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Mind The Gap: Psychological Barriers in Gold and Silver Prices

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Abstract

This study tests the popular claim that psychological barriers exist around key reference points in prices for gold and silver, namely around numbers ending in 0 (e.g. $450) and 00 (e.g. $200). Initial observations and tests show that the price of gold fixes less frequently on values ending in 0 and 00, suggesting the existence of barriers at these levels which manifest as gaps or fewer observations in the frequency distributions at these points. Subsequent statistical tests find support for the existence of barriers at numbers ending in 0 and 00 in the price of gold. Conversely, while initial observations and tests suggest that the silver price is not perfectly uniformly distributed, there is no statistically significant evidence to support that barriers exist at either 0 or 00 for this metal.

1. **Introduction**

As two of the oldest financial assets gold and silver have a unique psychological relationship with investors. While neither provides a yield both are seen by many as true assets as they are free from counterparty risk. There is however scant research around behavioural issues in precious metals (PMs), see O'Connor et al. (2015) for a full review. That markets believe psychological barriers exist in PMs is evident in many press reports on the market[1].

Using intra-day data from 1975-2015 this paper examines whether barriers exist at psychologically important price levels in gold and silver, providing the first evidence for silver and expanding Aggarwal & Lucey's (2007) findings on gold.

It is an opportune time to examine this issue as price volatility for both metals has been high recently. Gold and silver prices peaked near $1,900 and $50 an ounce in 2011, the highest since the Hunt Brothers cornered the silver market. Figure 1 shows that as the effects of the 2007/8 financial crisis fadded and gold's safe haven property became less important to investors (Baur and Lucey, 2010) their price declines have been dramatic - with gold and silver prices falling by over $700 and $30 from their peaks.

[Insert Figure 1 about here]

2. Reasons for Psychological Barriers in Asset Prices

If markets were always rational and efficient then we would not expect to see any significant psychological barriers in precious metals prices. Despite this, the existence of psychological barriers in markets is taken almost for granted with suggestions of resistance levels and support levels whenever an asset reaches a number ending in 0, 00 or 000.

Research suggests that the existing decimal place-value system encourages individuals to think in multiples of ten, and encourages rounding (Mitchell, 2001). In marketing literature cognitive accessibility is the accepted reason for "even-ending" prices (round numbers ending in 0). Consumers tend to identify with round numbers (Palmon *et al.* 2004).

A growing number of economists have come to interpret the anomalies seen in financial markets as being consistent with several irrationalities individuals exhibit when making complicated decisions. These irrationalities stem from two main premises, information processing and behavioural biases. For example, the concepts of anchoring and heuristic simplification in behavioural finance are closely related to the issue of psychological barriers in asset prices. The concept of anchoring draws on the tendency to attach or "anchor" our thoughts to a reference point - even though it may have no logical relevance. Heuristic simplification is the reliance on simple heuristics or other such methods to make decisions. Kahneman et al. (1982) found that the anchoring effect is so strong that it still occurs in situations where the anchor is random. Another bias closely linked with barriers is herding (Avery and

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[1] *"When gold futures prices pushed below the major psychological and technical level of $1,500.00 on Friday it was a "game-changer" from a longer-term technical perspective." (Kitco News, Forbes.com Special Report 12/04/2013)*
"Gold rises for third day; hits resistance at $1,700 per ounce" (Reuters.com 04/09/2012)
"The next downside price breakout objective for the silver bears is closing prices below major psychological support at $30.00." (Kitco News, Forbes.com 25/01/2012)

Zemsky, 1998) the tendency for individuals to mimic the actions of the group, whether rational or irrational.

Westerhoff (2003) develops a formal model of how traders cluster their expectations around round numbers in forex markets. Mitchell and Izan (2006) test for the presence of clustering and psychological barriers separately in exchange rate markets finding a clustering effect but little evidence of psychological barriers. Therefore, while the two aspects are related they are not synonymous. Clustering is a necessary, but not a sufficient condition, for a psychological barrier to exist.

Psychological barriers have been shown to exist in a number of traded financial assets. Aggarwal and Lucey (2007) show that at the 100's level gold reaches a point where it is less likely to continue on an upward or downward price path. In particular it is shown that gold's volatility changes when its price is near or has just crossed a barrier especially when price is falling. In oil prices Dowling et al. (2014) find barriers for Brent crude oil prices but not WTI at the $10 level, with the effect dissipating post financial crisis.

3. Data

We use intraday gold prices composed of the London AM and PM fix which take place at 11.00am and 3.00pm GMT from 02/01/1975 – 30/06/2015 (20,452 observations) and daily silver prices from the London fix over the same period. Both are available from the LBMA website.

4. Testing for of Psychological Barriers

Three broad approaches have been advocated to examine the existence of psychological barriers in asset prices:

1. Tests of the *distribution* of the digits
2. Tests of the *frequency* of digits around presupposed barriers
3. Tests of the *behaviour* of returns around barriers

Underlying these approaches is the examination of the significant digits of the price series. Let P_t be the value of the gold price at time t and M_t be the two trailing digits - the last two digits in the integer portion of the price at 100-levels or in the case of barriers at 10-levels, the pair of digits bracketing the decimal point. For example, if $P_t = 397.97$, then $M_{t100} = 97$ and $M_{t10} = 79$. Barriers at 100-levels in the price (e.g., 300, 400, 1100, etc.) thus become a barrier at $M_{t100} = 00$ and barriers at 10-levels in the price (e.g., 310, 450, 760, etc.) become a barrier at $M_{t10} = 00$. If there are no barriers then the probability of any set of the relevant digits will be equal to that of any other - the distribution of these will be uniform.

4.1 Visual inspection

Figure 2 presents a chart of the 100s and 10's frequency distributions for gold and silver. It is clear that the 100s and 10s frequency distributions do not conform to a uniform distribution, especially for the gold 100's where far fewer observations are present at 00. These gaps or fewer than expected observations at barrier points are indicative of price clustering away from these points.

Uniformity of digits distribution is too simple a measure by itself (Fan Lu and Giles, 2010). Benford's Law notes that because the digits, 1, 2, 3 etc. are not increasing at a constant percentage rate; the limit distribution of such digits does not need to be uniform. However, the larger the sample the closer the distribution would be to uniform. As we are dealing with large samples this issue is not a problem.

4.2 Statistical Tests to Study Uniformity

Two statistical tests have been used in studies of the uniformity of digits, the chi-square test and a regression test.

Koedijk and Stork (1994) use a chi-squared test to test uniformity for equity indices. If there are no psychological barriers, we would expect each M-value to have approximately the same amount of occurrences and to be distributed uniformly. In order to test this we divide the M-values into ten separate categories of equal size, i.e. 06-15,...96-05. For each we note the number of times the price closes with an M-value inside this category. A chi-squared goodness-of-fit test is used to compare the actual and hypothetical number of observations per category. The test-statistic χ^2 and its p-value for gold and silver are reported in Table 1.

The results for gold and silver show that, for both the 100 and 10 digits, the M-values are not uniformly distributed which may indicate the presence of barriers.

Following Donaldson and Kim (1993) we analyse uniformity using a regression approach. Four dummies are introduced with a value of 1 if the index is within a certain distance of a psychological barrier and zero otherwise. The regression uses the frequency of the trailing digits as the dependent variable against a dummy variable which takes on a value of 1 when close to the presupposed psychological barrier of 00. Under the null of no barriers the assumption is that each set of digits (of the 100 pairs) will be equally likely. Thus, the intercept term is expected to be .01 and the slope coefficient insignificantly different from zero.

Generally, however, a variety of markets have been shown to deviate from this assumption, with negative coefficients on the intercept indicating fewer than hypothesised occurrences of the digits near the 00 pair.

Barrier Proximity

To test for systematic deviation from uniformity in the distribution, f(M) is defined to be the frequency with which the price closes with its trailing digits in cell M, minus 1 percent. A first price level test involves regressing f(M) for each of the 100 M-cells on a constant and a dummy variable that isolates groups of cells in the neighbourhood around M = 00.

The regression is:

$$f(M) = \alpha + \beta D_{ij} + U_M; \qquad M = 00, 01, \ldots, 99 \qquad \textbf{(1)}$$

where D_{ij} is a dummy variable that isolates cells in the range from i to j, and U_M is a random error.

The dummies are:

$$D_{98\text{-}02} = 1 \text{ if } M \geq 98 \qquad \text{or} \qquad M \leq 02, = 0 \text{ otherwise;} \qquad \textbf{(2)}$$

$$D_{95\text{-}04} = 1 \text{ if } M \geq 95 \qquad \text{or} \qquad M \leq 04, = 0 \text{ otherwise;} \qquad \textbf{(3)}$$

$$D_{90\text{-}09} = 1 \text{ if } M \geq 90 \qquad \text{or} \qquad M \leq 09, = 0 \text{ otherwise.} \qquad \textbf{(4)}$$

Under the no-barriers null hypothesis β should be zero, while under the barriers alternative hypothesis the β should be negative.

[Insert Table 2a about here]

The negative slope coefficients on the dummy variables in Table 2a reject the null hypothesis of no-barriers for the price of gold and confirm this study's earlier observation that the price of gold closes less frequently on values whose last trailing digits are in the area around 00. The coefficient on $D_{98\text{-}02}$ for the 100s digits, for example, implies that the price on average closes (0.2384% - 0.0119%) 0.2265% less frequently than expected in each of the five cells around $M = 00$. The barrier effect weakens the further away from 00 we go. However, while there are negative coefficients on the dummy variables, only those for the 100s are statistically significant.

[Insert Table 2b about here]

Like gold, there is some evidence in Table 2b to reject the no-barriers null hypothesis for silver with negative slope coefficients on the dummy variables ($D_{98\text{-}02}$ and $D_{95\text{-}04}$) for the 100s digits and ($D_{90\text{-}09}$) for the 10s digits. However, while there are negative coefficients on the dummy variables, they are not statistically significant. Next a Barrier Hump Test examines the entire shape of the distribution, not just the tails. The null hypothesis is that the distribution should be uniform, indicating an absence of barriers. The alternative states that the distribution should have some particular shape if barriers are present. Bertola and Caballero (1992) suggest that a hump-shape is an appropriate alternative. One can examine this possibility by running the regression:

$$f(M) = \alpha + \beta M + \delta M^2 + U_M; \qquad M = 00, 01, \ldots \ldots 99 \qquad \textbf{(5)}$$

Under the null of no barriers δ should be zero, while under the alternative δ will be negative. The results are presented in Table 3.

[Insert Table 3 about here]

While there appears to be some evidence of a barrier at 10 for gold the negative δ is not statistically significant. For silver, we cannot reject the null of no barriers at 5% as δ is zero in both cases.

4.2.3 Conditional Returns Test

Finally the price's behaviour is studied as it progresses through various M-cells from one closing price to the next. To conduct this test, we first calculate:

$$R_t = Ln(P_t) - Ln(P_{t-1}) \qquad \textbf{(6)}$$

where R_t is the return at time t. Second, the value of R_t is assigned to each of the M-cells implicitly passed by the price at time t. Thus, if $P_{t-1} = 1492$ and $P_t = 1497$, then the return $R_t = 0.0033$ would be assigned to cells $M = 93$ to 97 since these are the cells through which the price passes as it rises from 1492 to 1497. This procedure is repeated for every day in the sample.

Finally, for each of the 100 M-cells (M = 00, 01,..., 99) the mean of all the returns that were assigned to that cell is calculated. The average is defined as R_M: the average daily return conditional on having passed through cell M (M = 00, 01, 02,..., 99). The behaviour of R_M across the M-cells forms the basis for the conditional returns test. The existence of a barrier at 100-levels (or at 10-levels) in an asset price implies a negative correlation between R_M and M for three reasons.

1. Once the price crosses a barrier buying pressure associated with traders' optimism as the price rises up will push the index well past the 00-level resulting in less frequent closings of the price just above the 00-level and in larger-than-normal positive returns.
2. As falling through a barrier is considered bad news by the market subsequent selling pressure pushes the price down by more than warranted once a 00 barrier is crossed resulting in less frequent price observations just below the 00-level and in larger than normal negative returns.
3. If the barrier restrains movements past a 00 resistance level, then movements up toward high M-values would be restrained to be smaller than normal.

So with a barrier low M-cells are filled with larger than normal increases and smaller decreases, and vice versa for high M-cells implying a negative correlation between R_M and M.

To test this we run the regression,

$$R_M = \alpha + \beta M + U_M; \quad M = 00,01,\dots 99 \tag{7}$$

where U_M is a random error. The results of this are presented in Table 4 below.

[Insert Table 4 about here]

Under the no-barriers null hypothesis β should be 0, while under the barriers alternative β should be negative. The significant negative β for the 10s digits rejects the no-barriers null in favour of the barriers alternative, while for the 100s digits, the null cannot be rejected. These results are interpreted as support for the existence of barriers at 10-levels in the price of gold, but not at 100-levels. For silver, we cannot reject the no-barriers null hypothesis and interpret the results as evidence against the existence of barriers at both the 100-levels and 10-levels.

5. Conclusions

Prior research on stock indices, government bonds and other commodities has found evidence for the existence of psychological barriers. Using a number of statistical procedures to assess psychological barriers for gold and silver prices over 40 years, this paper tests whether evidence exists to support psychological barriers in these assets.

Initial observations and statistical tests show that the price of both precious metals fixes less frequently on values ending in 0 and 00. This leads to gaps in the frequency distributions suggesting evidence of clustering away from these values which is a necessary but not sufficient condition for the existence of psychological barriers. Subsequent tests for psychological barriers find some evidence to support the existence of barriers at numbers ending in 0 (e.g. $450) and 00 (e.g. $200) in the price of gold. Conversely there is no evidence that any statistically significant barriers exist at numbers ending in either 0 or 00 for silver.

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Tables

Table 1: Chi-Square Test for Uniformity

	Gold		Silver	
	100s Digits	**10s Digits**	**100s Digits**	**10s Digits**
χ^2	519.58	111.94	332.86	375.00
p-value	0.00	0.00	0.00	0.00

Table 2a: Price Level Tests for Gold Price Density

	100s Digits			10s Digits		
	$D_{98\text{-}02}$	$D_{95\text{-}04}$	$D_{90\text{-}09}$	$D_{98\text{-}02}$	$D_{95\text{-}04}$	$D_{90\text{-}09}$
α	0.0119	0.0216	0.0274	0.0083	0.0141	0.0234
	(0.0216)	(0.0218)	(0.0234)	(0.0545)	(0.0559)	(0.0593)
β	-0.2384	-0.2158	-0.1370	-0.1663	-0.1414	-0.1172
	(0.0965)	(0.0689)	(0.0524)	(0.2437)	(0.1769)	(0.1326)
p-value	0.02	0.00	0.01	0.50	0.43	0.38

Note: Standard error given in brackets p-value relates to β

Table 2b: Price Level Tests for Silver Price Density

	100s Digits			10s Digits		
	$D_{98\text{-}02}$	$D_{95\text{-}04}$	$D_{90\text{-}09}$	$D_{98\text{-}02}$	$D_{95\text{-}04}$	$D_{90\text{-}09}$
α	0.0016	0.0020	-0.0032	-0.0302	-0.0119	0.0008
	(0.0172)	(0.0176)	(0.0187)	(0.1387)	(0.1432)	(0.1519)
β	-0.0323	-0.0200	0.0160	0.6034	0.1190	-0.0042
	(0.0767)	(0.0557)	(0.0418)	(0.6205)	(0.4528)	(0.3397)
p-value	0.67	0.72	0.70	0.33	0.79	0.99

Note: Standard error given in brackets, p-value relates to β

Table 3: Price Level Tests for Hump-Shape

	Gold		Silver	
	100s Digits	10s Digits	100s Digits	10s Digits
A	-0.2286	-0.1059	0.2037	0.1657
	(0.0530)	(0.1562)	(0.0415)	(0.4007)
B	0.0056	0.0076	-0.0064	-0.0033
	(0.0025)	(0.0073)	(0.0019)	(0.0187)
δ	0.0000	-0.0001	0.0000	0.0000
	(0.0000)	(0.0001)	(0.0000)	(0.0002)
p-value	0.56	0.25	0.17	1.00

Note: Standard error given in brackets, p-valve relates to δ

Table 4: Conditional Returns Tests

	Gold		Silver	
	100s Digits	10s Digits	100s Digits	10s Digits
α	0.1409	0.0539	-0.0183	-0.2304
	(0.0194)	(0.0019)	(0.0145)	(0.2595)

β	0.0002	-0.0004	0.0000	0.0082
	(0.0003)	(0.0000)	(0.0003)	(0.0045)
p-value	0.571	0.000	0.998	0.072

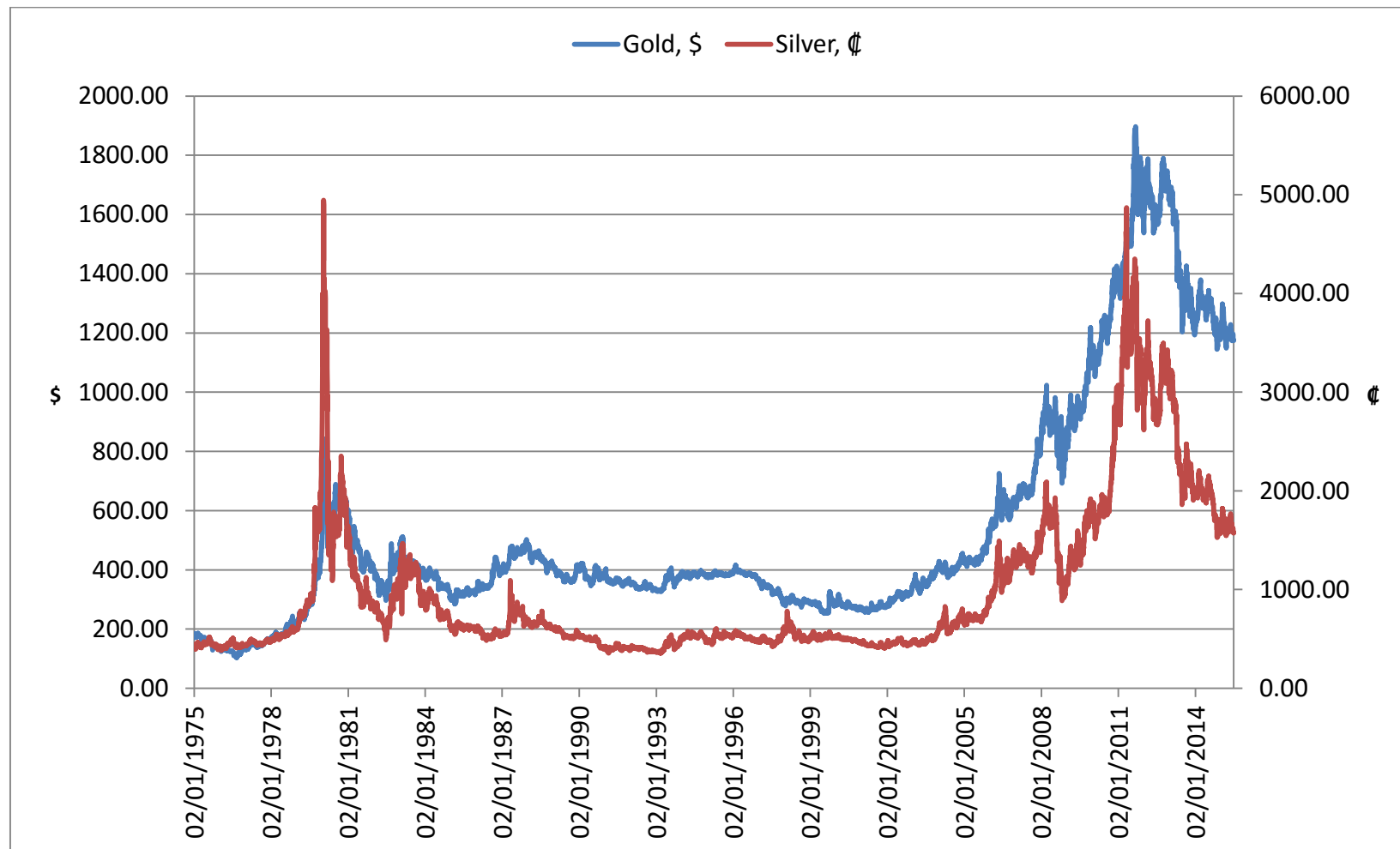*Note: Standard error given in brackets, p-value relates to β*
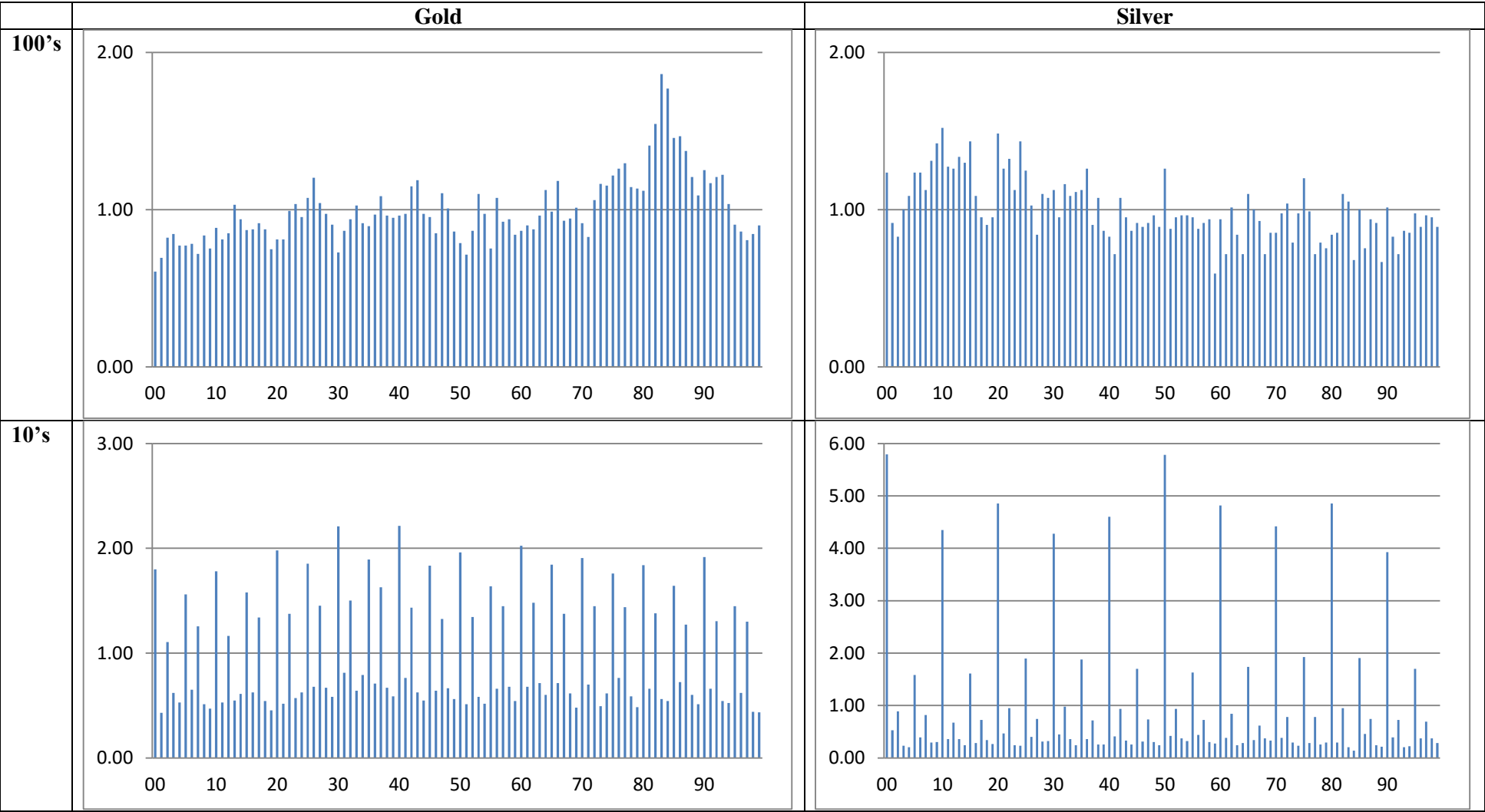
Figure 1: Gold and Silver Prices

Figure 2: M-Values

Alternative Figure 2: M-Values