Method in the Madness: Bubbles, Trading and Incentives

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Executive Summary

- A long period of elevated asset valuation raises some fundamental questions: How can assets sustain prices way above their fundamental value for extended periods of time? Why are investors willing to bid up expensive assets?
- Our research shows that for an expensive asset to sustain its valuation, the probability of further price increases must be high. Currency and equity option markets provide evidence that supports this finding.
- We show that asset managers might have incentives to go long, instead of short, expensive assets if their prices are more likely to increase; and the presence of return-chasing investors could drive asset prices well above their fundamental value before the bubble bursts.

When the S&P 500 hit an all-time high in November 2019, conventional valuation metrics suggested that the price was high relative to fundamentals–for example, both the cyclically adjusted price-to-earnings ratio (CAPE) and the market cap-to-GDP ratio lived in the tail close to the highest 10th percentile. On the one hand, prices may continue to rise, but arguably the room for growth is limited without drastic changes in fundamentals. On the other hand, a downside correction may be large and painful. Given this, what can be said about stock prices and probabilities of positive and negative stock returns?

U.S. equity markets are no exception when it comes to expensive assets. The 10-year Japanese government bond (JGB) is trading at a negative yield, while the country's total debt-to-GDP ratio is close to 250%. Although Japan faces significant tail risks and investors could suffer large losses in a default scenario, yields have continued to decline.

These examples raise some related questions: How can assets sustain prices way above their fundamental value for extended periods of time? Why are investors willing to bid up expensive assets? Is deviation from fundamentals a reflection of a paradigm shift in which the losers are left holding a hot potato?

In this article, we set forth to show that for equilibrium to be sustainable there must be a high chance the bubble will continue. We also put forth that the currency and equity option markets offer evidence supporting this idea — and that under certain conditions it is rational for investors to feed the bubble.

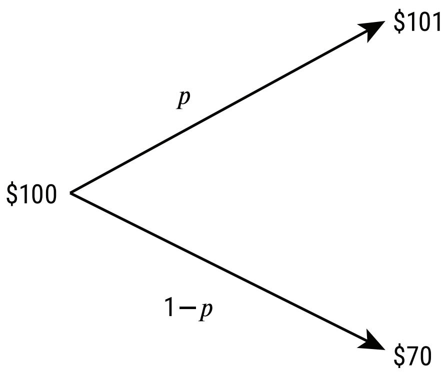
1. WHY THE PARTY (LIKELY) GOES ON: THERE IS NO ANGRY WAY TO SAY ‘BUBBLE’

How do we justify high prices for assets with moderate upsides but devastating downsides? Consider the simple one-period example illustrated in Exhibit 1: a 10-year bond currently trading at \$100. Suppose there are two possible outcomes: Over a short period, the yield could drop to zero and the price increase to \$101, or the bond might default, with the investor recovering \$70. If the “risk-free” interest rate is 0% and the risk premium is -0.5%, then

$$100 = \left(101p + 70(1-p)\right)e^{0.005}. \qquad (1)$$

Solving Equation 1, we find that the probability of a price increase p is 95%![1] This simple example illustrates a striking fact that makes intuitive sense: If an asset has a negative (or small) risk premium and the upside is moderate while the downside is severe, then the probability of a high price going higher must be high.

Exhibit 1: Illustration of a two-period binomial tree



Source: PIMCO. **Hypothetical example for illustrative purposes only.**

We should note that while we focus our discussion on expensive assets in this article, the asymmetry in probability is really a feature of assets with highly skewed returns. Furthermore, these assets are fairly priced given their potential payoffs.

2. BUY HIGH, SELL LOW: INCENTIVES GONE AWRY

“Buy low, sell high” is a market cliché, yet it is easier said than done in a bubble environment, even (or, perhaps, especially) for professional investors. Let us consider the simple example of an asset manager who collects a fixed dollar fee and seeks to maximize income. We will show that it might make sense for that manager to buy rather than sell “bubbly” assets.

We continue to use a binomial tree but expand it to multiple time periods. Suppose that in every period the asset’s price could either mildly increase with probability p or severely crash with probability $(1 - p)$. To simplify the problem, we assume managers are committed to either a buy-and-hold or a sell-and-hold strategy.

Poor performance is a prime reason investors fire their asset managers – perhaps the portfolio has underperformed for some time or losses have exceeded some threshold. On the one hand, managers who buy the bubble are exposed to crash risk; in a crash scenario, we assume investors will fire bullish asset managers. On the other hand, a bearish manager who short-sells an asset will suffer some (mild) losses if the market continues to rise. In this scenario, we assume the manager would only be fired if prices kept rising for n consecutive periods – think of n as investor patience.

In this setup, the expected tenure (T^{buy}) for a bullish manager is $\frac{1}{1-p}$, while that for a bearish manager[2] (T^{sell}) is $\frac{p^{-n}-1}{1-p}$. As asset managers wish to keep investments for as long as possible – which under fixed fees is equivalent to maximizing income – they would choose to buy as long as $T^{buy} > T^{sell}$ or

$$p > p^{\star} = \left(\frac{1}{2}\right)^{1/n}. \qquad (2)$$

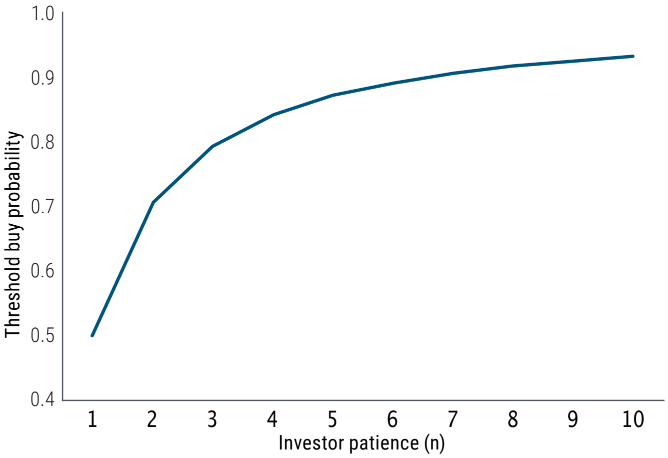
That is, given investor patience in the market, n, the manager will choose to buy as long as the probability of a price increase is higher than some threshold $p^{\star}$ that increases with investor patience (Exhibit 2). As shown earlier, p could be much higher than 50% in a bubble environment. Thus, buying potentially overvalued assets could make sense for managers who face not-so-patient investors.[3] This relationship also tells us that, given the same level of risk premium, managers have an incentive to buy bubbly (with high p and the risk of a severe crash) rather than normal (low p and a mild sell-off) assets.

1 When assets are expensive, it is not unreasonable to assume negative risk premia. However, this assumption is not critical. For a range of risk premia, p can be high.

2 The tenure for a manager follows a geometric probability law. As an example, when $p = \frac{1}{2}$, $T^{buy} = 2$, a bull manager is expected to survive two periods. If $n = 1$, then $T^{sell} = 2$ and a bear manager is also expected to survive two periods. If $n = 2$, then the bear manager lasts, on average, $T^{sell} = 6$, or six periods.

3 It might not be hard to argue that in a rising market investors are not willing to sustain multiple periods of losses unless they hold a strong contrarian view.

Exhibit 2: Threshold for up-probability above which managers choose long over short, as a function of investor patience



Source: PIMCO. **Hypothetical example for illustrative purposes only.**

3. EVIDENCE FROM THE CURRENCY MARKETS

Do expensive assets actually exhibit these characteristics? That is, do expensive assets tend to get more expensive, earn negative risk premia and be exposed to downsides larger than upsides? We turn to the currency markets for evidence.

To this end, we calculate a value signal based on deviations from purchasing power parity (PPP) every month and evaluate currency returns in subsequent months.[4] If our characterizations of bubbly assets are correct, returns of expensive currencies (high positive deviation from PPP) are more likely to be positive, yet they are negatively skewed and the average return is negative.

Exhibit 3: Distribution of returns conditional on high PPP deviation

Percentile	Top 5th	Top 15th
Probability of positive return	50.6%	50.5%
Average returns	-3.5%	-1.0%
Skewness of returns	-1.14	-0.79

Source: Bloomberg. **Hypothetical example for illustrative purposes only.**

Exhibit 3 shows monthly returns following PPP deviations for the top 5th and 15th percentiles. The probability of a positive return on the currency following extreme positive PPP deviations is just above 50%. Even though these conditional returns are more likely to be positive than negative, average returns are negative, suggesting that the risk premia are likely to be negative, on average. Positive returns are likely to be more moderate and negative returns more severe – an observation supported by the negative skewness. Furthermore, all of these results are more pronounced when we zoom into the more extreme 5% tail.

To state these results another way: If we simply bought expensive currencies every month and held them for a month, we would expect to make money on more than half of the trades, but we would expect to lose money, on average.

4. CALL SPREAD AND IMPLIED SKEWNESS

Are there ways to take advantage of these return patterns? As seen in the previous example, even though investors are expected to more likely make money buying expensive assets, the strategy wouldn't work because the frequent small gains would not compensate for the rare large losses. However, if the profit and loss depended only on the sign of, but not the actual, returns, then we would expect a strategy that bought expensive assets to pay off. Binary option payoffs, for example, depend on the sign and not the magnitude of the returns on the underlying asset.

Suppose the current S&P 500 price is P_t. An at-the-money (ATM) binary call option pays 1 at expiry time T if $P_T > P_t$ and is worthless otherwise. Therefore, the expected payoff at expiry is simply the probability that $P_T > P_t$ and the current price of the option is just the discounted value of the probability. Formally,

$$C_t^{binary} = e^{-r(T-t)} Q[P_T > P_t] \qquad (3)$$

where Q denotes the risk-neutral probability and r is the T-maturity zero-coupon bond yield at time t.

The risk-neutral probability, Q, can be viewed as the future value of the option price. By contrast, the expected payoff of the option is the actual probability of a stock market appreciation. A binary option will be all the more profitable when the actual probability exceeds the risk-neutral probability.

As discussed above, the actual probability of an expensive asset appreciating tends to be high. Therefore, buying binary calls on an expensive asset would be expected to be profitable. This is counterintuitive because it suggests being long expensive assets through binary calls on these assets.

When it comes to expensive assets, the S&P 500 is among the usual suspects. We therefore test this strategy on S&P 500 binary calls.

4 We look at 31 exchange rates against the USD on a monthly frequency between 1990 and 2018. For each month, we calculate the deviation of PPP from its 36-month moving average: ,$\widehat{PPP}(i,t) = log(e_t^i) - \frac{1}{36}\sum_{k=1}^{36} log(e_{t-k}^i)$, where e_t^i is the real spot exchange rate for currency i at time . We use the full sample of data across all currencies to determine a threshold of PPP deviation, above which we consider a currency to be expensive.

Exhibit 4 shows the results of two trading strategies. The first is a naive strategy that daily buys an ATM call and holds it until expiry. The second strategy buys an ATM call conditional on the risk-neutral probability of a price increase being lower than 0.5, as well as on having a high CAPE ratio, to explicitly consider high equity valuation. Even though we do not explicitly consider valuation in the first strategy, the S&P 500 is considered expensive for most of the sample, so we should expect even the naive strategy to perform well, and indeed it does. Furthermore, we can see that the average cost declines (because volatility tends to decrease as assets get more expensive) and the average payoff increases (because the probability of expensive assets gaining in value is high) as we impose additional filters.

Exhibit 4: Binary option strategy

	1-month option			3-month option		
	Average cost	Average payoff	Average return	Average cost	Average payoff	Average return
Full sample	0.49	0.62	27%	0.49	0.67	38%
< 0.5 and CAPE > 21	0.48	0.68	34%	0.47	0.67	42%

Source: JPMorgan and Bloomberg. **Hypothetical example for illustrative purposes only.** Sample of at-the-money SPX call options from January 1996 to July 2018 in daily frequency. We calculate option prices and risk-neutral probability using ATM volatility. The first row shows the strategy that buys a binary call option each day and holds it until expiry. The second row shows the results of a strategy that only buys if the risk-neutral probability is less than 0.5 and CAPE is larger than 21.

5. MOMENTUM AND FUNDAMENTALS: THE LIFE OF A BUBBLE

Thus far, we have focused on the implications of asymmetric returns of expensive assets, but not on how these bubbles are formed. In this section, we consider a simple example to show that traders' behavior might contribute to the formation (and bursting) of an asset bubble.

Consider a simple environment with one asset with a fundamental value of θ and two types of traders. We will call the first type a momentum trader, whose demand for the asset is given by

$$X_t^M = A - \rho P_t + c(P_{t-1} - P_{t-2}). \quad (4)$$

We will refer to the second type as a fundamental trader, whose demand function is

$$X_t^F = A - \rho P_t - d(P_{t-1} - \theta). \quad (5)$$

P_t denotes the price and constants $A, \rho, c, d > 0$. Here both traders' demands decrease with the price. The two types differ in that the momentum trader's demand increases if the asset just experienced positive return and the fundamental trader's demand decreases if the asset is trading far above its fundamental value. Exhibit 5 summarizes how past returns affect trader demand.

Exhibit 5: How previous returns affect the asset demand of momentum and fundamental traders

	Above fundamental	Below fundamental
Prices going up	Momentum ↑ Fundamental ↓	Both ↑
Prices going down	Both ↓	Momentum ↓ Fundamental ↑

Source: PIMCO. **For illustrative purposes only.**

Suppose the total supply of the asset is X and momentum traders represent a share of total trading. Then the price is[5]

$$P_t = \theta + c^{\star}(P_{t-1} - P_{t-2}) - d^{\star}(P_{t-1} - \theta). \quad (6)$$

What does Equation 6 tell us about prices in a bubble scenario? When the price is above its fundamental value and on the way up, the two types of traders will push and pull the price in different directions. As long as the momentum traders' chasing incentive is strong enough, the price would be expected to continue to increase. However, as prices increase, fundamental traders would be expected to create more selling pressure, which might slow down the price growth. Note that as soon as fundamental traders dominate and prices start to go down, momentum traders would be expected to start selling as well, accelerating the price declines and causing the bubble to burst.[6]

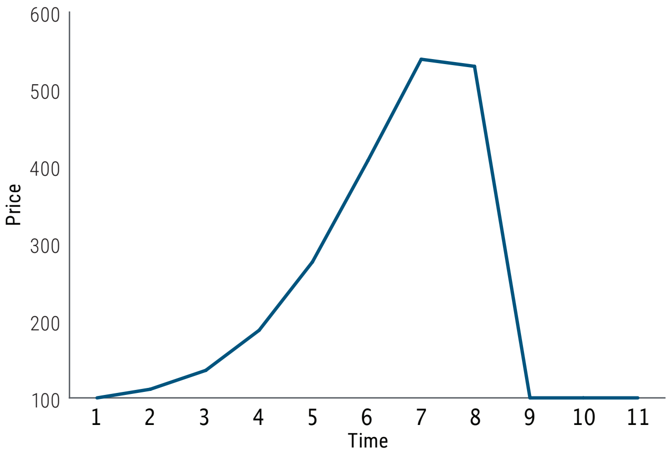
Consider a numerical example: $\theta = 100, P_0 = 100, P_1 = 110, d^* = 0.1$ and $c^* = 3.6$. Exhibit 6 plots the resulting price process. In this case, the price continues to grow until $t = 7$, when it gets too far from the fundamental value and fundamental traders' negative demand dominates. This drives the price slightly down at time $t = 8$. As discussed earlier, once the price starts to fall, both types of traders' demand functions would be expected to pull the price down, resulting in a free fall back to the asset's fundamental value and bursting the bubble.[7]

5 Also assume $A = X + \rho\theta$ to arrive at (6), where constants $c^{\star} = \frac{\alpha c}{\rho}$ and $d^{\star} = \frac{(1-\alpha)d}{\rho}$.

6 This model is used to describe the cycle of a bubble once it has already started; how the bubble begins is outside the scope of this paper. Note that if the asset is already trading at its fundamental value for several periods ($P_{t-1} = P_{t-2} = \theta$), then it will remain at that level indefinitely, because there is no shock to the demand function.

7 We assume that once the price starts to fall, it has a lower bound of θ. One could think of it as if once the bubble bursts, the share of return-chasing traders falls to zero.

Exhibit 6: Example of an asset price across time



Source: PIMCO. **Hypothetical example for illustrative purposes only.**

6. CONCLUSION

In this article, we showed that for an expensive asset to sustain its valuation, the probability of a moderate price increase must be high. Given that payoffs are asymmetric, asset managers might rationally buy expensive assets. We showed that currency returns exhibit conditional skewness and backtested a binary call trading strategy based on this characteristic. A dynamic example illustrated that the presence of return-chasing investors could drive asset prices well above their fundamental value before the bubble burst.

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