

# Myrmikan Research

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## The Economics of Gold Mining



Sources: Historical Statistics of the United States; Bureau of Labor Statistics; Federal Reserve

The chart above demonstrates that gold is and remains free market money; it displays the record of attempts to make it not so; and it reveals the collapse of all statist efforts to create “new eras” of “permanent prosperity.” All other markets are subservient to this master of finance.

Gold is unlike any other good. Most commodities are consumed soon after production—their value, therefore, depends on marginal demand interacting with the marginal producer. As improvements in technology force all production costs to fall and also drive efficiency in use, the value of the marginal unit tends to fall as well.

Unlike other commodities, gold is not consumed and does not decay—golden artifacts are easily converted into bars and coins and back again, and nearly all the gold

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ever mined in history remains available in the market at the right price. Even gold buried with the dead usually finds its way back to the market—it took a pyramid to keep grave robbers out of pharaoh's tomb.

Demand for gold, therefore, interacts not just with the amount of new supply from mining, but with the total accumulated supply from all of history. Gold mining adds just 1.5% to the above ground supply of gold each year, which means that declining costs of mining have little influence on gold's value.

Gold's relative stability of value in the face of technological progress forces the value of other goods to fall in terms of gold over time. Since 1784, for example, copper priced in gold has declined 0.7% per year on average, cotton by 1.0%, and wheat by 1.1%. The price of crude oil has been relatively constant in terms of gold for the past forty-five years, yet fuel efficiency has soared—the average new passenger car in 2014 drove 36.4 miles on a gallon of gas, as opposed to only 12 miles in 1973. The value of consumer goods—cars, appliances, computers—plummets over time in terms of gold, retaining only curiosity value. The longer a man holding a gold coin delays his purchase, the more he gets, his reward for saving. The man who invests in capital projects may do much better, but only by taking on much more risk.

Gold, therefore, offers an economically risk-free means not just to store but to increase purchasing power (assuming continued technological advancement)—in other words, gold has a negative discount rate, which is why man has a propensity to store it in vaults to save it for the future. Gold deposited in a mine, however, is a very different story. The project risk of a mine makes the gold in the deposit have a positive discount rate, prompting man to dig it up.

Warren Buffet famously remarked:

[Gold] gets dug out of the ground in Africa, or someplace. Then we melt it down, dig another hole, bury it again and pay people to stand around guarding it. It has no utility. Anyone watching from Mars would be scratching their head.

On the contrary, assuming the Martians were economically literate, they would understand that gold mining is the act of moving gold from a positive to a negative discount rate environment. Financial bubbles may prompt insane economic enterprises temporarily, but for Warren to impugn an activity in which man has been engaged without interruption for at least thirty thousand years displays supreme hubris.

The continual decrease of commodities priced in gold has profound implications for the economics of gold mining. A gold mine is essentially a spread trade between industrial commodities (which represent the costs of mining) and gold (which determines revenue). As the gold-to-commodity ratio increases over time, gold deposits become more valuable, and submarginal ore becomes economic.

Cut-off grades a century ago, for example, were roughly one ounce per ton (meaning miners left behind any ore below that grade); by the 1930s deposits of half-an-ounce were regularly mined; today cutoff grades in many deposits are below a gram per ton (there are vast differences in cutoff grades for particular projects, of course, driven by the mining method, metallurgy, taxes, labor costs, proximity to public infrastructure,

etc., but the overall, long-term trend is down). This transformation explains the adage that the best place to search for gold is in the shadow of a headframe. Past-producing mines nearly always leave a halo of uneconomic gold behind that becomes economic through the passage of time. There are gold mines in South America, in fact, that have been mined so slowly that they have been in continuous production for hundreds of years—by the time the ore is depleted, the surrounding sub-marginal ore has become payable, creating perpetual cash flow machines.

This is the correct way to mine gold, though almost no one does it today. Modern mining executives have no appreciation of gold's unique characteristics, so they treat it as a base metal. Bank analysts generally value gold mines using a 5% discount rate (though they can't explain why), then CEOs whisper to investors that they use 10% internally to be more conservative. The difference is pronounced. At a 5% discount rate (which itself is too high for a conventional mine in a stable jurisdiction), cash flows in year 12 are still worth 54% of present value, a figure that drops to only 28% when discounting at the typical internal rate of 10%. As a result, companies scale their capital expenditures to dig up all of a deposit within twelve years—very few feasibility studies extend beyond that time frame. Then, once in production, the mine must add back at least 9% in new reserves per year in order to keep the mine life stable to justify the invested capital—all of the cash flow gets poured back into exploration to feed the voracious mill until the payable ore is depleted, leaving the poor equity investors with nothing.

Mining executives of old understood that extending mine life boosts value because of increasing margins driven by the naturally increasing gold-to-commodity ratio. In a 1973 speech to the Committee for Monetary Research & Education, for example, the Chairman of Homestake Mining Company said:

Indeed, with the present increase in the 'price' of gold, we will probably see a decrease in the quantity of gold produced by the existing mines of the world, because every one of the mines, especially the great mines of the Rand, will take advantage of the opportunity to extend the life of their ore reserve by working lower grade ores which cannot be worked when the 'price' of gold is low. That is good practice.

Following this advice, the Homestake mine produced 40 million ounces of gold over 124 years and paid dividends for most of that time.

Homestake's policy would be anathema to any MBA-trained executive—maximizing NPV would seem to demand always mining the highest grade ore first to accelerate cash flow, which is what modern miners do. Even worse, many companies use the cash flow from the initial years of production to back loans to expand their plant to shorten mine lives—executives imagine they are boosting NPV by accelerating cash flows, whereas in fact they are destroying value through margin compression and increasing the potential for financial distress, an even more potent means to destroy the value of a gold mine.

The chart at front shows that commodity prices fall against gold over long periods of time, but it also displays numerous spikes during times in which the government becomes actively involved in the economy, most notably during war. The reason why government spending boosts commodity prices is somewhat complex, but merits a full explanation.

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In a free market for money, private banks issue notes redeemable into gold that compete in the market (in an open market, no one would prefer an irredeemable note). If one bank over-issues its notes, their value will decline—speculators will buy them at the discounted rate and demand full redemption in gold, earning a profit and draining the offending bank of its capital. It is speculators in the private market who ensure that paper money remains always within its proper bounds. As the Bullion Commission of 1810 noted:

So long as the paper of the Bank [of England] was convertible into specie at the will of the holder . . . [t]hey could not much exceed the proper bounds in respect of the quantity and amount of bills discounted, so as thereby to produce an excess of their paper in circulation, without quickly finding that the surplus returned upon themselves in demand for specie [gold and silver].

However, when the state accepts the liabilities (i.e., notes and deposits) of its various banks at face value in the payment of taxes (which is nearly all of the time), then Gresham’s Law dictates that market participants will hoard the more valuable bank liabilities and tender the least valuable at market, which accepts them because they can be paid over to the government at face value. Instead of over-issued notes disappearing, they proliferate, and prices become pegged to the depreciating currency.

A depreciating currency does not increase prices uniformly. Banks place their liabilities into circulation by lending against assets. Asset prices are determined by discounting future cash flows. As bank financing drives asset prices higher, it appears as though the natural discount rate is falling. Changes in the discount rate have vastly more influence on the value of a long-term project versus a short-term one, changing the structure of production, as Figure 1 below illustrates.

Consider two projects: Project A requires only a small investment and runs for two years before the capital is exhausted. Project B requires a large investment and runs for ten years. Lines 3 and 4 show that Project A has a positive net present value at a 15% discount rate, whereas Project B does not. When the discount rate falls to 5% as shown in Lines 5 and 6, the long-term, capital-intense Project B becomes far more valuable than the short-term project, and investors will prefer it (note in Line 7 that the more distant the cash flow, the more affected it is by a change in the discount rate).

FIGURE 1: FALLING RATES LENGTHEN STRUCTURE OF PRODUCTION

Year		0	1	2	...	9	10	Sum
1	Project A	-\$100	\$100	\$100				<b>\$100</b>
2	Project B	-\$600	\$100	\$100	\$100	\$100	\$100	<b>\$400</b>
3	Project A @ 15%	-\$100	\$85	\$72				<b>\$57</b>
4	Project B @ 15%	-\$600	\$85	\$72	...	\$23	\$20	<b>-\$144</b>
5	Project A @ 5%	-\$100	\$95	\$90				<b>\$85</b>
6	Project B @ 5%	-\$600	\$95	\$90	...	\$63	\$60	<b>\$162</b>
7	Percent change 15% to 5%		12%	25%		174%	200%	

The lowering of discount rates thus prompts investment in projects with very distant cash flows, such as such as ships, buildings, houses, factories, airports, all of which tend to demand huge amounts of industrial commodities, which soar in price,

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which brings on new supply. Eventually, overinvestment in the highest orders of capital creates overproduction, prices fall, the industrial sector cannot meet its interest payments, banks teeter, and depositors scramble to get their money out.

Governments resist the crash, of course, claiming intervention is needed to “stabilize” the economy, as in the 1920s and after the panic of 2008. Printing money can bail out the banks and a rising price level can make interest payments manageable even for malinvestments. But, the result is more overcapacity until either the currency breaks in a hyperinflation or the central bank surrenders and allows the malinvestments to liquidate. As Hayek noted in 1932: “We must not forget that, for the last six or eight years, monetary policy all over the world has followed the advice of the stabilizers. It is high time that their influence, which has already done harm enough, should be overthrown.”

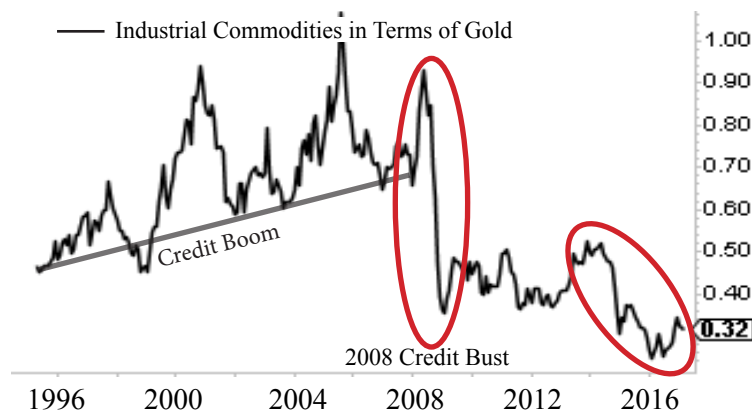
The reason why credit bubbles tend to happen around war time is that our system requires the banks to use treasury bonds as reserves against their loans and deposits. When the government is spending a lot of money, during war or “stimulus” times, the banking system becomes flooded with reserves and boosts its financing of assets.

Gold, meanwhile, is relatively unaffected by credit booms and busts: as its detractors point out, it has no income and is not generally demanded in industry, so it is relatively immune to changes in the discount rate. As George Gilder has pointed out, it is impossible to measure a system by means of something inside the system, and it is gold’s relative immunity to the credit cycle that makes it such good money.

Credit bubbles are bad for gold mining—rising costs relative to revenues compress margins to lower cash flows. Then, in the bust, commodities collapse in terms of gold, sending margins soaring. This is why gold mining did so well during the 1930s, 1970s, and after the 2008 crash.

One of the primary values of gold mining, therefore, is to stabilize the cash flow of a broad portfolio—in finance terms: it is the only asset class with a negative beta, and is therefore hugely valuable for portfolio construction. Levering up a mine, however, destroys this value. Credit bubbles occur in the context of rising prices—in a fiat currency regime, even gold rises in price, though not as fast as the costs of mining. The chart below shows that despite the surge in gold prices from 2000 to 2007, gold underperformed industrial commodities during the credit boom.

FIGURE 2: COMMODITIES RISE IN TERMS OF GOLD DURING BOOMS



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A gold mining firm that is mainly debt-financed does very well in the boom, not because its margins are increasing in terms of gold, but because the real value of its debt melts away (though not as well as bubble activities such as banking). Conversely, during the crash, even though gold falls in price less than mining costs (peak-to-trough during the panic of 2008, for example, gold fell 29%, whereas oil fell 79%), debt financing becomes unpayable in nominal terms, and gold equities collapse. This is how debt financing turns what is naturally a hugely valuable negative beta asset into a much less valuable positive beta asset. Because mining executives are nearly universally ignorant as to gold's unique qualities, they plead instead the standard MBA rationale that leverage adds value through the tax shield.

There is a second reason (besides ignorance) that prompts mining executives to grossly over-lever their projects. Most executives, and especially mining executives, are compensated with call options. Under the Black-Scholes model, volatility is a major factor in determining the value of an option, especially a long-term option. Executives lever up their companies' cash flows to acquire ever larger projects in order to boost volatility, which increases the present value of their call options. Eike Batista used this strategy first in the gold sector and then the energy sector to amass a \$32 billion personal fortune—the problem was when commodity prices fell, and the debt pyramid could not be maintained, he ended up being worth negative \$1 billion (probably a record) and getting a jail sentence as well. Their incentive structures lead most mining executives to become aspiring Batistas, which leads to the chronic, debt-financed overcapitalization that causes the storied volatility of the industry.

There are strategies investors can use to mitigate the effects of management malincentives. For example, exploration and development companies typically have no debt, which allows them to survive troughs if they have enough cash, and they are generally purchased by firms using debt, meaning investors get the benefit of management recklessness without the costs. Producing firms that have debt with long maturities are similarly less risky, since a falling general price level is also threatening to the state, and therefore not allowed to proceed very far or for very long.

Moreover, the price level does not always fall during a credit crunch. The 1970s is a prime example—rampant inflation melted away the existing stock of debt: in this case, all prices rose, except that gold rose faster. This environment is ideal for gold mining because real margins increase and the pernicious errors of management are devalued—and it is into precisely this kind of environment that the world is likely heading.

The Federal Reserve's balance sheet is in much worse shape than it was in 1970, rates have barely begun to rise. As discussed at length in previous letters, the value of the dollar is held aloft by a short-squeeze: there are roughly \$4 trillion in base dollars and \$90 trillion in U.S. dollar denominated debt, which requires constant interest payments to maintain. The first-order effect of raising rates is to increase the demand for dollars to meet interest obligations, strengthening the dollar and putting pressure on gold. The longer-term and more powerful effect is to devalue the bonds that the Fed holds that back the dollar. Once the short-squeeze breaks—and break it will—the dollar will trade at a value that reflects the Fed's assets, and rising interest rates are lethal to the long-term bonds the Fed now holds. The dollar will collapse along with

the burdern of past debts. Rising real rates will also devalue the malinvestments and cause commodity prices to plunge against gold, though perhaps not in nominal terms.

Observing the chart on the front page, it may not seem that commodities have far to fall to reach the trend line that projects forward the crash lows of previous credit cycles. This long time series includes soft commodities, which are subject to different dynamics than industrial commodities (the reason why it shows commodities falling during the 2000s whereas Figure 2 shows industrial commodities were rising). Even still, this series would have to fall by 29% or gold rise by 46% for the ratio to intersect the trend line.

There is no law that says the trendline cannot be broken to the downside, however, and in any case the move in industrial commodities is likely to be far more pronounced: overcapacity is caused by excess debt, and debt levels are today higher as a percent of GDP than they were in 2007, according to McKinsey and the Bank for International Settlements. When these debts liquidate—and liquidate they shall—commodities will crash 2008-style (at least in real terms), except it will commence from a lower initial starting point. And imagine what will happen when China implodes—the country is still responsible for roughly half of the global consumption of copper, zinc, aluminum, nickle, etc.

It would make sense that the largest debt debauch in history should result in the lowest commodity prices in history, evening accounting for technological progress. A epic run in gold mining equities would be the result, at least until the next bubble begins.



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