Happiness and Gold Prices

Byström, Hans

2020

Document Version:
Other version

Working Paper 2020:1

Department of Economics
School of Economics and Management

Happiness and Gold Prices

Hans Byström

February 2020

LUND
UNIVERSITY

Happiness and Gold Prices

HANS BYSTRÖM*

February 2020

We use the Twitter-based Hedonometer happiness index to study the link between happiness and gold price changes. We find no significant correlation between the two when we look at correlations across the entire distributions. However, turning to an extreme value theory (EVT) modeling of the tails of the non-normally distributed happiness distribution we find that during particularly depressing days the gold price often goes up. In a sense, gold is found to serve as a happiness-related safe haven, i.e. as a hedge against extreme unhappiness.

Keywords: Twitter; happiness; Hedonometer; gold price; tail; extreme value theory

JEL classification codes: G14; G41; G50; D83

* Hans Byström is from the Department of Economics, Lund University, Box 7082, 22007 Lund, Sweden (hans.bystrom@nek.lu.se).

"Money alone does not make you happy. You also need shares, gold and real estate." Regardless of the truth in the Danny Kaye quote, in this paper we find that during really unhappy days, holding some gold probably makes you a little happier. While we find the gold price to be essentially uncorrelated to the level of happiness during normal times, we find that during particularly depressing days the gold price tends to go up on average.

While we are not aware of any previous studies looking into the relationship between individuals' (un)happiness and gold prices, there is plenty of evidence, both anecdotal and scientific, of gold prices being related to market doom and gloom. In the short run there seems to be a positive link between the two (Baur et al., 2010). In the long run, however, there are many situations where a pending economical or financial crisis does not translate into immediate gains for the yellow metal. If you bought gold as a hedge against the second oil crisis in 1980 you would have had to sustain decades of subsequent losses, and if you bought gold in 2012 as a hedge against a Greek default during the Eurozone debt crisis, you would have had to wait seven years before your losses had turned to gains (Plender, 2020). In other words, it is not obvious that unhappy times, or unhappy investors, translate into rising gold prices.

We measure individuals' happiness using the Twitter-based Hedonometer happiness index (Dodds et al., 2011). This measure of happiness is generated from a randomly selected database with millions of Twitter posts, and it measures the happiness in the world of Twitter on a daily basis. We then compare the level of happiness to day-to-day gold price changes. While there are some studies (Zhang et al., 2016; You et al., 2017; Shen et al., 2018; Zhao, 2020) that have looked at the link between the Hedonometer index and stock prices, we are not aware of any study on gold prices. In addition, our study differs from the previous Hedonometer-studies in several ways. The main focus of our paper is on the tails of the happiness index, i.e. on extreme happiness and unhappiness, and we model the tails of the non-normal happiness distribution

using tools from extreme value theory. Tail indexes are computed and Generalized Pareto Distribution (GPD) parameters are estimated for each tail separately. By focusing on the tails, we also acknowledge the possibility of a non-linear relationship between happiness and gold prices. Indeed, our empirical results dismiss any linear relationship between the two, and instead indicate a non-linear dependency with extremely unhappy days behaving differently.

I. The Hedonometer Happiness Index

The Hedonometer happiness index data is downloaded from http://hedonometer.org/index.html. The index is generated from the Twitter Gardenhose feed database, a randomly selected database with 50 million (10%) of the total number of Twitter posts. The happiness index is constructed using approximate 10,000 sentiment-related words, such as love, happy etc. along with natural language process techniques provided by the Amazon's Mechanical Turk service.

The Hedonometer index is available on a daily basis and in this paper we study the time-period September 15, 2008 – December 6, 2019. We remove all weekend data since our aim is to compare daily happiness levels with daily gold prices. Moreover, Dodds et al. (2011) finds that annual religious, cultural, and national events often are associated with anomalously happy days and to remove this spurious and predictable pattern we remove the following days throughout the sample (the outlier days suggested on page 8 in Dodds et al. (2011)): Christmas Eve, Christmas Day, New Year's Eve, New Year's Day, Valentine's Day, Thanksgiving, Fourth of July, Easter Sunday and Mother's and Father's days (the latter three are already removed since they appear on Sundays). Finally, eight missing Hedonometer observations have been replaced by interpolated values and the first four observations in the database (September 9–12, 2008) were removed in order to start on a Monday (we end on a Friday). In total, we are left with 2871 days in our sample.

In Table I we present some descriptive statistics for the Hedonometer index. The happiness index is stationary, as indicated by the Phillips-Perron tests, and it fluctuates around a mean value of 6.014 with a standard deviation of 0.040. The distributional properties of typical financial variables, and their deviation from the Normal distribution, are often summarized by the skewness and kurtosis of the empirical distribution. Our (non-financial) Hedonometer index also demonstrates both skewness and kurtosis, but, as can be seen in Figure 1, the Hedonometer index is so far from normally distributed that these numbers are somewhat meaningless. Instead, we have chosen to model the tails of the distribution using models from Extreme Value Theory (EVT). This fits well both with our a priori aim in this study of looking at tail events, i.e. very happy and unhappy days, and with our empirical findings showing significantly non-normal happiness distribution tails.

The main purpose of EVT is to provide asymptotic models with which one can model the tails of a distribution. The theory has been around for some time (Fischer et al., 1928; Gnedenko, 1943; Gumbel, 1958) and applications have since appeared in different areas, including finance (see for instance Embrechts et al. (1997) and Reiss et al. (1997)). One of the most widely used EVT-models is the peaks-over-threshold (POT) method where one collects observations that exceed a certain high threshold u and models the distribution of these extreme observations.

A detailed discussion of the POT method can be found in Embrechts et al. (1997) and here we only give a brief presentation of the method. If we call a daily observation in our data series R and assume that it comes from a distribution F_R, then the observations above the threshold u follow the excess distribution $F_u(y)$ where y is the excesses over u, and R_F is the right endpoint of F_R. Now, if the threshold u is high enough, Balkema et al. (1974) and Pickands (1975) have shown that for a large class of distributions F_R the excess distribution $F_u(y)$ can be approximated by the so called generalized Pareto distribution (GPD)

$$G_{\xi,\alpha}(y) = 1 - \left(1 + \frac{\xi}{\alpha} y\right)^{-\frac{1}{\xi}} \quad \text{, if } \xi \neq 0 \tag{1}$$

$$G_{\xi,\alpha}(y) = 1 - e^{\frac{-y}{\alpha}} \quad \text{, if } \xi = 0$$

for $0 \leq y \leq R_F - u$. ξ is called the tail index and $\alpha > 0$ is a scaling parameter. For so-called fat-tailed distributions ξ is positive and for thin-tailed distributions ξ is negative.

The tail index ξ and the scaling parameter α are determined by fitting the GPD to the actual data using maximum likelihood methods. The POT method relies on a reasonable choice of threshold, u and in this paper we follow the recommendations in McNeil et al. (2000) and keep 5% (143) of the observations above the threshold. The estimated GPD parameters are shown in Table II and the right (happy) tail, is found to be thin-tailed with a negative tail-index equal to -0.20. The left (unhappy) tail, though, is fat-tailed like the typical financial return series. Its tail-index is +0.35.[1] Many variables in (social) sciences are normally distributed, but Twitter happiness does not seem to be one of them. The number (magnitude) of really unhappy days is higher (larger) than one would expect from an assumption of normality while the number (magnitude) of really happy days instead is lower (smaller). [2] Basically, there is an asymmetry to happiness, or at least to the way people express their happiness, on Twitter (on trading-days).

II. The Hedonometer Happiness Index and Gold Price Movements

The main aim of this paper is to study the link between happiness and gold prices, and we therefore download daily gold prices (Gold Bullion LBM $/t oz delay) from Datastream for the same time-period as the Twitter happiness index, i.e. September 15, 2008 – December 6, 2019.

[1] The tail-indexes remain qualitatively unchanged when we increase the tail-thresholds, i.e. when we go further out in the tails and leave just 2.5% (72) observations for the excess distribution $F_u(y)$.

With weekends and holidays removed to perfectly match the happiness data we end up with 2871 daily gold price observations.

LBM gold bullion prices are published at midnight London time the day the prices are set at the London auction (i.e. with a delay), and the gold return that we compare to the Hedonometer index is therefore the midnight-to-midnight return for the same calendar day that the Twitter happiness data is collected by the Hedonometer team.[3] We do not find a significant (linear) link between the Hedonometer happiness level and gold price returns. The Pearson correlation coefficient is not significantly different from zero, at +0.014, and any relationship between the degree of happiness and the increase in the gold price a certain day is either non-existent or non-linear in nature. The scatter plot in Figure 2 tells the same story, and the mood of Twitter users does not seem to affect the gold price in any meaningful way, at least not across the entire (non-normal) distribution and not in a simple linear (correlation/regression) fashion.

In order to test for the possibility that there once existed a linear happiness-gold price link that has now disappeared, or the opposite, that such a link has materialized itself as time has passed, we recalculate the correlation for different sub-periods. To test for both of these two possibilities we let the estimation window shrink either from the left or from the right; i.e. we either fix the end date to December 2019 and let the start date of the estimation window move forward, beginning in September 2008 (see the upper graph in Figure 3) or we fix the start date to September 2008 and let the end date of the estimation window move back in time beginning in December 2019 (see the lower graph in Figure 3). In both cases the estimation window shrinks (one week at a time) until it is only 12 months long, and from Figure 3 it is clear that the

[2] At least for the filtered data series used in this study where several very happy days are removed due to them occurring on weekends or on holidays (i.e. non-trading days).

[3] Both gold investors and Twitter users are of course globally distributed across different time-zones, but London time is used in this study due to London's location geographically right in between the Americas and Eurasia.

correlation estimate remains within the +/-0.1 range regardless of when the estimation period starts or ends, and regardless of the length of the estimation window. Our conclusion is that there is no overall correlation between happiness and gold prices, neither at present nor in the past, at least not when we look across the entire distribution of happiness levels.

While happiness does not seem to be related to the day-to-day gold price development in any meaningful way for typical happiness-levels, it is still possible that there is a link between the two on extremely happy or unhappy days. In the financial literature one often makes a distinction between a hedge and a safe haven, with a safe haven protecting against extreme negative market scenarios (Baur et al., 2010). Now, in the same spirit, but for (un)happiness, it is possible that gold is also more of a "safe haven", rather than a "hedge". We have therefore chosen to look at the tails of the Hedonometer index distribution, and on how the gold return is distributed and correlated (tail-correlations) to happiness during extremely happy or unhappy days. As for the correlations, in Table III we present Pearson tail-correlations between the Hedonometer happiness index and gold returns for various tail-thresholds, i.e. correlation coefficients for subsets of the data containing the 1.25%, 2.5%, 5% or 10% most extreme Hedonometer observations (days). From Table III it is clear that the tail-correlations are close to zero for all subsets except for those containing solely extremely unhappy days. If we limit the sample to the 2.5% or 1.25% most unhappy days, there does indeed seem to be a link between happiness and gold returns with tail-correlation estimates equal to 0.24 and 0.28, respectively. Figure 4 shows the same thing and, interestingly, there does not seem to be a corresponding significant link during extremely happy days.

The link between happiness and gold returns in the tails is further investigated by looking at the sign, number and magnitude of gold returns during extremely happy and unhappy days. We start by producing scatter plots for the unhappy tail of the Hedonometer distribution. Figure 5 shows

four different scatter plots for four different tail-thresholds, and these plots reveal that the further out in the unhappy tail we go the more the positive gold price changes dominate, both in size and in numbers. Basically, it seems that gold works as some kind of hedge, or safe haven, against extreme unhappiness. This is further quantified in Tables IV and V where we present the number of positive/negative gold returns as well as the mean gold returns in the Hedonometer happiness index tails for various tail-thresholds. Again, extremely unhappy days stand out as different from both ordinary happy/unhappy days as well as extremely happy days. On average, during these extremely unhappy days, the gold price goes up both more frequently and with bigger moves than on other days. In other words, gold seems to serve as a safe haven against extreme unhappiness, but not as a hedge against general unhappiness. Why this is, one can only speculate about. We also do not know anything about the causality between unhappiness and gold returns at this point, but if such causality exists it seems much more likely to be in the direction *from* unhappiness *to* gold price than in the opposite direction considering the way the happiness index is constructed.

III. Conclusion

We find no significant correlation between daily observations of the Twitter-based Hedonometer happiness index and daily gold price changes. However, when we look at the tails of the happiness distribution, we find gold prices to go up on particularly unhappy days. A slightly modified version of the famous quote by Leo Tolstoy "All happy families are alike; each unhappy family is unhappy in its own way" could possibly be applied to gold and gold investors. While happy days all seem to be alike to gold investors, all unhappy days are not; really unhappy days indeed seem to be different from other less unhappy days. Or put differently, while gold does not seem to work as a hedge against general unhappiness, it seems to work as a safe haven, i.e. as a hedge against extreme unhappiness.

ACKNOWLEDGEMENTS

This work was supported by *Handelsbankens Forskningsstiftelser*. The author thanks the Hedonometer Team for making the Twitter happiness data publicly available. All mistakes in this article are the author's.

REFERENCES

Balkema, A., and L. de Haan, 1974, Residual life time at great age, Annals of Probability 2, 792-804.

Baur, D. G., and B. M. Lucey, 2010, Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold, The Financial Review 45, 217–229.

Dodds, P.S., Harris, K. D., Kloumann, I. M., Bliss, C. A. Bliss, and C. M. Danforth, 2011, Temporal patterns of happiness and information in a global social network: Hedonometrics and Twitter. PLoS ONE, 6(12).

Embrechts, P., C. Kluppelberg, and T. Mikosh, 1997, Modelling extremal events (Springer, Berlin-Heidelberg).

Fisher, R. and Tippett, L., 1928, Limiting forms of the frequency distribution of the largest or smallest member of a sample, Proceedings of the Cambridge Philosophical Society 24, 180-190.

Gnedenko, B., 1943, Sur la distribution limite du terme maximum d'une série aléatoire, Annals of Mathematics 44, 423-453.

Gumbel, E., 1958, Statistics of extremes (Columbia University Press, New York).

Pickands, J., 1975, Statistical inference using extreme order statistics, The Annals of Statistics 3, 119-131.

Plender, J., 2020, Strange new world where tech stocks are seen as havens. Financial Times, Jan. 14.

Reiss R. and M. Thomas, 1997, Statistical analysis of extreme values (Birkhäuser, Basel).

Shen, D., Liu, L, and Y. Zhang, 2018, Quantifying the cross-sectional relationship between online sentiment and the skewness of stock returns, Physica A: Statistical Mechanics and its Applications, 490, 928–934.

You, W., Guo, Y., and C. Peng, 2017, Twitter's daily happiness sentiment and the predictability of stock returns, Finance Research Letters, 23, 58-64.

Zhang, W., Li, X., Shen, D., and A. Teglio, 2016, Daily happiness and stock returns: Some international evidence, Physica A: Statistical Mechanics and its Applications, 460, 201–209, 2016.

Zhao, R., 2020, Quantifying the cross sectional relation of daily happiness sentiment and stock return: Evidence from US, Physica A: Statistical Mechanics and its Applications, 538 January 2020, 122629.

Table I
Descriptive Statistics

In this Table we present descriptive statistics for the Hedonometer happiness index. The time period is September 15, 2008 – December 6, 2019, i.e. 2871 daily observations where weekends and certain important holidays are removed. *Skew* is skewness, *Kurt* is excess kurtosis and *PP* is the Phillips-Perron Test with 4 Lags with/without a trend.

	Mean	*Std. Dev.*	*Max*	*Min*	*Skew*	*Kurt*	*PP (trend)*	*PP*
Hedonometer	6.014	0.040	6.126	5.774	-0.131	-0.239	-309.0	-370.9

Table II
Tail Estimation – GPD-parameters

In this Table we present the GPD-parameters for the Hedonometer happiness index tails. The time period is September 15, 2008 – December 6, 2019, i.e. a total of 2871 daily observations, with 143 observations in each tail.

	μ	ξ	α
Happy tail	6.074	-0.203	0.015
Unhappy tail	5.954	0.354	0.010

Table III
Tail-Correlations – Hedonometer Happiness Index and Gold Returns

In this Table we present Pearson tail-correlations between the Hedonometer happiness Index and gold returns for various tail-thresholds. The entire time period (100%) is September 15, 2008 – December 6, 2019, and all correlations are estimated using daily observations.

Happy Tail	**Entire period**	0.01
	10%	-0.05
	5%	0.01
	2.5%	-0.06
	1.25%	-0.12
Unhappy Tail	**Entire period**	0.01
	10%	0.03
	5%	0.12
	2.5%	0.24
	1.25%	0.28

Table IV

Number of Positive/Negative Gold Returns in the Hedonometer Happiness Index Tails

In this Table we present the number of positive and negative gold returns in the Hedonometer happiness index tails, i.e. those days the Hedonometer index observations are extreme, for various tail-thresholds. The entire time period (100%) is September 15, 2008 – December 6, 2019, and we are using daily observations.

Happy Tail	**Entire period**	**Pos**	1464
		Zero	42
		Neg	1365
	10%	**Pos**	139
		Zero	8
		Neg	140
	5%	**Pos**	61
		Zero	6
		Neg	76
	2.5%	**Pos**	32
		Zero	5
		Neg	35
	1.25%	**Pos**	14
		Zero	3
		Neg	19
Unhappy Tail	**Entire period**	**Pos**	1464
		Zero	42
		Neg	1365
	10%	**Pos**	148
		Zero	2
		Neg	137
	5%	**Pos**	81
		Zero	2
		Neg	60
	2.5%	**Pos**	44
		Zero	1
		Neg	27
	1.25%	**Pos**	23
		Zero	1
		Neg	11

Table V
Mean Gold Returns in the Hedonometer Happiness Index Tails

In this Table we present mean gold returns in the Hedonometer happiness index tails, i.e. those days the Hedonometer index observations are extreme, for various tail-thresholds. The entire time period (100%) is September 15, 2008 – December 6, 2019, and we are using daily observations.

Happy Tail	**Entire period**	0.00028
	10%	-0.00024
	5%	-0.00083
	2.5%	-0.00056
	1.25%	-0.00055
Unhappy Tail	**Entire period**	0.00028
	10%	-0.00037
	5%	0.00057
	2.5%	0.00164
	1.25%	0.00109

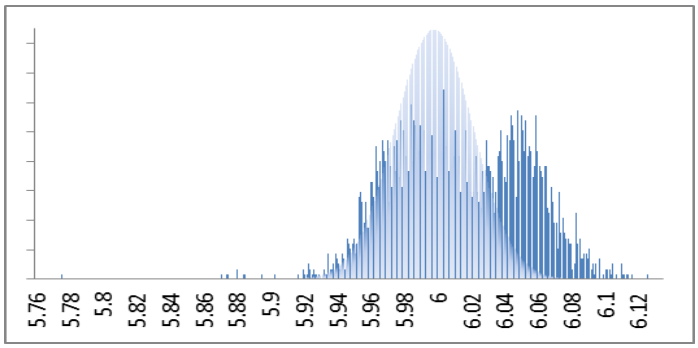

Figure 1. Hedonometer Happiness Index Distribution This graph shows the empirical probability distribution for the Hedonometer happiness index over the time period September 15, 2008 – December 6, 2019 (without weekends and holidays) together with the Normal distribution with the same mean and variance.

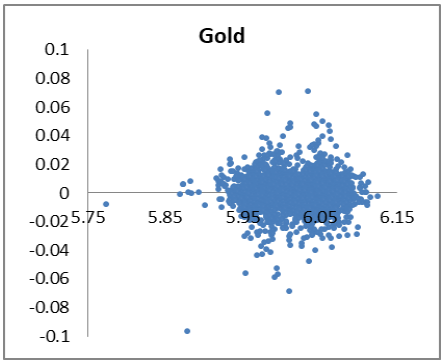

Figure 2. Scatterplot of Hedonometer Twitter Happiness Index vs. Gold Returns This graph plots daily Hedonometer index values (on the x-axis) vs. daily gold returns over the time period September 15, 2008 – December 6, 2019.

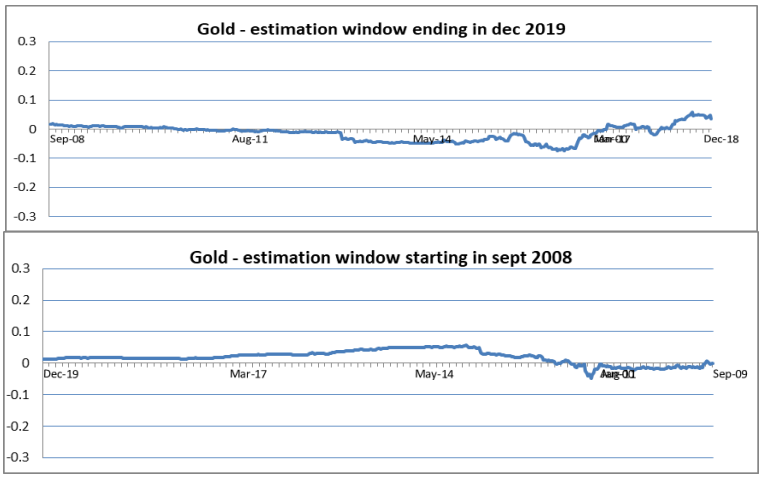

Figure 3. Correlation between the Hedonometer Happiness Index and Gold Returns vs. Estimation Window Dates The upper graph plots the correlation between the Hedonometer happiness index and gold returns (on the y-axis) vs. the date when the estimation window starts on the x-axis (a shrinking window as we move to the right, always ending in December 2019). The lower graph plots the same correlation between the happiness index and gold returns (on the y-axis) vs. the date when the estimation window ends on the x-axis (a shrinking window as we move to the right, always starting in September 2008). In both cases the window-size goes from a little more than eleven years to one year as we move to the right.

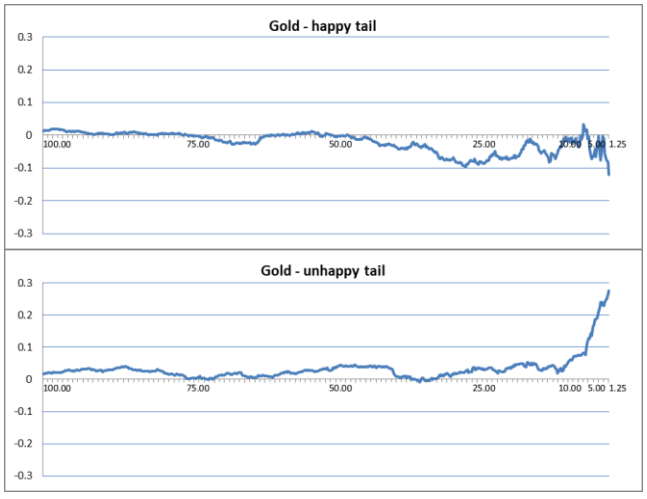

Figure 4. Tail-correlation between the Hedonometer Happiness Index and Gold Returns vs. Tail-threshold (%) This graph plots correlations between the Hedonometer happiness index and gold returns (on the y-axis) vs. the percentage of observations left in the tail of the Hedonometer empirical distribution. The Hedonometer tail-threshold, i.e. the share of the total number of observations that was used to compute the correlation coefficient, varies from 100% to 1.25%.

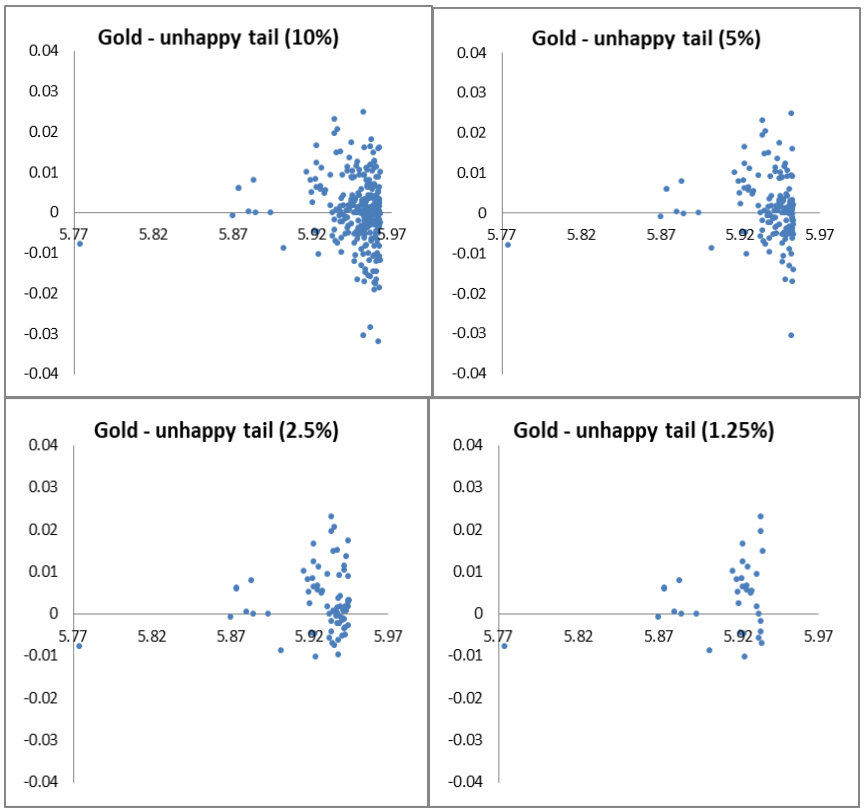

Figure 5. Scatterplot of the Unhappy Tail of the Hedonometer Happiness Index vs. Gold Returns This graph plots Hedonometer index values (on the x-axis) vs. gold returns for the unhappy tail over the time period September 15, 2008 – December 6, 2019 for four different Hedonometer index tail-thresholds.