetary base actually correspond to lower, rather than higher, levels of inflation.

Since 2007, the relationship between the two has not been statistically significant at the 5% level. In addition, it has had a negative correlation coefficient, which, taking 1973–1993 as an analogue, implies that the US economy remains firmly in crisis (or perhaps immediate post crisis) mode:

Exhibit 42: Scattergram, US CPI inflation vs change in total US monetary base, 2007–22
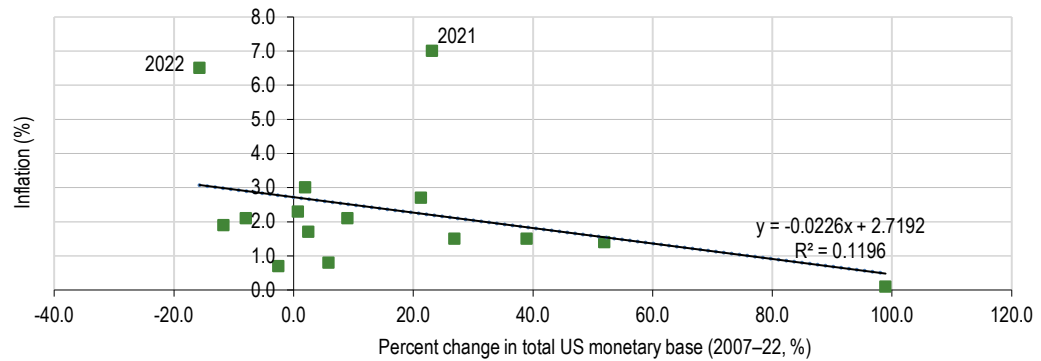
Source: Edison Investment Research, US Department of Labor, US Federal Reserve, dollardaze.org

Readers should note the widely differing axis ranges in Exhibits 41 and 42. One possible interpretation of this pattern is that, while a valid doctrine when the value of money was anchored to the price of gold (as in the period 1959–71), monetarist theory that excessive expansion of the money supply is inherently inflationary in the era of fiat money may require modification to include additional factors.

That said, should the close relationship between the total US monetary base and prices in the form of the absolute level of the CPI (ie Exhibit 39) reassert itself then, given the level of the former, we would expect the latter to stand at a level of 1,271.670 (cf 296.797 as at end-2022) or 4.28x its actual level. In this case, 1934's gold price of US$35/oz indexed to 2022 would stand not at US$785/oz (to which the 2022 average gold price was at a 129.5% premium – see Exhibits 15 & 17), but at US$3,364/oz, to which the 2022 average gold price would have been at a 42.6% (ie close to maximum) discount.

In this case, the 4.28x multiple could also be interpreted as measuring the additional, latent inflationary pressure within the US economy. Exhibit 43, below, shows how this may be dissipated over varying timeframes at different levels of annual inflation:

Exhibit 43: Annual inflation rate (%) required to dissipate latent inflationary pressure (as derived from the total US monetary base) over a predetermined timeframe

Years	Inflation rate (%)
5	33.8
10	15.7
15	10.2
20	7.5
25	6.0
30	5.0

Source: Edison Investment Research

Gold's relationship with US currency in circulation

Probably the simplest explanation for the apparent breakdown in the relationship between the US total monetary base and prices/inflation relates to the level of currency in circulation in the US economy.

The total US monetary base is made up of two components: 1) currency in circulation and 2) total reserve balances maintained by banks and depositary institutions at the Federal Reserve (crudely, currency that could be in circulation).

Traditionally, currency in circulation has made up the majority of the total monetary base. In fact, between 1959 and 2007, it accounted for an average 74% of the total monetary base, with a maximum of 91% (in 2006) and a minimum of 57% (in 1959). During the period since the start of quantitative easing however, this proportion has reduced sharply.

Exhibit 44: US total monetary base, comprising currency in circulation and reserve bank cash, 1959–2022
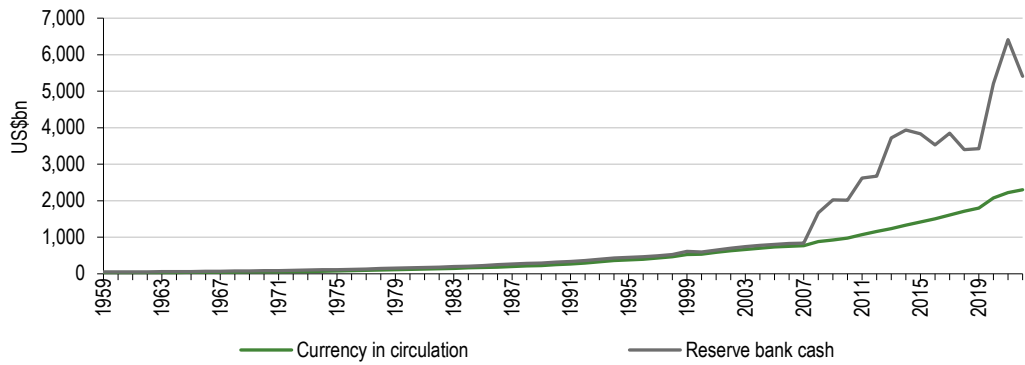
Source: Edison Investment Research, US Federal Reserve, dollardaze.org

Arguably, the increase in the total US monetary base since 2007 is what has been required to maintain growth in currency in circulation (and probably therefore growth in US GDP as well). Nevertheless, it leaves the proportion of currency in circulation as a percentage of the US total monetary base at just 42.5% as at end-December 2022 – ie well below pre-crisis levels.

Exhibit 45: Currency in circulation as a percentage of the US total monetary base, 1959–2022
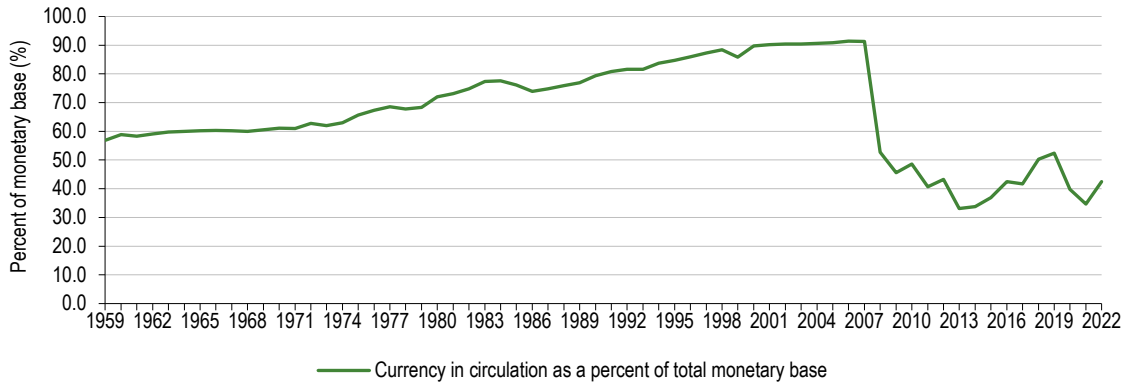
Source: Edison Investment Research, US Federal Reserve, dollardaze.org

Gold's relationship with currency in circulation

The correlation between the gold price and currency in circulation (0.930 for the period 1967–2022) is fractionally less positive than between the gold price and the total monetary base (0.934 for the same timeframe). However, it is still strongly statistically significant at the 5% level:

Exhibit 46: Gold price versus currency in circulation, regression analysis, 1959–2022
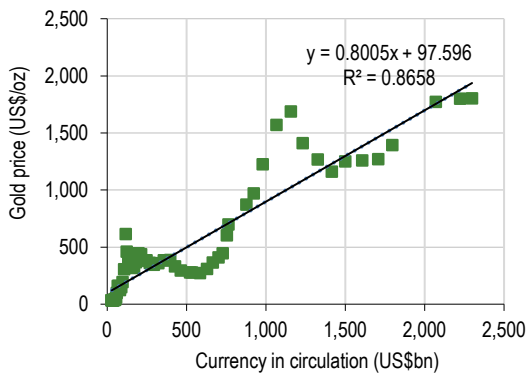
$y = 0.8005x + 97.596$
$R^2 = 0.8658$

Source: Edison Investment Research, South African Chamber of Mines, Bloomberg, US Federal Reserve, dollardaze.org.

Exhibit 47: Gold price and currency in circulation correlation, 1968–2022
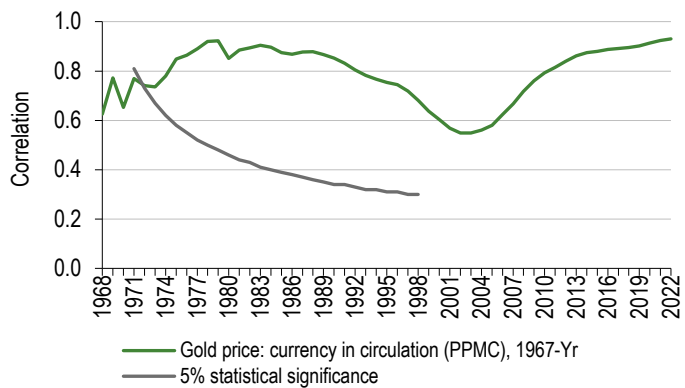
Source: Edison Investment Research (underlying historical data: South African Chamber of Mines, Bloomberg, US Federal Reserve, dollardaze.org).

As with its correlation to the total US monetary base, gold's correlation with currency in circulation – which had hitherto been very strong until the early 1990s – appeared to be breaking down towards 2003 before reconnecting again powerfully in the run up to the start of the global financial crisis in 2007, such that, as of 2022, the correlation (since 1968) as measured by the PPMC is now at a maximum.

Exhibit 48 depicts the gold price and currency in circulation since 1968, as well as the forecast estimate of the gold price had it been predicted solely on the basis of its relationship with currency in circulation as it would have been perceived at the time:

Exhibit 48: Gold price, currency in circulation and predicted gold price, 1968–2022
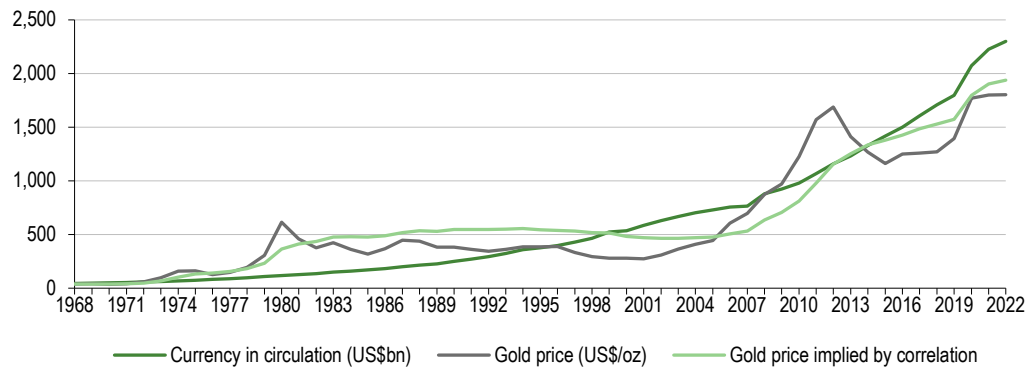
Source: Edison Investment Research, South African Chamber of Mines, Bloomberg, US Federal Reserve, dollardaze.org.

Applying the strict mathematical historical relationship between the two, currency in circulation of US$2,339bn at the end of July 2023 implies a gold price of US$1,969/oz – ie almost exactly where it is. Note that, statistically, the error of estimation of the regression analysis is ±US$193/oz, or 10.0% of the average price of gold to date in 2023 of US$1,931/oz, and marginally above the error of estimation derived from the correlation using the total US monetary base of ±US$188/oz. By contrast, in 2022, the discount of the actual price of gold relative to the one predicted by its currency in circulation correlation was 7.0% (cf 3.3% for the prediction made on the basis of gold's historical total US monetary base correlation).

As with inflation, the CPI and the total US monetary base however, the actual gold price has diverged from that predicted according to its correlation to currency in circulation in the past to the following extent:

Exhibit 49: Variation of actual gold price versus that predicted by currency in circulation correlation, 1968–2022
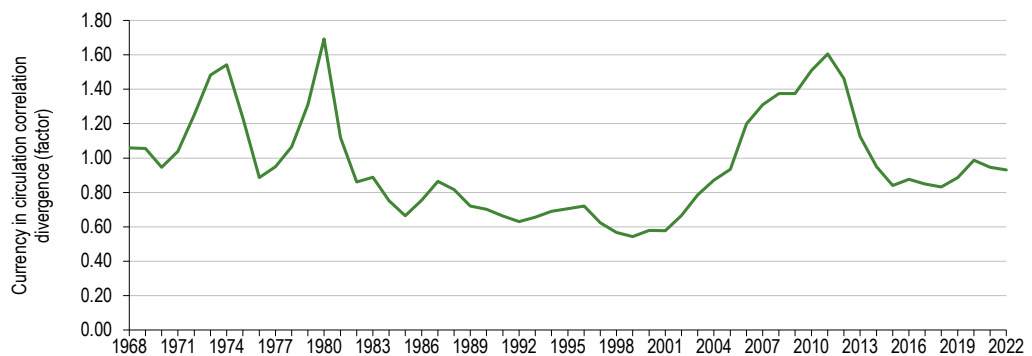
Source: Edison Investment Research (underlying data: US Federal Reserve, South African Chamber of Mines, Bloomberg, dollardaze.org)

Relative to currency in circulation, the gold price can be said to have reverted rapidly from the premiums that were typical of bull market conditions in 2006–12 to those that are typical of bear market conditions in 2014–19, before recovering to those of an approximately balanced market thereafter.

Of note is the almost exact repetition of a 60% price premium in each of the obvious three prior gold price bull markets, in 2011, 1980 and 1974. Also of note is the similarity between current market conditions and those in 1976, opening up the intriguing possibility that, if 2011 was an analogue for 1974 and 2022 is an analogue for 1976, then there may be another peak in front of us equating to 'another 1980' in the near future.

While the current market appears balanced however, the past level of divergence from balanced conditions suggests that the gold price could trade anywhere in a range from US$3,278/oz (equivalent to the 69.2% premium experienced in 1980 cf US$3,076/oz based on the monetary base correlation) to US$1,052/oz (equivalent to the 45.7% discount experienced in 1999). Unlike the total US monetary base however, since 1959, on an annual basis, currency in the circulation in the US has never contracted and therefore seems to be on an 'up only' trajectory. Assuming therefore that currency in circulation remains flat for the remainder of 2023 and then begins to expand at its long-term trend rate from 1959 to 2022 of 7.2% per year, our gold price scenario (based on the strict mathematical correlation between the two) is:

Exhibit 50: Gold price scenario, 2023–30e based on currency in circulation correlation

Year	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Forecast gold price (US$/oz)	1,969	2,104	2,248	2,402	2,567	2,744	2,934	3,137

Source: Edison Investment Research

Note that, under the two long-term growth scenarios posited above for the total US monetary base and currency in circulation, the latter would slowly increase as a percentage of the former to achieve approximately the bottom end of its pre-crisis range by 2051, as shown in the graph below:

Exhibit 51: Currency in circulation as a percentage of the US total monetary base, 1959–2051e

Currency in circulation as a percent of total monetary base
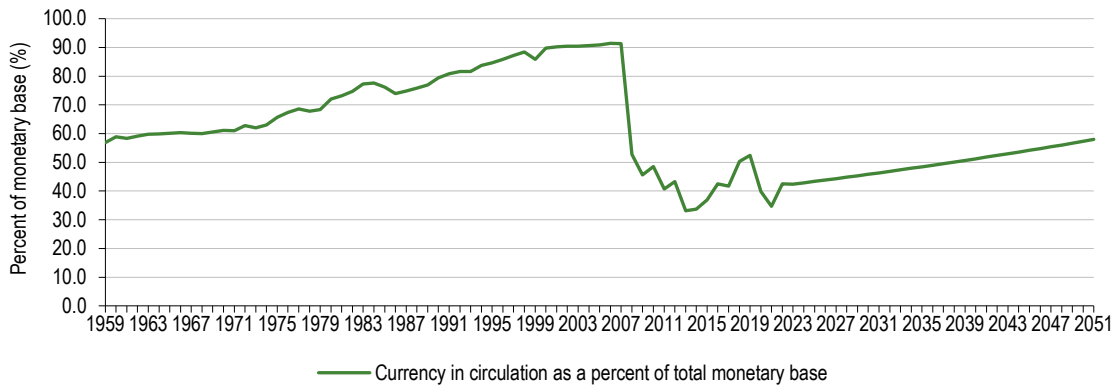
Source: Edison Investment Research and (historical) US Federal Reserve, dollardaze.org

Gold's relationship with real US interest rates

As per Exhibit 15, we consider the period from January 1971 to December 1981 to have been a fundamentally bull market as far as the gold price is concerned, followed by a fundamentally bear market from 1982 until 2002, characterised by positive real interest rates in the US, with the last of a series of interest rate hikes in May 2000 in response to the irrational exuberance of the dot-com boom. However, we believe that this fundamentally changed as the dot-com boom turned into the dot-com bust of 2001 and the terrorist attacks against the US of 11 September 2001. The Nasdaq Composite peaked in February 2000 but would not bottom out until September 2002. Along the way, the stock market meltdown spilled over into the real economy, driving a contraction in GDP and an eight-month long recession including, among other things, higher unemployment, during which time the Fed lowered interest rates by a total of 4.75 percentage points steadily throughout 2001.

Exhibit 52: US Fed funds effective rate (%) and US CPI inflation (%), 2000–23
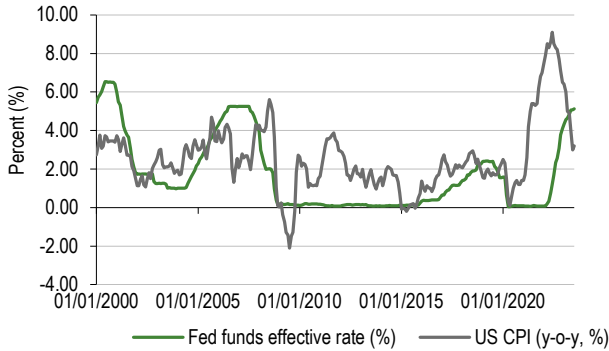
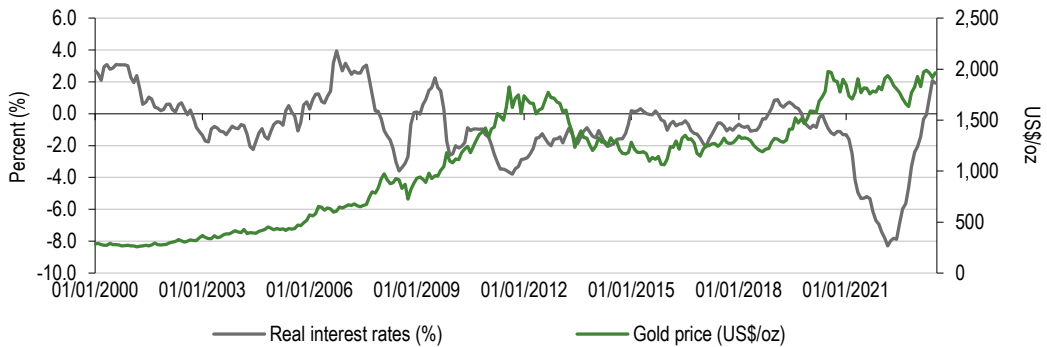Source: Edison Investment Research (underlying data: Bloomberg, monthly)

**Exhibit 53: US real interest rates (Fed funds effective rate minus CPI inflation rate, %), 2000–23**
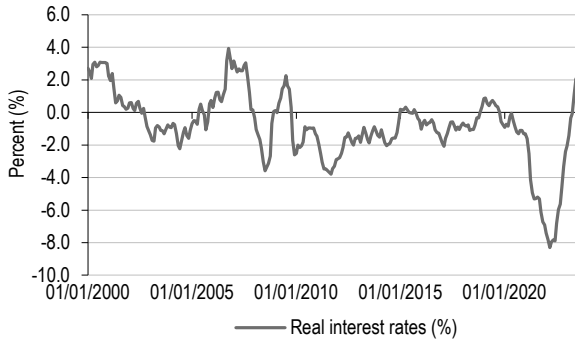
Source: Edison Investment Research (underlying data: Bloomberg, monthly)

During this timeframe, the gold price hit its nadir of US$257.95/oz in March 2001 (source: Bloomberg, monthly data), before gathering upward momentum, first with the Fed's response to 9/11 and then, later, as real interest rates went negative in August 2002, for the first time since September 1980. It then paused as real interest rates appeared to normalise from June 2006, before reasserting its upward momentum with the onset of the global financial crisis from September 2007.

Exhibit 54: US real interest rates (%) versus the gold price (US$/oz), 2000–23

Source: Edison Investment Research (underlying data: Bloomberg, monthly)

Readers' attention is drawn to the pattern whereby rapidly falling or negative real interest rates appear to support the gold price, whereas rapidly rising real rates (or anticipated rapidly rising rates) appear to suppress it.

Performing a regression analysis between real US interest rates and the gold price since June 2004 (the relevance of this date will become apparent shortly) yields the following graph (with the latest datapoint – corresponding to July 2023 – indicated by the circle):

Exhibit 55: US real interest rates (%) vs gold price (US$/oz), 2004–2023
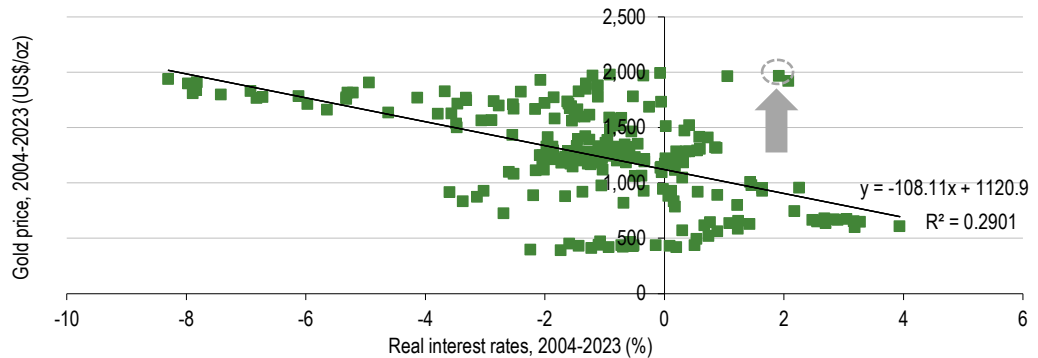
Source: Edison Investment Research (underlying data: Bloomberg, monthly)

For the number of data points in the analysis (230), the regression analysis's PPMC of -0.538 is definitely statistically significant at the 5% level, indicating that there is less than a 5% chance that the observed correlation between the two variables occurred by random chance.

The 1970s parallel

As noted previously, real interest rates in the US went negative in August 2002, for the first time since September 1980. Since then, real interest rates in the US have spent much time in negative territory, just as they spent much time prior to September 1980 is negative territory, as shown in the graphs below:

Exhibit 56: US Fed funds effective rate (%) and US CPI inflation (%), 1970–81	**Exhibit 57: US real interest rates (Fed funds effective rate minus CPI inflation rate, %), 1970–81**
Source: Edison Investment Research (underlying data: Bloomberg, monthly)	Source: Edison Investment Research (underlying data: Bloomberg, monthly)
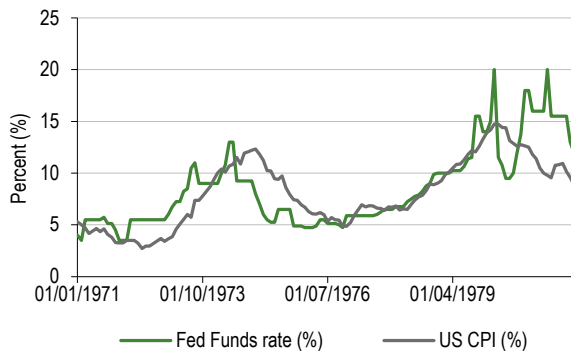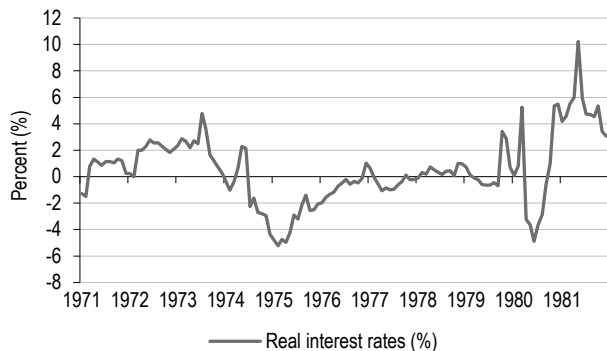
As in the case of the late 1990s and early 2000s, economic conditions in the late 1960s were relatively benign to the point of being buoyant. Towards the end of this period, however, the US began to run twin deficits, which put downward pressure on the dollar. After President Nixon finally decoupled the dollar from gold in August 1971, the latter's subsequent devaluation had the effect, among other things, of importing inflation into the United States, which jumped from a containable 3.4% in 1972 to a virtually unprecedented 8.7% in 1973. As in the period July 2005 to July 2006, between November 1971 and August 1973, the Federal Reserve reacted conventionally by tightening monetary policy and raising interest rates, which comprehensively burst the internal US credit bubble and started to suck markets into a debilitating debt-deflation spiral. In 1973–74, the Dow Jones Industrials average lost 45% of its value, while the US economy slowed from 7.2% real GDP growth in 1972 to a 2.1% contraction in 1974. Facing the prospect of a depression, the Fed reacted to the new threat by reducing interest rates to the minimum possible and by expanding the

total US monetary base. Inevitably, this put further downward pressure on the value of the dollar in the foreign exchange markets and again imported price rises, leading to a second peak in inflation later in 1979, which was only brought under control after Fed Chair Paul Volcker increased (real) interest rates aggressively to defend the value of the dollar from August 1979, albeit at the expense of a further debilitating recession in the early 1980s. A graph of the path of real interest rates and the gold price over the 11-year period from January 1971 to December 1981 is as follows:

Exhibit 58: US real interest rates (%) versus the gold price (US$/oz), 1970–81
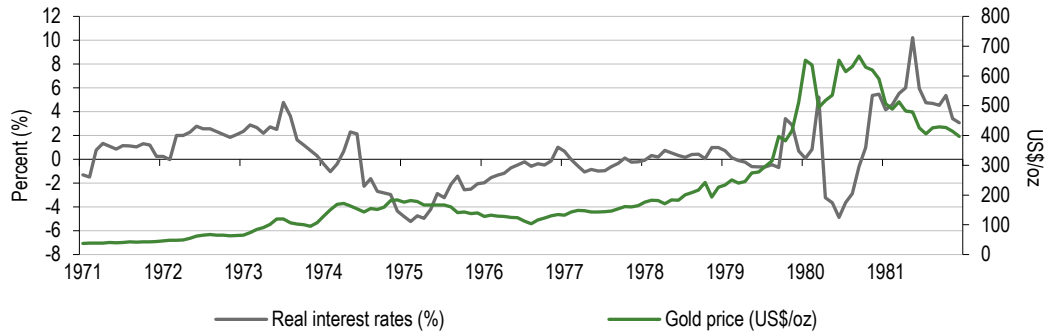
Source: Edison Investment Research (underlying data: Bloomberg, monthly)

Once again, readers' attention is drawn to the pattern whereby rapidly falling or negative real interest rates appear to support the gold price, whereas rapidly rising real rates or real rates above approximately 4% have the reverse effect.

Performing a regression analysis between real US interest rates and the gold price over this timeframe however, yields (at first glance) an entirely different pattern as follows:

Exhibit 59: US real interest rates (%) versus gold price (US$/oz), January 1971 to December 1981
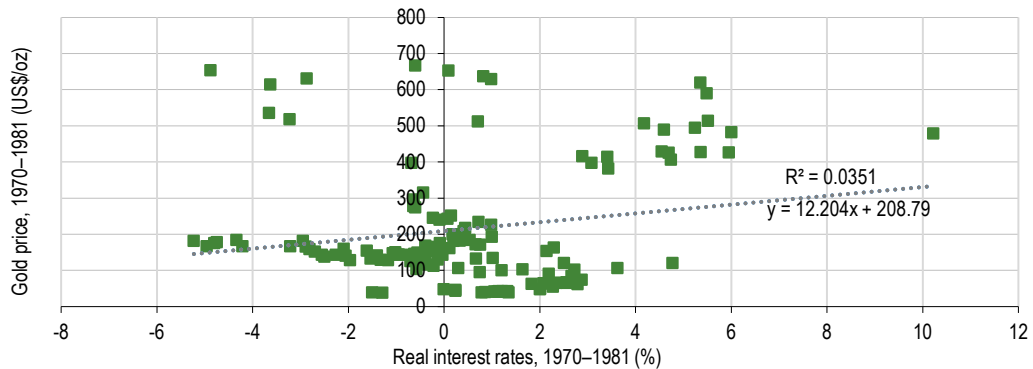
Source: Edison Investment Research (underlying data: Bloomberg, monthly)

While mathematically consistent, the positive gradient of the best-fit line is profoundly counterintuitive implying, as it does, that the gold price should be higher with higher real interest rates. This apparent logical inconsistency may be overcome however, if the period in question is resolved into two distinct phases, namely January 1971 to August 1979 and September 1979 to December 1981, as shown below:

Exhibit 60: US real interest rates (%) versus gold price (US$/oz), January 1971 to August 1979 and September 1979 to December 1981
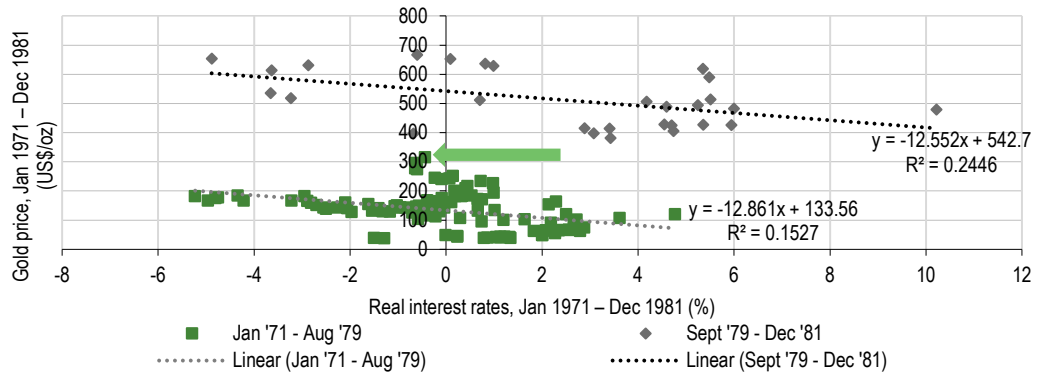
Source: Edison Investment Research (underlying data: Bloomberg, monthly)

Several features of Exhibit 60 are noteworthy:

- Whereas the best-fit line between real interest rates and the gold price was positive for the whole period January 1981 to December 1981, when subdivided into two phases (January 1971 to August 1979 and September 1979 to December 1981), the best-fit lines of the two phases are both negative (as expected). This is roughly the statistical equivalent of two negatives making a positive.

- The gradients of each best-fit line are almost identical (-12.552 and -12.861) and equate to approximately 5.9% of the average price of gold over the whole period.

- Although much shorter in duration, the second phase of this gold price market (September 1979 to December 1981) was characterised by a wider range of real interest rate fluctuations than the first.

- The last chronological point of the first phase (corresponding to August 1979) before transitioning to the second phase is marked with an arrow.

- Given the similarity of the gradients of the two best-fit lines, the essential difference between them may be regarded as an increase in the constant between the lower and the upper of 409.14 or 4.06x – that is to say the upper line may be considered to be 409.14 units (in this case US$/oz) higher than lower line or 4.06 times higher than the lower line (when the x-value is at zero).

The obvious conclusions from this analysis are threefold:

- Between 1971 and 1981 (the last period of economic history analogous to 2004–23), the gold market existed in two distinct phases: a lower price phase from January 1971 to August 1979 and a higher price phase from September 1979 to December 1981 (during which, using monthly data, the gold price peaked in September 1980).

- The second, shorter phase of the gold market (during which the price of gold peaked) was characterised by material volatility in real interest rates.

- The gold price did not peak until real interest rates were within sight of exceeding 4% on a sustained basis.

Considering Exhibit 55 again, we can see that there is little evidence that the gold price in the period 2004–23 has moved beyond one phase of the gold market's evolution. Exhibit 61, below, shows the future evolution of the gold market from a first phase to a second phase if the second phase is characterised by 1) a gold price that is US$409.14/oz higher (the 'mid' line) than in the first phase (the 'low' line) and 2) a gold price that is 4.06x higher (the 'high' line) than the first phase (when the x-value is at zero), but with the same gradient:

Exhibit 61: US real interest rates (%) versus gold price (US$/oz), 2004–23 plus potential second phase indicators
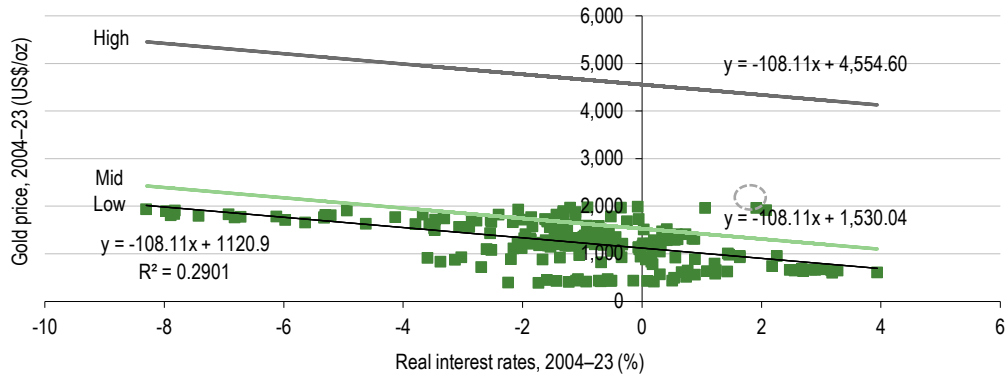
Source: Edison Investment Research (underlying data: Bloomberg, monthly)

Readers should note that the gradient of each of the three lines of best-fit is the same (namely -108.11) and that this gradient equates to 8.7% of the average price of gold to date in 2004–23 (cf 5.9% in the period January 1971 to December 1981). Stated alternatively, for every one percentage point by which real interest rates rise, one would mathematically expect the gold price to go down by US$108.11/oz (or 8.7% of the average price of gold in the period 2004–23). For the purposes of projecting gold prices, we have denoted these best-fit lines 'high', 'medium' and 'low' (as shown in Exhibit 61) and a summary of the anticipated gold price, given a range of possible future real interest rate scenarios, is as follows:

Exhibit 62: Gold price scenarios (US$/oz) based on its assumed correlation with real interest rates (%)

	Real interest rates (%)																
Correlation	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
Low	1,986	1,878	1,770	1,661	1,553	1,445	1,337	1,229	1,121	1,013	905	797	689	580	472	364	256
Mid	2,395	2,287	2,179	2,071	1,962	1,854	1,746	1,638	1,530	1,422	1,314	1,206	1,098	990	881	773	665
High	5,419	5,311	5,203	5,095	4,987	4,879	4,771	4,663	4,555	4,446	4,338	4,230	4,122	4,014	3,906	3,798	3,690

Source: Edison Investment Research

Given its current price (US$1,931/oz), it could be said that gold appears to be discounting real US interest rates of:

- around negative 8% (on the 'low' level correlation)
- around negative 4% (on the 'mid' level correlation)
- around positive 24% (on the 'high' level correlation).

A direct comparison between the two periods of monetary and economic crisis may be seen in the following graph:

Exhibit 63: US real interest rates (%) versus the gold price (US$/oz), 1970–81 and 2004–23
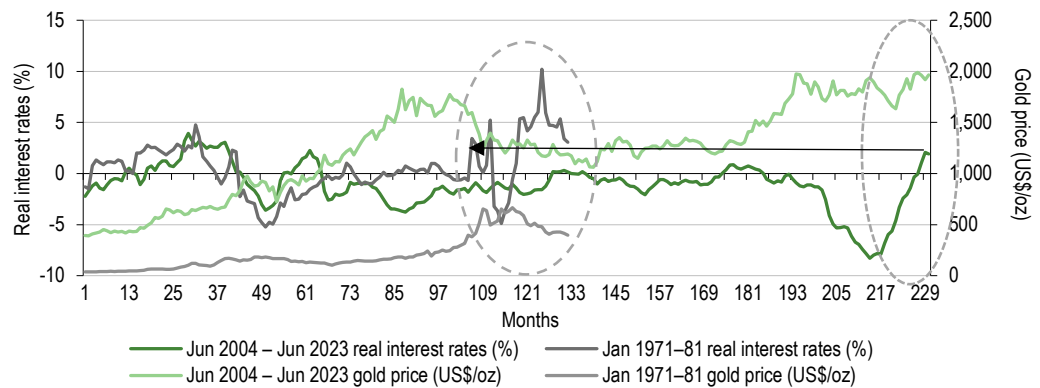
Source: Edison Investment Research (underlying data: Bloomberg, monthly)

In broad terms, both crises begin in month 1 (corresponding to January 1971 and June 2004) in an environment of rising real interest rates. Apart from Nixon decoupling the dollar from gold, the 1970s debt-deflation crisis begins in September 1973 (month 33 of the timeline). The 2004–23 crisis begins in October 2007 (month 41 of the timeline). Both crises are then calibrated so that their real interest rate nadirs occur in month 50 (corresponding to February 1975 and July 2008) – this being the relevance of the June 2004 date (see above). Real interest rates then recovered slightly to near zero in both cases, until September 1980 in the case of the 1970s crisis and May 2023 in the case of the 2004–23 crisis. However, note that it took longer for real interest rates to genuinely achieve a level of near zero in the 2004–23 crisis than in the 1970s crisis. Note also that the duration of the later crisis has now been almost twice as long as that of the former crisis.

Finally, readers should note the one, real, conspicuous difference between the 1970s crisis and the 2004–23 crisis, which is the COVID-19 'tail' of the later crisis, obvious in the form of a dive in real interest rates from July 2020 (or month 190 of the crisis), from which the US economy is only now really emerging but, in doing so, still providing an excellent analogue – in terms of real interest rates – with its emergence from the 1970s crisis in October 1979 (month 106), shown by the arrow in Exhibit 63. The 1970s being seen as a good analogue for the current condition of the US economy, it is not unreasonable to have the following expectations:

- Material volatility in real interest rates; this may take the form of volatility in either nominal interest rates or inflation or both simultaneously.
- There is a good chance that the gold price will rebase to a permanently higher level, as shown in Exhibit 61.
- The gold price will not peak until real interest rates can be seen to reasonably exceed at least 4% for a sustained period of time. After passing 4% in November 1980 (for the first time since July 1973), real interest rates in the US remained above 4% for all but three months until March 1987. During this period the average rate of real interest rates was 5.4%. The average rate of real interest rates in the US during the whole period of gold's bear market, between January 1982 and December 2001 was 3.2% (see Exhibit 64, below).

Exhibit 64: US real interest rates (%) versus gold price (US$/oz), January 1982 – December 2001
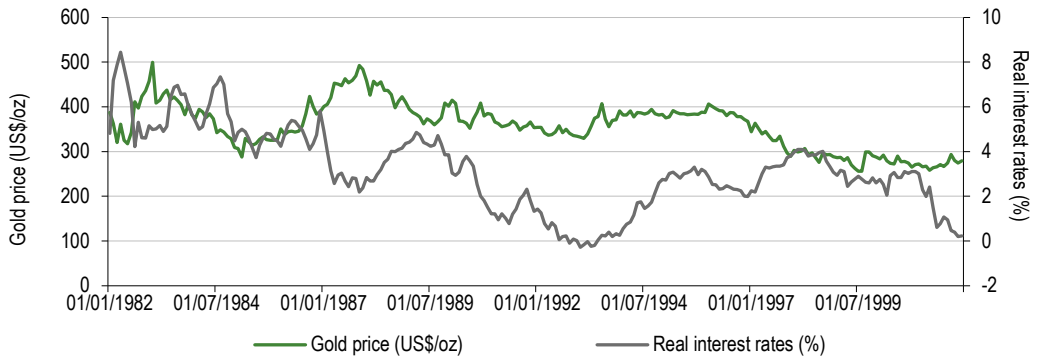
Source: Edison Investment Research (underlying data: Bloomberg, monthly)

In the event of real interest rates from August 2023 onwards following the path of October 1979 onwards, our gold price scenarios for the remainder of the decade are as follows:

Exhibit 65: Gold price scenarios (US$/oz) based on three different correlations with real interest rates

Basis	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Real interest rates (%)	0.8	4.6	7.2	5.0	5.0	5.0	4.8	4.0
Gold price correlation								
Low	1,525	1,058	530	479	484	485	635	594
Mid	1,696	1,467	939	888	894	894	1,044	1,003
High	**2,956**	**4,492**	**3,964**	**3,913**	**3,918**	**3,919**	**4,069**	**4,027**

Source: Edison Investment Research.

Readers are reminded that, in the equivalent 1970s period, the gold price had by now already shifted to either the 'mid' or the 'high' level correlation shown in the table. Given the gold price implied by anticipated real interest rates in the period 2025–30 for even the 'mid' level correlation however – which we would regard as effectively impossible given the level of gold miners' costs (average AISC in Q123 US$1,358/oz: source World Gold Council and Metals Focus) – we have therefore made the 'high' level correlation the basis of our forecast gold price in the summary section below (based on real US interest rates).

Geopolitics of the 1970s

For those readers not distinguished enough to remember the late 1970s, below is a list of political events around the world – in no particular order – in 1979 to put that era into perspective:

- Vietnamese 'boat people' create an immigration crisis in South-East Asia.
- A steady trickle of East German escapees to the West.
- Defections from the Soviet Union.
- A coup d'état in the Central African Empire (now the Central African Republic).
- Basque separatists active.
- Equatorial Guinea's dictator executed.
- Shah flees Iran and is eventually admitted to hospital in New York.
- Greensboro massacre, in which members of the Ku Klux Klan and the American Nazi Party shot and killed five participants on a 'Death to the Klan' march, organised by the Communist Workers Party.
- Iran hostage crisis.
- The US prepares for a nuclear attack. On 9 November 1979, Strategic Air Command was notified of an impending attack and nuclear bombers prepared for take off. Within 6–7 minutes

- of the initial response however, satellite and radar systems were able to confirm that the attack was a false alarm.
- US embassy in Libya attacked.
- Voting in Iran.
- Ayatollah Khomeini becomes supreme leader of Iran.
- South Korea's president assassinated.
- State of emergency declared in the Grenadines.
- Iranian prince assassinated in Paris (possibly after being tried in absentia by an Islamic Revolutionary Tribunal). A captain in the Imperial Iranian Navy, friends of the prince described him as quiet and unpretentious. He was also at pains to distance himself from the financial dealings of others in his family. Iranian revolutionary authorities had condemned several members of the Shah's family to death in absentia. However, Prince Shahriar was not explicitly among them.
- Libya's Colonel Gaddafi calls on Palestinians to wreck Egyptian oilfields and destroy the Suez Canal in response to the Egypt-Israel peace accord.
- Zimbabwe-Rhodesia revokes Rhodesia's Unilateral Declaration of Independence (UDI) of 11 November 1965.
- US ends Rhodesia embargo.
- Swedish singing group ABBA popular.
- The US bails out Chrysler.
- America lunches its first Advanced Manoeuvrable Re-entry Vehicle; the AMaRV was an anti-ballistic missile-eluding prototype ICBM warhead built by McDonnell-Douglas and flown three times on Minuteman 1 test vehicles.
- Rhodesia ceasefire.
- Hafizullah Amin executed/assassinated by Soviet operatives at the Tajbeg Palace on 27 December 1979 as part of the USSR's Operation Storm-333, which kickstarted the 10-year Soviet–Afghan War. He was Afghanistan's former minister of foreign affairs and latterly its communist head of state (in the form of the general secretary of the People's Democratic Party), who served from September 1979 until his assassination. He organized the Saur Revolution of 1978 and co-founded the Democratic Republic of Afghanistan.
- Soviet invasion of Afghanistan.

Gold price forecasts

A summary of our gold price scenarios, derived according to the methods set out heretofore is as follows:

Exhibit 66: Gold price scenarios (US$/oz) based on five different methodologies

Basis	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Non-cycle adjusted								
CPI index	1,514	1,585	1,659	1,736	1,815	1,898	1,985	2,075
Total US monetary base	1,898	1,998	2,104	2,216	2,335	2,461	2,594	2,736
Currency in circulation	1,969	2,104	2,248	2,402	2,567	2,744	2,934	3,137
Average	**1,794**	**1,896**	**2,004**	**2,118**	**2,239**	**2,368**	**2,504**	**2,649**
Cycle adjusted								
Inflation	2,178	2,266	1,617	1,324	1,498	1,277	1,126	1,343
Real interest rates	2,956	4,492	3,964	3,913	3,918	3,919	4,069	4,027
Average	**2,567**	**3,379**	**2,791**	**2,619**	**2,708**	**2,598**	**2,598**	**2,685**
Average	**2,103**	**2,489**	**2,318**	**2,318**	**2,427**	**2,460**	**2,542**	**2,664**

Source: Edison Investment Research

If however, we regard the current condition of the US economy as being analogous to that in approximately September 1979 (± one month) then, given historical divergence from their respective correlations (ie Exhibits 24,36 and 49), we would anticipate gold prices to evolve as follows:

Exhibit 67: Gold price scenarios (US$/oz) based on five different methodologies*

Basis	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Inflation	2,178	2,266	1,617	1,324	1,498	1,277	1,126	1,343
CPI index	3,117	3,263	1,643	1,334	1,592	1,382	1,282	1,642
Total US monetary base	3,077	3,257	2,294	1,885	2,094	1,850	1,689	1,989
Currency in circulation	3,333	3,560	2,514	2,067	2,281	2,061	1,950	2,371
Real interest rates	2,956	4,492	3,964	3,913	3,918	3,919	4,069	4,027
Average	**2,932**	**3,368**	**2,406**	**2,105**	**2,277**	**2,098**	**2,023**	**2,274**

Source: Edison Investment Research. Note: *Assuming the price of gold and the US economy evolve from July 2023 onwards in the same way that they did from September 1979 onwards.

Taking it all together (a Parthian shot)

Hitherto, in this report, we have analysed the price of gold with respect to its historical correlation with 1) the CPI index, 2) the total US monetary base, 3) currency in circulation and 4) real US interest rates individually. However, it is also possible to run a multiple regression analysis of the gold price against all four of these variables simultaneously. Implicitly, this approach posits that the gold price is (or should be) some function of all four variables and calculates that function. It should be noted that the approach is probably not without difficulty. Technically, there should not be a close linear relationship (ie there should be a low correlation) among the four regressor variables. An argument can probably be made to this effect. In reality however, it is likely that real interest rates and the level of the CPI are – at least to some extent and/or some periods in time – related to one another (see Exhibit 72). Statistically, currency in circulation and the total US monetary base are definitely related to one another. As such, adopting this approach could raise issues of multi-collinearity with respect to the results of the analysis. Nevertheless, having now performed this analysis, we believe that the results do have merit and are worth reproducing. For the purposes of this report, 52 years' worth of annual data has been analysed from 1971–2022 and the results presented below, verbatim:

Exhibit 68: Gold multiple regression analysis versus four variables, outputs

Regression statistics						
Multiple R	0.946123971					
R Square	0.895150569					
Adjusted R Square	0.886227213					
Standard Error	174.4570034					
Observations	52					

Analysis of variance						
	df	SS	MS	F	Significance F	
Regression	4	12212503.17	3053125.793	100.3154629	2.12049E-22	
Residual	47	1430456.563	30435.24602			
Total	51	13642959.74				
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-3.607723981	91.81682444	-0.039292624	0.96882352	-188.3193495	181.1039016
Actual CPI	2.681725375	1.047078887	2.561149317	0.013702533	0.575274358	4.788176392
Currency in circulation (US$bn)	-0.351324992	0.253805335	-1.384230128	0.172825751	-0.861915467	0.159265484
Total US monetary base (US$bn)	0.336418953	0.068989306	4.876392741	1.27606E-05	0.19763037	0.475207536
Real interest rates (%)	8.135545163	11.69339365	0.695738586	0.490018661	-15.38852859	31.65961891

Source: Edison Investment Research

A number of features of the analysis are noteworthy (highlighted):

- The very low level of 'Significance F', which suggests that we have a good regression.
- The high values of 'Multiple R', 'R Square' and 'Adjusted R Square' all of which suggest that approximately 90% of the movements in the gold price can be explained by movements in the four variables analysed, with only c 10% attributable to other factors.

- Low P-values for the 'Actual CPI' and 'Total US monetary base' variables, suggesting that there is much more certainty surrounding the levels of the coefficients relating to these variables than for the other two variables ('Currency in circulation' and 'Real interest rates').

Two noteworthy potential problems are:
- The coefficient relating to 'Currency in circulation' is both relatively uncertain (it has a relatively high P-value) and is negative; this suggests that the gold price should fall as 'Currency in circulation' increases (all other things being equal), which is counterintuitive.
- The coefficient relating to 'Real interest rates' is also both relatively uncertain (ie it has a relatively high P-value) and, in this case, positive, which suggests that higher real interest rates put upward pressure on the gold price, which, again, is counterintuitive.

These observations could cause readers to place more emphasis on the gold price scenarios relating to the analyses with respect to the total US monetary base and the actual level of the CPI in the preceding sections of this report, rather than those with respect to currency in circulation and real interest rates. Nevertheless, with these caveats, the equation derived from this multiple regression analysis for predicting the price of gold is as follows:

$$\text{Gold price} = -3.6 + (2.68 \times CPI) - (0.351 \times CiC) + (0.336 \times TUSMB) + (8.13 \times RiR)$$

where:
- CPI is the absolute level of the CPI,
- CiC is US currency in circulation in US$bn, and
- TUSMB is the total US monetary base in US$bn, and
- RiR is real interest rates (for these purposes, defined as the effective Fed funds rate minus CPI inflation) expressed in percent.

Readers should also note the standard error of this function as a predictor of the gold price being, in this case, ±US$174/oz (or ±9.0% the current price of gold).

If we apply this equation to our projections for the four variables in question – as already set out in the preceding sections of this report – then our predicted gold prices for the period 2023–30 are as follows:

Exhibit 69: Predicted gold price, 2023–30e, based on four variables indicated

Year	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Predicted gold price (US$/oz)	1,866	1,982	2,092	2,167	2,264	2,366	2,470	2,574
Actual CPI	308.759	321.203	334.149	347.617	361.627	376.202	391.365	407.138
Currency in circulation (US$bn)	2,338.5	2,506.2	2,685.8	2,878.4	3,084.8	3,305.9	3,543.0	3,797.0
Total US monetary base (US$bn)	5,517.2	5,847.1	6,196.7	6,567.2	6,959.9	7,376.0	7,817.0	8,284.4
Real interest rates (%)	0.8	4.6	7.2	5.0	5.0	5.0	4.8	4.0

Source: Edison Investment Research

A second Parthian shot

Given the reservations noted above with regard to the relationships between currency in circulation and the total US monetary base and between real interest rates and the absolute level of the CPI, we have also conducted the same analysis based upon only two regressors, being the CPI and the total US monetary base. In this case, the results of the analysis over the same 52 years of annual data between 1971 and 2022 are as follows:

Exhibit 70: Gold multiple regression analysis versus two variables, outputs

Regression statistics						
Multiple R	0.942971932					
R Square	0.889196065					
Adjusted R Square	0.884673455					
Standard Error	175.6442152					
Observations	52					
Analysis of variance						
	df	SS	MS	F	Significance F	
Regression	2	12131266.11	6065633.055	196.6112806	3.90483E-24	
Residual	49	1511693.626	30850.89033			
Total	51	13642959.74				
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	74.25965331	78.2106322	0.949482842	0.347034805	-82.91049643	231.4298031
Actual CPI	1.599290115	0.638057654	2.506497813	0.015561167	0.317065253	2.881514977
Total US monetary base (US$bn)	0.238379401	0.027167801	8.774335604	1.28224E-11	0.183783662	0.292975141

Source: Edison Investment Research

As before, a number of features of the analysis are noteworthy (highlighted):

- The very low level of 'Significance F', which suggests that we have a good regression.
- The high values of 'Multiple R', 'R Square' and 'Adjusted R Square', all of which again suggest that approximately 90% of the movements in the gold price can be explained by movements in the two variables analysed, with only c 10% attributable to other factors.
- Low P-values for both variables, suggesting that there is a good degree of certainty surrounding the levels of the coefficients relating to these variables.

Sadly, there does appear to be a statistical relationship over the period in question between the absolute level of the CPI and the total US monetary base. Possibly, this is to be expected, in which case readers may wish to revert to Exhibits 66 and 67 for their gold price forecasts. Otherwise, with this caveat, the equation derived from this multiple regression analysis for predicting the price of gold is:

$$\text{Gold price} = 74.3 + (1.60 \times \text{CPI}) + (0.238 \times \text{TUSMB})$$

where:

- CPI is the absolute level of the CPI, and
- TUSMB is the total US monetary base in US$bn.

Readers should also note the standard error of this function of ±US$175/oz (or ±9.1% the current price of gold) – ie almost identical to the prior equation, derived using four variables.

If we apply this equation to our projections for the two variables in question, based on long-term trend rates, then our predicted gold prices for the period 2023–2030 are as follows:

Exhibit 71: Predicted gold price, 2023–2030e, based on two variables indicated

Year	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Predicted gold price (US$/oz)	1,883	1,982	2,086	2,196	2,312	2,434	2,564	2,700
Actual CPI	308.759	321.203	334.149	347.617	361.627	376.202	391.365	407.138
Total US monetary base (US$bn)	5,517.2	5,847.1	6,196.7	6,567.2	6,959.9	7,376.0	7,817.0	8,284.4

Source: Edison Investment Research

Conclusion

As demonstrated above, a key problem in performing the multiple regression analysis is that the 'independent' variables may be somewhat inter-related. Exhibit 72, below, shows the degree of correlation between any two factors:

Exhibit 72: Pearson Product Moment (correlation) Coefficient (PPMC) between any two of four factors considered in gold price multiple regression analysis

	Absolute CPI	Currency in circulation	Total US monetary base	Real interest rates
Absolute CPI	1.000	0.917	0.834	-0.457
Currency in circulation	0.917	1.000	0.967	-0.586
Total US monetary base	0.834	0.967	1.000	-0611
Real interest rates	-0.457	-0.586	-0.611	1.000

Source: Edison Investment Research

Readers' attention is drawn to the symmetry of this table about the central diagonal line (as expected). Otherwise, we can observe that about the least correlated factor is real interest rates. Performing a multiple regression analysis between the gold price and the total US monetary base and real interest rates reveals the following relationships:

Exhibit 73: Gold multiple regression analysis vs two variables, outputs

Regression statistics

Multiple R	0.937023655
R Square	0.87801333
Adjusted R Square	0.873034282
Standard Error	184.2945305
Observations	52

Analysis of variance

	df	SS	MS	F	Significance F
Regression	2	11978700.51	5989350.255	176.3416167	4.11769E-23
Residual	49	1664259.226	33964.47399		
Total	51	13642959.74			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	225.7775587	41.5624843	5.432244067	1.7305E-06	142.2546195	309.300498
Total US monetary base (US$bn)	0.308532609	0.019883094	15.51733392	1.52048E-20	0.268576036	0.348489182
Real interest rates (%)	13.41868059	12.1752604	1.102126784	0.275790642	-11.04842122	37.88578239

Source: Edison Investment Research

As before:

- The very low level of 'Significance F' suggests that we have a good regression.
- The high values of 'Multiple R', 'R Square' and 'Adjusted R Square' suggest that approximately 90% of the movements in the gold price can be explained by movements in the two variables analysed, with only c 10% attributable to other factors.
- Low P-values for both the coefficients relating to the total US monetary base and the intercept, suggest that there is a good degree of certainty surrounding the levels of the coefficients relating to these variables.

As noted before, there does appear to be a statistical relationship over the period in question between the total US monetary base and real interest rates and it does appear to be statistically significant. In addition, the positive value of the coefficient relating to real interest rates is, once again, counterintuitive, suggesting that a higher gold price correlates with high real interest rates. With these caveats, the equation derived from this multiple regression analysis for predicting the price of gold is:

$$\text{Gold price} = 225.8 + (0.309 \times \text{TUSMB}) + (13.4 \times \text{RiR})$$

where:

- TUSMB is the total US monetary base in US$bn, and
- RiR is real interest rates in percent.

Readers should also note the standard error of this function of ±US$184/oz (or ±9.5% the current price of gold), which is almost identical to the prior two equations.

If we apply this equation to our projections for the two variables in question, then our predicted gold prices for the period 2023–30 are as follows:

Exhibit 74: Predicted gold price, 2023–30e, based on two variables indicated

Year	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Predicted gold price (US$/oz)	1,939	2,091	2,234	2,319	2,440	2,569	2,701	2,835
Total US monetary base (US$bn)	5,517.2	5,847.1	6,196.7	6,567.2	6,959.9	7,376.0	7,817.0	8,284.4
Real interest rates (%)	0.8	4.6	7.2	5.0	5.0	5.0	4.8	4.0

Source: Edison Investment Research

A summary of the predicted gold price results of our three multiple regression analysis calculations is shown below, compared with the results of our gold price projections (US$/oz) based on the five different methodologies individually, both cyclically adjusted and non-cyclically adjusted (see Exhibits 66 and 67):

Exhibit 75: Predicted gold price, 2023–30e, based on three multiple regression analyses (US$/oz)

Year	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Average of non-cyclically adjusted (Exhibit 66)	1,794	1,896	2,004	2,118	2,239	2,368	2,504	2,649
Average of cyclically adjusted (Exhibit 67)	2,932	3,368	2,406	2,105	2,277	2,098	2,023	2,274
Predicted gold price (CPI, CiC, TUSMB & RiR)	1,866	1,982	2,092	2,167	2,264	2,366	2,470	2,574
Predicted gold price (CPI & TUSMB)	1,883	1,982	2,086	2,196	2,312	2,434	2,564	2,700
Predicted gold price (TUSMB & RiR)	1,939	2,091	2,234	2,319	2,440	2,569	2,701	2,835
Average of multiple regression analyses	**1,896**	**2,018**	**2,137**	**2,227**	**2,339**	**2,456**	**2,578**	**2,703**

Source: Edison Investment Research

While we recognise that there is significant scope for upside, in deference to the principle of conservatism, we have decided to make our formal gold price forecasts – for the purposes of our gold equity valuations – the lowest number from each of the years shown above (highlighted in grey). Nevertheless, this remains a considerable increase relative to our prior forecasts (see: A Golden Future published in June 2020), as shown below:

Exhibit 76: Edison gold price forecasts, nominal and real (US$/oz), current cf prior

Year	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Current forecast (nominal US$/oz)	**1,896**	**2,004**	**2,105**	**2,239**	**2,098**	**2,023**	**2,274**
Current forecast (real, 2023 US$)	**1,822**	**1,851**	**1,869**	**1,912**	**1,722**	**1,596**	**1,725**
Prior (nominal US$/oz)*	1,892	1,892	1,892	1,892	1,892	1,892	1,892
Prior (real, 2023 US$)	1,819	1,749	1,681	1,617	1,555	1,495	1,437
Increase (nominal, US$/oz)	**4**	**112**	**213**	**347**	**206**	**131**	**382**
Increase (real, 2023 US$/oz)	**0.2**	**5.9**	**11.2**	**18.3**	**10.9**	**6.9**	**20.2**
Increase (nominal, %)	**3**	**102**	**188**	**295**	**167**	**101**	**288**
Increase (real, %)	**0.2**	**5.9**	**11.2**	**18.2**	**10.7**	**6.8**	**20.0**

Source: Edison Investment Research. Note: *See: A Golden Future published in June 2020

Graphically, the same data may be depicted as follows:

Exhibit 77: Edison gold price forecasts plus contingent scenarios (US$/oz), 2024–30e
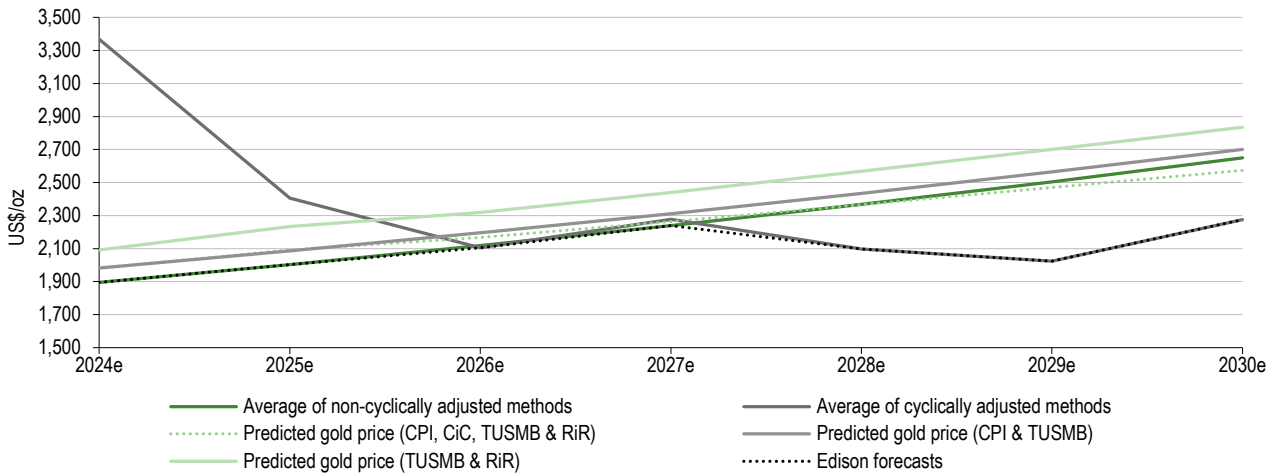
Source: Edison Investment Research. Note: CPI = the absolute level of the US CPI; CiC = US currency in circulation; TUSMB = total US monetary base; RiR = real US interest rates.

Footnote

In addition to the correlation conducted by Edison between the total US monetary base and the price of gold, for the first time, in this report, we have also attempted to conduct a correlation between the gold price and the global monetary base – the thinking being that this might become a more relevant relationship in the event of a significant or material degree of global de-dollarisation in the future. One immediate problem is that statistics for the monetary base are less readily available for the world than for the US. In this case therefore, we have aggregated the data from 36 countries and monetary institutions from around the world to serve as a proxy for the global monetary base (and global central banks' gold holdings) since 2001. These may be summarised as:

■ Europe (ex-UK),

■ Australia,

■ Canada,

■ China,

■ Japan,

■ South Korea,

■ Philippines,

■ Russia,

■ Turkey,

■ US, and

■ Venezuela.

Owing to the need to convert sovereign countries' monetary bases into a common currency (inevitably still the US dollar) for the purposes of direct comparison, the correlation is potentially affected by inconsistencies in foreign exchange markets. In addition, whereas US gold holdings have been effectively flat since 1972 and absolutely flat since 2008, the gold holdings of other central banks are constantly fluctuating. Nevertheless, with these caveats, our analysis yielded the following results:

1. While the total US monetary base and the global monetary base went up approximately in tandem between 2001 and 2012, the total US monetary base went up further and faster between 2012 and 2016, before being caught up with again in 2017. The total US monetary

base then contracted slightly more between 2017 and 2019 than the global one, but both went up by approximately the same amount in response to the COVID-19 crisis between 2019 and 2022. As a result, the US's share of the global monetary base has fluctuated between 19.8% in 2007 and 41.6% in 2014 and is currently at 28.8% as of 2022. By contrast, the value of global gold reserves increased at a faster rate than the global monetary base between 2001 and 2012 before falling back into line by 2015. Perhaps surprisingly, it then increased at a slower rate between 2019 and 2021, over the period of the COVID-19 pandemic, but is now approximately back in line once again as of 2022.

Exhibit 78: Graph of global monetary base cf total US monetary base (US$bn), 2001–22	**Exhibit 79: Graph of global monetary base versus the value of global gold reserves (US$bn)**
Source: IMF (aggregated data for 36 countries), US Federal Reserve, Edison Investment Research	Source: IMF (aggregated data for 36 countries), Edison Investment Research (underlying historical data: South African Chamber of Mines, Bloomberg).
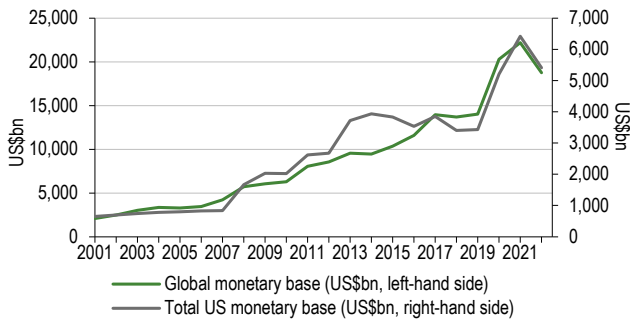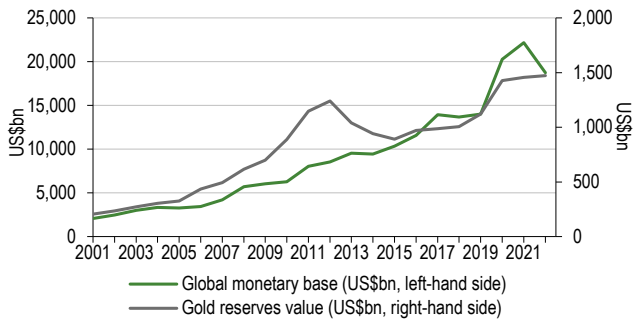
2. Over the period in question, global central bank gold holdings declined between 2001 and 2008, at an average rate of 292t per year, before recovering in the period 2008 to 2022 (at an average rate of 246t per year). The decline between 2001 and 2008 is perhaps surprising, given negative real interest rates in the US at the time and may suggest that some of the world's central banks were on autopilot in selling their gold reserves. It remains to be seen what the effect of positive real interest rates from 2023 onwards will be. Over the entire time frame however, global gold reserves increased by 7.5%, or the equivalent of a compound annual average growth rate of just 0.3% per year. By contrast, while the percentage of the global monetary base covered by gold generally increased between 2001 and 2012, it contracted sharply thereafter, from 14.5% in 2012 to 6.6% in 2021, and is currently standing at 7.9%. Over the same time frame, the percentage of the total US monetary base covered by its gold reserves has decreased from 11.0% in 2001 to 8.7% in 2022.

Exhibit 80: Global central banks' gold holdings (tonnes), 2001–22
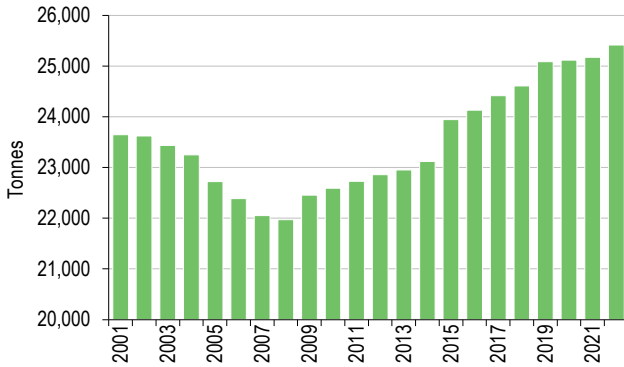
Source: IMF (aggregate of 36 countries and financial institutions)

Exhibit 81: Percentage of global monetary base covered by gold reserves (%)

Source: IMF (aggregate of 36 countries and financial institutions), Edison Investment Research (underlying data: South African Chamber of Mines, Bloomberg)

3. As a consequence, the correlation between the global monetary base and the value of global gold reserves is strong – with a PPMC of 0.901 – and has been consistently strong since at least 2001. The correlation between the global monetary base and the gold price is only slightly less strong (given that global gold reserves have been close to constant since 2001), at 0.857. However, it is slightly less strong than that between the total US monetary base and the gold price, which exhibited a PPMC of 0.924 over a longer timeframe (see Exhibit 27).

Exhibit 82: Regression analysis of the global monetary base (US$bn) and the gold price (US$/oz), 2001–22
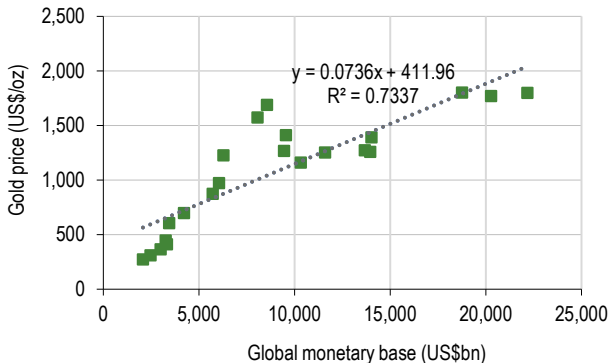
$y = 0.0736x + 411.96$
$R^2 = 0.7337$

Source: Edison Investment Research (underlying data: IMF (aggregated data for 36 countries), South African Chamber of Mines, Bloomberg)

Exhibit 83: PPMC global monetary base and value of countries' gold reserves, 2001–22
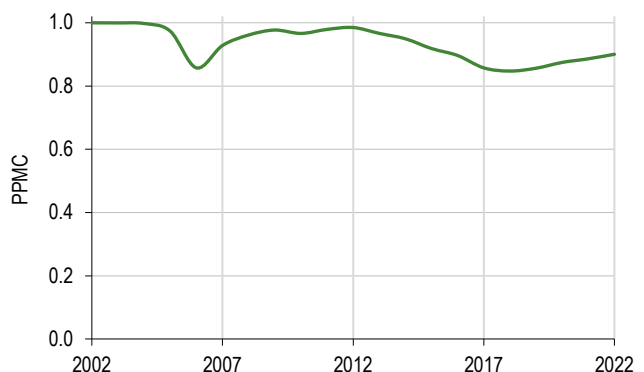
Source: Edison Investment Research (underlying data: IMF (aggregated data for 36 countries), South African Chamber of Mines, Bloomberg)

Between 2001 and 2022, the global monetary base (as represented by the aggregated data of 36 countries) has increased at a compound average annual growth rate of 11.1% per year. Note that this may overstate the long-term trend rate of growth pre-2007. If we project this rate of growth forward however, from 2022 until 2030, then we can use the relationship between the two to calculate the value of countries' gold reserves. If we combine this with the level of countries' gold holdings (in tonnes), similarly increased by their compound annual average growth rate of 0.3% per year, then we can calculate the gold price required in those years to deliver the necessary value of countries' gold holdings. Alternatively, we can also use the direct correlation between the global monetary base and the gold price (as shown in Exhibit 82) to calculate the future price of gold directly.

In this case, the results of these two methods for calculating the gold price are as follows:

Exhibit 84: Gold price scenario (US$/oz), 2023–30e, based on global monetary base

(US$/oz)	2023e	2024e	2025e	2026e	2027e	2028e	2029e	2030e
Forecast based on required value of countries' gold reserves	1,898	2,065	2,251	2,456	2,684	2,936	3,215	3,523
Forecast based on direct correlation with the gold price	1,945	2,115	2,303	2,512	2,744	3,002	3,288	3,606

Source: Edison Investment Research

In general, the future gold prices calculated by these two methods are in excess of those calculated in Exhibits 75 and 76. In large part, this may be attributed to the higher compound average annual growth rate that we calculated for the global monetary base compared with the total US monetary base. As a result – and owing to the novel nature of the approach and the uncertainties around using a sample of 36 (albeit big) countries to act as a proxy for the world – we have decided not to allow any contribution from this method to our overall gold price forecasts. However, we will keep the data under review and may reconsider this position, as circumstances dictate.

Appendix

Historical investment returns

Gold is often thought of as a relatively pedestrian real asset, the returns from which are equally conservative. In fact, while there are periods in which this may be true, over the long term, gold has proved itself an investment to compete with the best. While the Dow Jones Industrial Average increased by 36.6x from 1967 to 2022, for example, the price of gold has increased by 51.5x.

Exhibit 85: Gold price performance versus Dow Jones Industrial Average index performance, 1967–2022
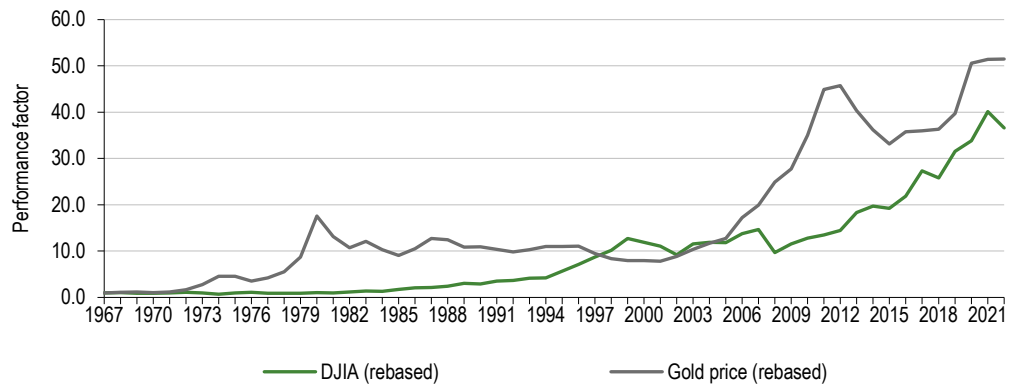
Source: Edison Investment Research (underlying data: Bloomberg, South African Chamber of Mines)

Of course, in the normal course of events, gold would not be expected to derive an income for its investor, while the Dow Jones would, in the form of dividends. In annual percentage terms however, the capital returns from gold over the period are equivalent to 7.4% per year, while those from the Dow Jones are equivalent to 6.8% per year (both geometric averages). Notwithstanding the absence of income, that is still a pretty impressive performance for an asset that is often characterised as a portfolio diversifier or insurance policy. As a consequence, the ratio of the Dow Jones Industrial Average to the gold price stood at 0.711 in 2022 (rebased), compared to a time weighted average over the period of 0.566.

Exhibit 86: Dow Jones Industrial Average/gold price, 1967–2022
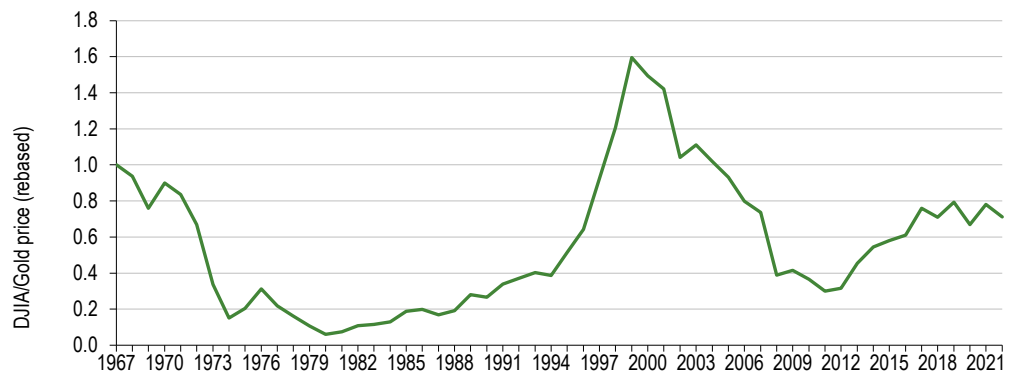
Source: Edison Investment Research (underlying data: Bloomberg, South African Chamber of Mines)

In part, this mischaracterisation of gold in terms of its investment qualities may derive from long-term historical experience. A chart of gold's real returns since 1913, on an annual percentage basis, is as follows:

Exhibit 87: Gold real annual percentage returns, 1913–2022 (%)
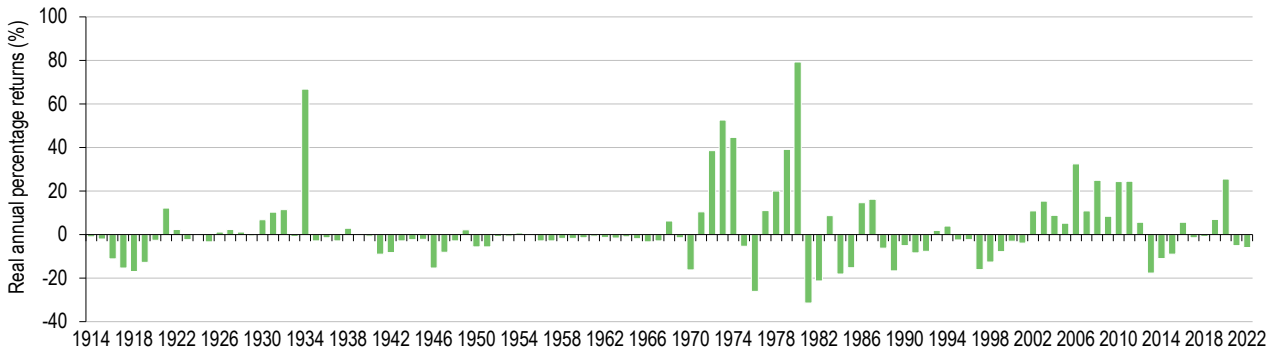
Source: Edison Investment Research (underlying data: South African Chamber of Mines, US Bureau of Labor Statistics, Bloomberg)

Over the period, the (geometric) average real return for gold has been 1.0% with a standard deviation of ±16.5% (both calculated assuming that the distribution of returns is normal), as depicted in the histogram below:

Exhibit 88: Histogram of gold's real annual percentage returns, 1913–2022
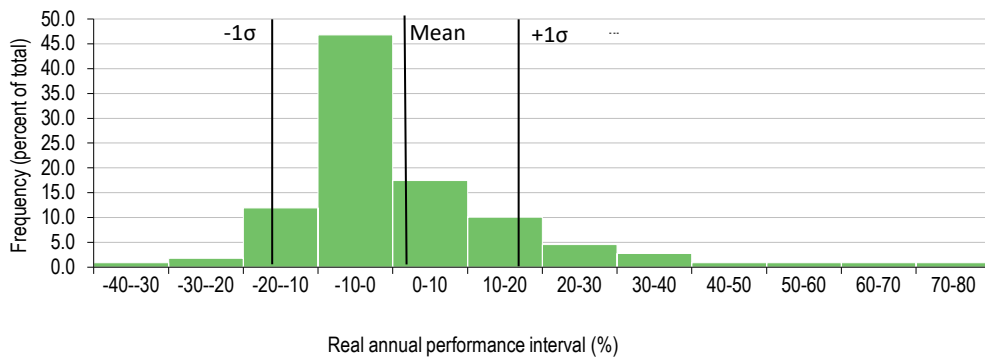
Source: Edison Investment Research (underlying data: South African Chamber of Mines, US Bureau of Labor Statistics, Bloomberg)

However, the median return is in the interval -10–0%, which corresponds with the long period from 1913–67, during which the nominal gold price moved effectively only once (when it was revalued from US$20.67/oz to US$35.00/oz in January 1934), but was still generally characterised by a small amount of positive inflation, leading to a negative real return. As such, the graph may suggest a log-normal distribution with its characteristic skew to the right. This (relatively predictable) outcome may be the origin of the investing public's belief that the probability of abnormally high positive returns is small and the probability of negative returns is higher than the probability of positive returns.

By contrast, a chart of gold's nominal returns from 1967 to 2022, on an annual percentage basis, is as follows:

Exhibit 89: Gold nominal annual percentage returns, 1967–2022 (%)
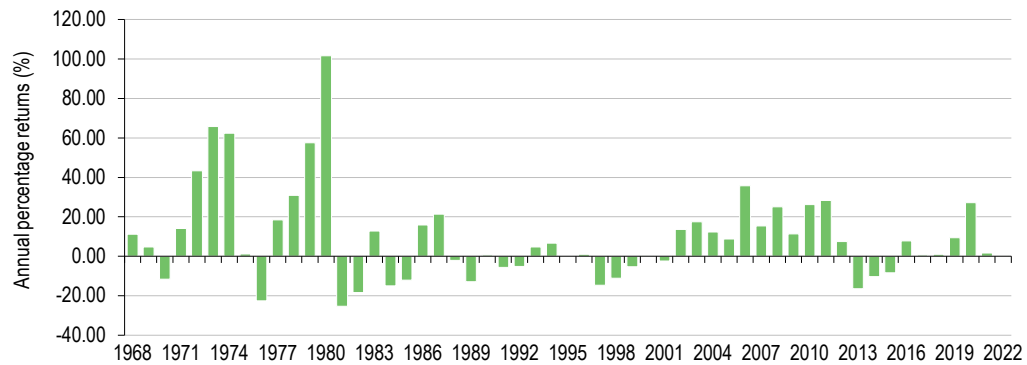
Source: Edison Investment Research (underlying data: South African Chamber of Mines, US Bureau of Labor Statistics, Bloomberg)

While the chart may bear a superficial relationship that in Exhibit 87 (from 1968 onwards), in fact the distribution of returns (albeit nominal rather than real) during the period is significantly different:

Exhibit 90: Histogram of gold's nominal annual percentage returns, 1967–2022
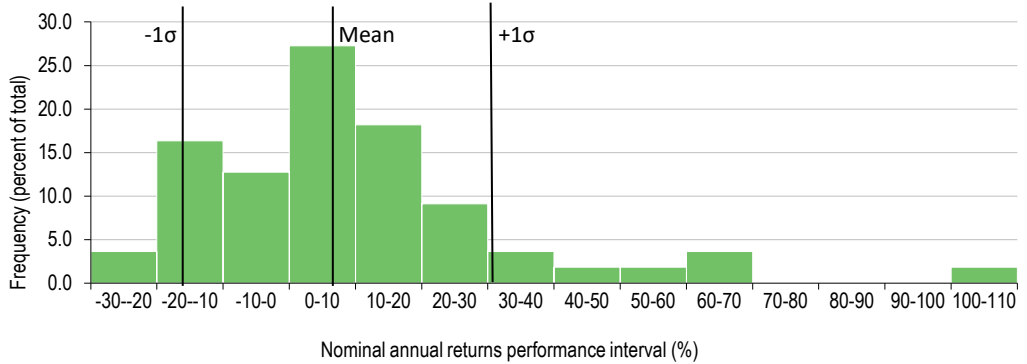
Source: Edison Investment Research (underlying data: South African Chamber of Mines, US Bureau of Labor Statistics, Bloomberg)

Even allowing for the fact that there was a modest increase in the average inflation rate between the two periods (from an average of 2.3% for the period from 1913–67 to 4.0% for the period from 1967–2022), it is also apparent that there is a materially increased probability of a positive annual investment return from gold since 1967, a materially increased probability of an outsized positive investment return (eg >40%) and a materially decreased probability of a negative return in the interval -10–0% compared to the chart of real gold price returns. In this case, the (geometric) average nominal return for gold is 7.4% with a (sample) standard deviation of ±23.5% (NB the population standard deviation is ±18.3%). Note that these calculations are again based on the assumption that returns are normally distributed.

Finally, it is worth observing that gold's return to investors in recent years (in this case since January 2002) has been almost at the apex of a sample of 18 metals and minerals, as shown in the graph below:

Exhibit 91: Capital returns from 18 metals and minerals, January 2002 to August 2023 (%)
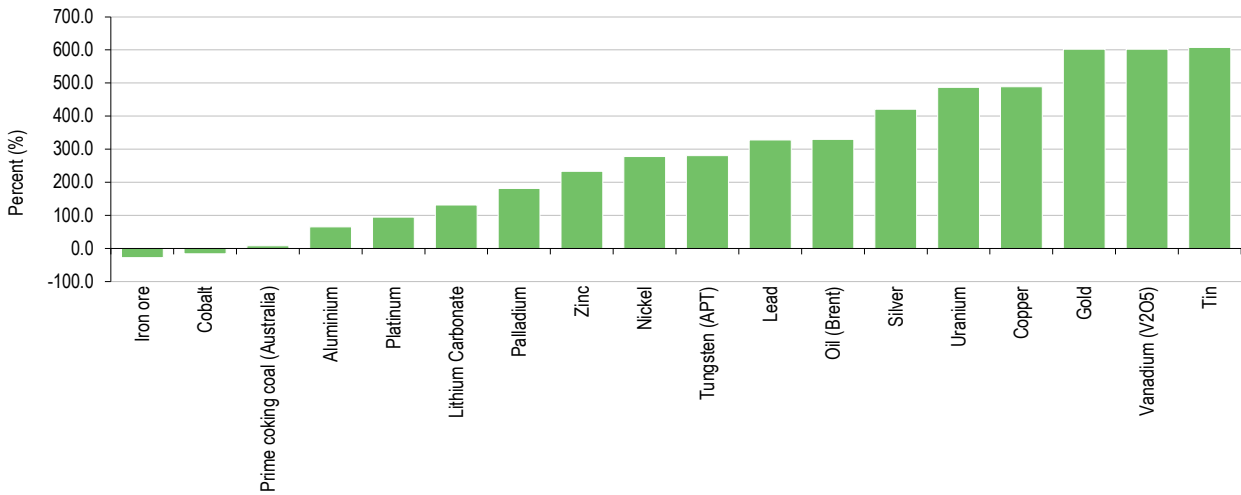
Source: Edison Investment Research (underlying data: Refinitiv, Cameco). Note: Statistics for iron ore, cobalt and lithium carbonate not directly comparable to the remainder of the sample owing to later start dates.

Moreover, it has provided these returns at a level of risk (as measured by the standard deviation of those same investment returns) that is generally lower than those of its peers:

Exhibit 92: Graph of risk (standard deviation of daily investment returns) versus reward (final investment return), January 2002 to August 2023 (factors)

Source: Edison Investment Research (underlying data: Refinitiv, Cameco). Note: Statistics for iron ore, cobalt and lithium carbonate not directly comparable to the remainder of the sample owing to later start dates.

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