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Is This Purgatory, Or Is It Hell?

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GMO is often accused of being a “glass half empty” investor, and I admit that in a year that has seen the S&P 500 rise 8.3%, MSCI All-Country World rise 3.7%, and the Barclays U.S. Aggregate rise 4.1% through the third quarter, the words “Purgatory” and “Hell” are unlikely to come to mind to most investors when opening their brokerage statements. It has been a dull year, perhaps, but certainly not a hellish one. So what is bringing Dantesque visions of damnation into our slightly warped minds? As is often the case, our moods are driven far less by a look in the rearview mirror and more by what we see through the windshield. A little over a year ago, my colleague James Montier wrote about the current opportunity set for investors and referred to it as the “Purgatory of Low Returns.” He called it Purgatory on the grounds that we assume it is a temporary state and higher returns will be available at some point in the future. But as we look out the windshield ahead of us today, it is becoming clearer that Purgatory is only one of the roads ahead of us. The other one offers less short-term pain, but no prospect of meaningful improvement as far as the eye can see. At the risk of stretching this metaphor further than I should, I need to point out that we are merely passengers in this car, with no more ability to affect the road taken than my toddler when he exclaims that today we should drive to Legoland instead of pre-school.¹ All we can do is shout from the back seat to the financial markets taking us on this ride to “Take the Purgatory exit! Take the Purgatory exit!” and cross our fingers.

And which road we take will be of more than theological interest. The two paths not only differ in their implications for the long-term returns to financial assets, but also in the appropriate portfolio to hold today and into the future. To skip to the punchline, if we are in Hell, the traditional 65% stock/35% bond portfolio actually makes a good deal of sense today, although that portfolio should be expected to make several percentage points less than we have all been conditioned to expect. If we are in Purgatory, neither stocks nor bonds are attractive enough to justify those weights, and depending on the breadth of your opportunity set, now is a time to look for some more targeted and/or obscure ways to get paid for taking risk or, failing that, to reduce allocations to both stocks and bonds and raise cash.

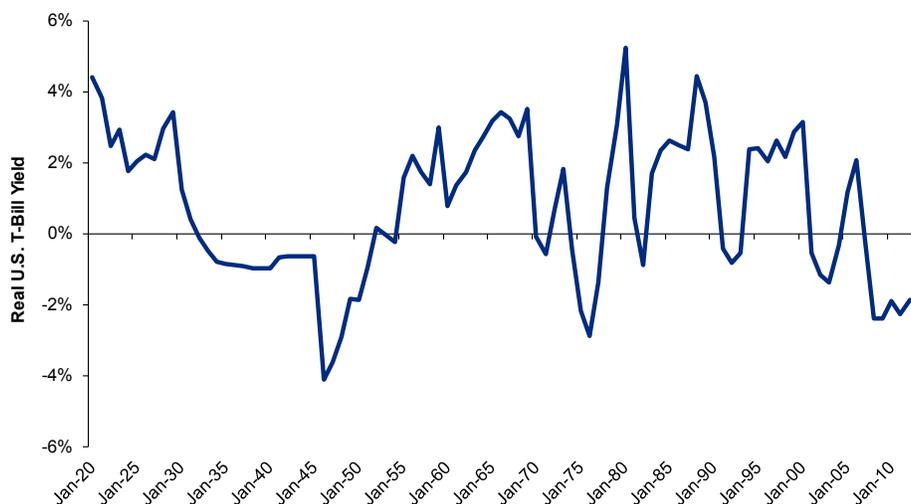
¹ My son’s obsession with Legoland is a bit of a mystery to the rest of us as he isn’t particularly enamored of Legos, has never been to a theme park of any kind, and has no idea whatsoever what he would do should he ever actually cajole us into taking him to Legoland. But the heart wants what the heart wants, and his heart seems to be currently shaped out of little rectangular plastic blocks.

Mean Reversion and Fair Value

In this April's note "In Defense of Risk Aversion" I wrote about how a belief in mean reversion would lead an investor to move his asset weights around by much more than they would in the absence of that belief. Here I'm not going to be talking about the general question "Do asset class prices mean revert?" but rather "What are prices going to mean revert to starting today?" While we use the phrase reversion to the mean a lot in describing our beliefs about financial markets, in reality what we believe is that asset class prices should revert to fair value. Fair value may or may not be approximately equal to the average of historical valuations, but we find it instructive to start with an analysis of historical valuations in trying to understand what fair value might be.

One of the toughest assets to get our brains around turns out to be cash. The real yield on U.S. T-Bills is shown in Exhibit 1.²

Exhibit 1: U.S. T-Bill Real Yields



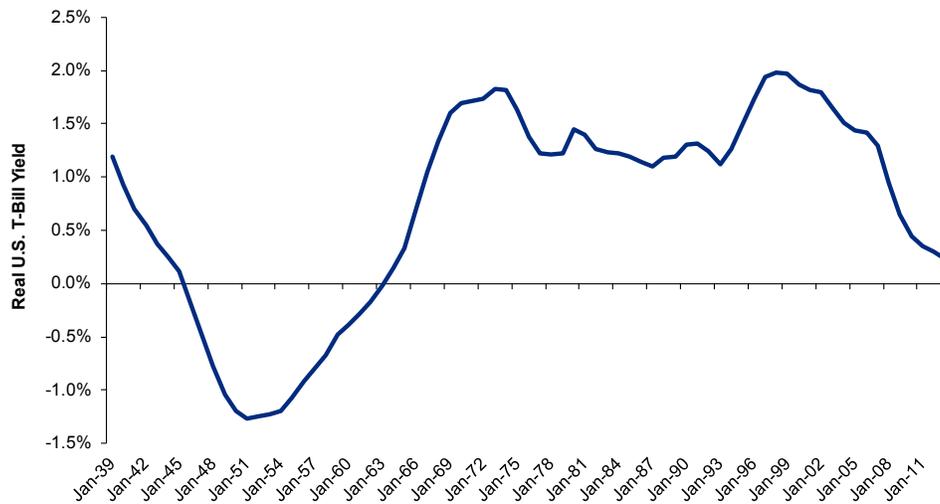
As of August 1, 2014

Source: U.S. Department of Labor: Bureau of Labor Statistics

A real optimist could look at that chart and say that it's pretty clear ex-ante real cash yields have been bounded somewhere between -2% and 4%. But -2% to 4% is an awfully big range, disappointingly big for anyone who is hoping to build fair values for other asset classes off of the returns available on the "risk-free asset." There is a certain amount of cyclical that one should expect for cash yields. The appropriate cash rate in a recession is significantly lower than what makes sense in an economic boom. And for figuring out fair value for long-lived assets such as equities, those cyclical shifts shouldn't matter, only the long-term average. But no matter how much we smooth the yields to damp down the cyclical, we are left with a problem, as you can see in Exhibit 2.

² The chart is showing approximate ex-ante real T-Bill yields – that is what buyers of T-Bills probably thought they were going to get after inflation. Ex-post real T-Bill yields are much easier to calculate, but they aren't that relevant for this purpose because they may or may not bear much resemblance to what the buyers of the bills expected to achieve.

Exhibit 2: 20-Year Average of Real T-Bill Yields



As of August 1, 2014

Source: U.S. Department of Labor: Bureau of Labor Statistics

We've still seen rates bounce around from -1% to +2%, which is a very big deal for fair value estimates. To put it in perspective, if equities were to give a 4.5% risk premium above cash and expected long-term cash yields moved from -1% to 2% real, the fair normalized P/E on the stock market would move from 29 to 15. That is such a wide range as to be basically useless for anyone hoping to figure out when equities are worth owning.

Implications for GMO Forecasts

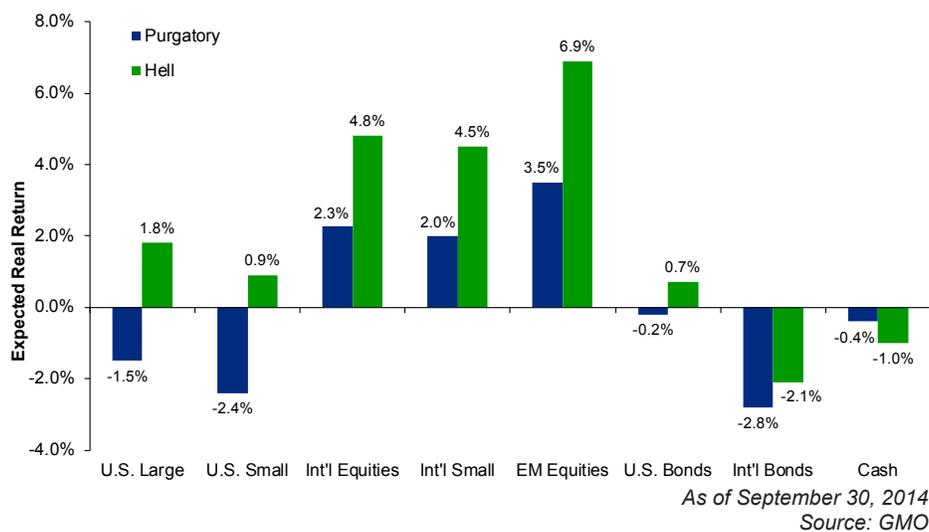
When we started building our asset class forecasts in the mid 1990s, we felt sufficiently confident that we knew where cash rates were going that we didn't worry much about it. Somewhere around 1.5% to 2% over inflation seemed right, and we blithely ignored the low rates of the 1930s to 1950s as a combination of the very long cycle of the Great Depression and the confusion of investors who didn't realize the important inflationary implications of going permanently off of the gold standard. But the events of the last 12 years or so call into question the confidence we used to feel in the level of normal cash rates. At our internal investment conference in September, we had a lively debate over "Secular Stagnation" – the argument, popularized by Larry Summers, that the developed world is suffering from a lack of aggregate demand that has driven the equilibrium cash rate far lower than it had been in the past 40 years. I wouldn't say that the stagnation proponents decisively carried the day, but it was striking how little consensus there seems to be across the firm. The two basic camps were our current base case – real cash rates in the developed world will move to around 1.25% on average in the long run – and secular stagnation – cash rates in the long run would average around 0% real. The average response in the post-conference survey was 0.75% real with fairly close to half of the GMO investment professionals believing that rates were going to be close to zero real into the indefinite future.

And make no mistake about it, a world in which cash rates average 0% from here on out is a fairly hellish one. It is our belief that investors get paid for taking unpleasant risks. That compensation is in the form of a risk premium over the "risk-free" rate, and while there are no truly risk-free assets out there, T-Bills are a good enough approximation for many purposes. If that rate is going to be zero real, stocks, bonds, real estate, and everything else investors have in their toolkit should have their expected returns fall as well. In that world there are likely to be no assets priced to deliver as much as 5% real, and the expected return to a 65% stock/35% bond portfolio would drop from 4.7% real to about 3.4% real. Starting from 4.7% real, it's easy to believe you can do enough smart things to get your portfolio to a return of 5% real or above. For the system as a whole, that belief is a delusion, as the average investor cannot hope to have above-average returns. But 0.3% of alpha is not so

much to hope for as to seem irresponsible for an investment committee to expect. When you raise that 0.3% to 1.6%, it does start to seem implausible, particularly when you are thinking of it as not the “hoped for alpha” but the “budgeted for alpha.” This is where the difference between the market value of a portfolio and the ongoing spending it can support becomes a big issue. If we imagine for a moment that one could become convinced that the expected return to the standard portfolio has fallen from 4.7% to 3.4%, the ongoing spending that can be supported by that corpus has fallen 28%. This is, by an odd coincidence, the same effect as removing all of the gains from a 65/35 portfolio since September 2010. That is to say, the last four years of gains across the stock and bond markets look nice on paper, but have not increased the spending supportable from the portfolio.³ And while that may seem inconvenient enough for an entity that bases spending off of current wealth, the problem is much bigger for any entity who will be doing a chunk of their wealth accumulation in the future. If you are a 35-year-old worker who has another 30 years to go saving for retirement, the prepayment of future returns has been a real disaster, as all of your future savings will be accreting at a much lower rate. Such a worker will wind up with about 21% less in his retirement account than if prices had never risen in a way consistent with a 0% real risk-free rate forever. Compounding the problem (no pun intended) is the fact that a given pool of retirement savings can support less spending in a lower rate environment, making the effective shortfall more like 33%.

Pretty inconvenient for anyone saving for retirement. So we can all hope we aren’t on the road to Hell. But the other option, you’ll remember, wasn’t an immediate trip to Heaven, but a stay in Purgatory. So what is Purgatory, and is it really any better? The answer to that really depends on your time horizon. Purgatory would mean that cash rates will eventually go back up to more “normal” levels of around 1.25%, which means that the rest of the financial asset pyramid will go back to more normal expected returns as well. The bad news is that valuations will have to fall in order to get there, so if you are thinking about returns over, say, the next seven years, Purgatory is actually worse than Hell. Exhibit 3 shows our current seven-year asset class forecasts, which assume a Purgatory path, compared to the forecasts under the Hell scenario.

Exhibit 3: Purgatory and Hell Forecasts



The chart represents real return forecasts for several asset classes and not for any GMO fund or strategy. These forecasts are forward-looking statements based upon the reasonable beliefs of GMO and are not a guarantee of future performance. Forward-looking statements speak only as of the date they are made, and GMO assumes no duty to and does not undertake to update forward-looking statements. Forward-looking statements are subject to numerous assumptions, risks, and uncertainties, which change over time. Actual results may differ materially from those anticipated in forward-looking statements.

³ Strictly speaking, this is only true for infinite life entities like endowments and foundations. The shorter the time period that the money is to be spent over, the larger the incremental spending that is supportable. If the money was going to be spent tomorrow, for example, the fact that future returns are lower is irrelevant and the 38% larger portfolio actually does support 38% more spending.

All of the forecasts (except for the cash forecast) are higher under the Hell scenario, because Purgatory requires a repricing of assets downward as cash yields rise.⁴ So for the next seven years, we'd be better off in Hell than Purgatory. But in the longer run, the calculus shifts. Our hypothetical 35-year-old worker will wind up with 15% more in his retirement account if we take the Purgatory road than if we head to Hell. That still leaves our worker 5% short of where he would have been had we never had the boom in the first place, but a 5% shortfall is a lot less of a disaster than a 33% shortfall is.

Portfolio Implications

So, for investors with a long time horizon, we can certainly hope that we go down the Purgatory path. But hope is not an investment strategy, and the trouble is that the right portfolio to hold today is pretty different if we go down the Purgatory path or Hell path. If Hell is our destiny, then both equities and bonds are a pretty decent hold today. The expected return to global equities goes from 0.5% real to 3.5% real – perhaps coincidentally, that 3.5% return is precisely a 4.5% return premium over cash. Meanwhile, U.S. bonds go from -0.2% to +0.7%, with the +0.7% a slightly greater than “fair” 1.7% premium to cash. In other words, if we are in Hell and we felt that 65/35 was the appropriate portfolio to hold if risk premia were normal, then we should hold almost exactly that 65/35 portfolio. If we are in Purgatory, the equity risk premium is +0.9% for global equities and +0.2% for bonds, a small fraction of the normal payment for taking stock and bond risks. How much less of equities and bonds to hold under that circumstance is a bit of a matter of taste, but it's almost certainly a good deal less of both. For an investor operating with a constant aversion to risk, the 65%/35% stock/bond portfolio turns into a 20% stock/58% bond/22% cash portfolio, with an expected return of -0.1% real. No, that is not a typo. Running the same risk aversion that would get you to 65%/35% under “normal” circumstances says that the right portfolio to run today actually has an expected return less than inflation. Putting that in perspective, though, the 65/35 portfolio only has an expected return of +0.25% real, so you aren't exactly giving up a stirring expected return for the sake of risk reduction. If we are actually in for Hell instead of Purgatory, the comparison is +0.9% real for the low risk portfolio and +2.5% real for the 65/35 version, which is a much more material give-up of 1.6% in expected return for the lower risk portfolio.

A Path to Redemption?

So, is there anything we can do other than hope we're in Hell if we have a short time horizon and Purgatory if we are taking the long view? Maybe. One of the interesting implications of Hell is that the rise we've seen in asset prices over the last few years would have been a repricing of those cash flows to a lower discount rate. Investors are used to thinking only about the duration of bonds, but all sorts of assets have a definable duration with regard to the discount rate applied to their cash flows, and equities, as not only a perpetuity but a growing perpetuity, have a ton of duration to them. Table 1 shows the approximate duration with regard to the discount rate on their cash flows of a variety of assets, along with the expected gain in their price if the discount rate were to have fallen by 1.25%.

⁴ Okay, I have to admit to a big caveat here. This set of Hell forecasts assumes that the return on capital on the current stock of economic capital for corporations is not affected by the fall in the discount rate. In these forecasts the lower discount rate only impacts the return on capital on future investments. As James Montier has pointed out to me, this assumes a significant disequilibrium will persist for quite a while, although the disequilibrium will eventually dissipate as today's capital is depreciated away. If you assume that the return on current economic capital is fairly quickly eroded by the lower discount rate, the Hell forecasts for equities wind up actually a little worse than the Purgatory ones. I chose not to make that assumption because I couldn't think of a plausible mechanism that would cause the quick erosion, but that could just be due to my lack of imagination. Bond forecasts are not affected by any of this because their cash flows are fixed.

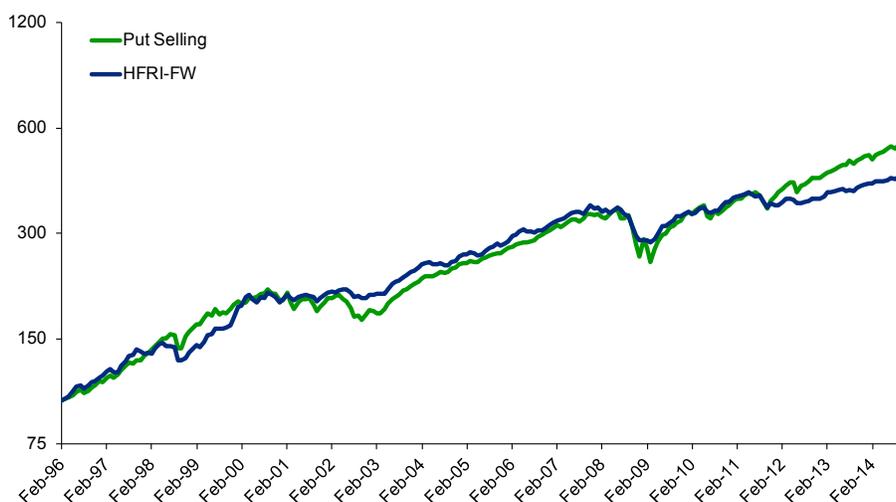
Table 1: Duration of Selected Asset Classes

	Duration	Expected gain from 1.25% fall in discount rate
Equities	35	44%
Value stocks	25	31%
Growth stocks	42	53%
Real estate	18	23%
Infrastructure	14	18%
10-year bond	9	11%
30-year bond	19	24%
Cash	0.25	0%

There is a certain amount of guesswork to these figures as, apart from bonds, none of them have fixed cash flows that can give a precise measure of duration, and partially for that reason I didn't bother to try to calculate the associated convexity effect of the change in discount rate. But taking the figures at face value, let's say that you can justify a 44% rise in equity valuations if the required return on equities has fallen from 5.7% real to 4.5% real.

Investors have found themselves doubly disappointed by hedge funds since the onset of the Global Financial Crisis. First, investors were shocked by the extent to which hedge funds fell in sympathy with the stock market in 2008. And ever since, they have been disappointed by the fact that hedge fund strategies have failed to come close to the performance of equities – or in many cases even keep up with the performance of bonds – in the rally since 2009. One way to reconcile this disappointing performance is to recognize that many hedge fund strategies are underwriting the same basic risk as the equity market, but doing so in a fashion that has much less duration. Stafford and Jurek showed a few years ago that most hedge fund strategies can be reasonably modeled as variants on equity put selling. Exhibit 4 shows the performance of a put-selling strategy versus the HFRI fund weighted index of hedge funds.

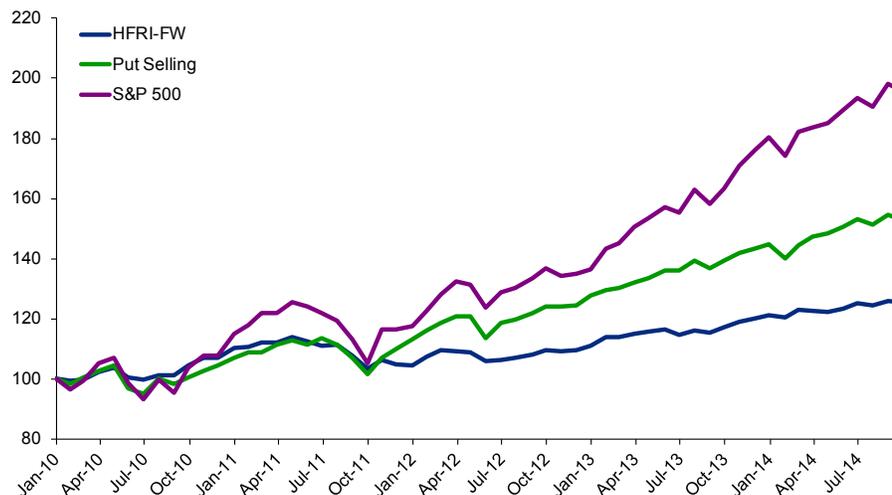
Exhibit 4: Performance of Hedge Funds and Put Selling



As of November 3, 2014, Source: Stafford and Jurek
 Note: The performance relating to put selling represents the performance that would have been obtained by selling puts on the S&P 500 and does not represent the performance of any GMO fund or strategy. The hypothetical returns for this put selling strategy include transactions costs.

This isn't exactly the strategy Stafford and Jurek used in their paper, which was levered and sold out-of-the-money puts. It is a simpler unlevered strategy selling at-the-money puts every month. The reason I'm using this version is that it is nice and straightforward to understand that an at-the-money unlevered put-selling strategy is underwriting the same risk as an unlevered equity position – you lose money one-for-one when the equity market falls – but the way you get paid is different, because rather than collecting the gains on equities, you get paid a premium for the option you have sold. This method of payment means that put selling has a much shorter duration than equities do, and would not be expected to keep up in an environment in which a falling discount rate has driven up the price of equities. The performance of the S&P 500, put selling, and the HFRI since 2010 is shown in Exhibit 5.⁵

Exhibit 5: Performance of Put Selling, Hedge Funds and S&P 500 Since 2010



As of November 3, 2014, Source: Stafford and Jurek
 Note: The performance relating to put selling represents the performance that would have been obtained by selling puts on the S&P 500 and does not represent the performance of any GMO fund or strategy. The hypothetical returns for this put selling strategy include transactions costs.

The performance of put selling has been one half that of the S&P 500 since 2010, and for hedge funds, one quarter. It is far too facile to say that put selling has half the duration of the stock market and hedge funds one quarter the duration. In fact, I haven't been able to figure out a sensible way to calculate a duration of either of them given the nature of their cash flows, but it is almost certainly the case that for both of them the duration answer is "a lot less duration than stocks."⁶

But if we are in an environment today where we aren't sure whether stocks are very overvalued or whether they have been repriced to give a lower, but still fair, return, taking equity risk in a fashion that has less duration looks like a pretty good idea. If we are in Purgatory, we'll do a lot less badly than in stocks (depending on how long mean reversion takes, we might actually make decent money) and if we are in Hell, the tailwind for equities that has made such strategies look uninteresting is probably over and there is no particular reason why they don't have a decent shot of keeping up with standard equities.

⁵ I picked 2010 as a starting point because it was a time when asset pricing had generally recovered from crisis levels, but participants still seemed to be assuming cash rates would normalize. I'm not sure how to pick a "perfect" starting point for this analysis, but 2010 seemed as good as any.

⁶ I don't mean to imply that I think hedge funds have less duration than put selling, or that their underperformance relative to that simple strategy is readily explainable or excusable. Hedge funds look to have done worse than one would have expected over the past five years. They should not have been expected to keep up with the stock market in this kind of environment, but it would have been nice if they had kept up with a simple put-selling strategy.

And if you look at what we are doing in our benchmark-free strategies, that's exactly the direction we've been moving toward in recent months, adding to merger arbitrage where we structurally can and doing more put selling than we had been, while reducing our weighting in standard stocks. This has not been driven directly by the Purgatory/Hell debate but rather by the fact that the attractiveness of these shorter-duration strategies has been naturally rising to us relative to our slowly falling forecasts for equities.

Conclusion

It would be incredibly convenient right now to know if we are going down the Purgatory route or the Hell route. Our official forecasts are for the Purgatory path and our hopes are there as well because Hell is a very unpleasant long-run outcome for investors. But if we knew we were in Hell, the right solution today is a decently risked-up portfolio. That portfolio doesn't make sense in a Purgatory scenario, as the extra risk gives almost no additional return. There is no solution that is right for both scenarios, but having assets whose expected returns are reasonably unaffected by which path we go down is a help. The strategies that most fit the bill are the very "hedge fund-y" strategies that have so disappointed investors in recent years. That benefit is well short of an argument for happily paying 2% and 20% for such strategies, but if you can find a way to do it more cheaply (or you can actually find some managers talented enough to pay for their fees), we believe now is a pretty good time to be on the look-out for shorter-duration ways to take standard risks.

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Bubble Watch Update

Jeremy Grantham



The January Rule

As you may remember, the January Rule serves as a kind of barometer for the behavior of the market in the coming year. Historically, when January was down, the rest of the year had over twice the declines than one would expect randomly, far more mediocre months, and a very sub average return. But it is far from perfect and it had the unusual problem this year of bumping into the positive signal from the Presidential third year, which started for us on October 1. For the statistically-minded, or the trivia-minded, the four previous such conflicts between the January Rule and the Presidential Cycle were inconclusive but the simple rule would have been to end the January Rule enterprise on September 30. This year was flattish by then and the new Presidential Cycle has gotten off to a good start since September 30.

The Presidential Cycle

Regular readers know the score: +2.5% a month for the seven months from October 1 to April 30, in year three on average since 1932 (a total of +17%). This is now the 21st cycle. The odds of drawing 20 random 7-month returns this strong are just over 1 in 200 according to our 10 million trials. But 17 of the actual 20 historical experiences were up and the worst of the 3 downs was only -6.4%, so the odds of this consistency plus the high return would be much smaller. The remaining 5 months of the Presidential year have a good but not remarkable record, over .75% per month, but the killer here is that the remaining 36 months since 1932 averaged a measly +0.2% a month!

With the 7 months having returned over 10 times the average of the 36-month desert, it may seem like a no-brainer investment for those seven of us not intimidated by the obvious simplicity of the idea, but be advised that going into this particular cycle there appear to be more negatives than normal. (Though many of the previous 20 occurrences may well have seemed that way to investors at the time. Who knows?) The negatives this time include the ending of the Fed's bond purchase program. There is also talk of a rate increase early next year, given the recent recovery of the U.S. economy reflected in the improved employment report of early October (5.9% unemployed) and positive adjustments to the previous month's employment numbers. Other negatives include the potential for escalation of several minor but intractable wars and the recent Ebola outbreak.

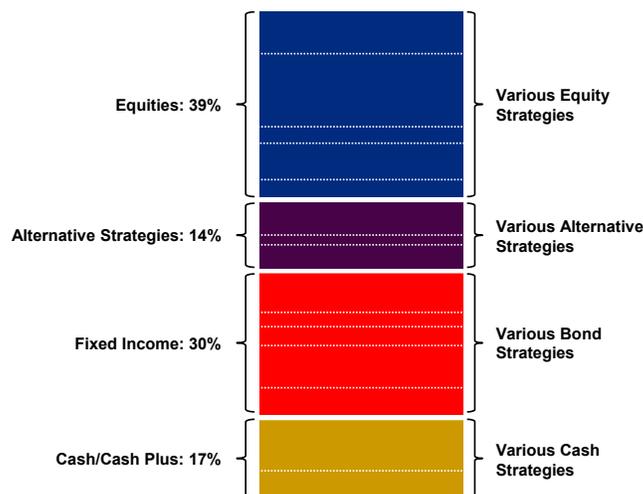
Some would mention the very substantial overpricing of the U.S. market at the top of the list but, surprisingly, overpricing has had no material effect on third-year returns or the particularly sweet seven-month subset: an average of 17% for seven months becomes 19% if cheap and 15% if expensive. Big deal. Value, however, is very

important for the other three years in which the cheapest 25% have produced a respectable return of +12%, and the other three quartiles are absolutely not worth having, all three together averaging almost exactly nil! More disturbing to me than the obvious overvaluation is the large and growing number of other negatives – technical and psychological – put together by Hussman and other market experts. Nevertheless, despite my nervousness I am still a believer that the Fed will engineer a fully-fledged bubble (S&P 500 over 2250) before a very serious decline.¹

The Prudent Investor

As always, the prudent investor (unlike the political year three) should definitely recognize overvaluation, factor in regression to the mean, and calculate the longer-term returns that result from this process. More easily, such prudent investors can use our seven-year numbers, which have a decent long-term record measured when we have viewed markets as overpriced, as we believe they are today, and a better record measured in the periods after bubbles break. The other necessary ingredients to the investment mix are suitable measures of risk, and when these are added to estimated returns we believe efficient portfolios can be produced. On our data, with U.S. large cap equities offering negative returns (-1.5%) except for high quality stocks (+2.2%), with foreign developed and emerging equities overpriced (+3.7%), and with bonds and cash also very unattractive, investors have to twist and turn to find even a semi-respectable portfolio. It is a particularly tough process today with nowhere to hide and no very good investments compared to, say, the time around the 2000 bubble when there were several. My colleagues Ben Inker and James Montier have written in some detail about the problems of investing in these difficult times.² Designed to help your thinking about this topic, Exhibit 1 shows an example of a portfolio that might be used in a world that excludes private equity and venture capital, and for a client who can do without a benchmark and can settle for owning a (hopefully) sensible long-term efficient portfolio. Efficient, that is, in terms of trying to minimize risk per unit of estimated returns. As always, and particularly in this type of overpriced environment, there are no guarantees of success even if every GMO recommendation were to be implemented for, regrettably, we too are often imperfect.

Exhibit 1: Benchmark-Free Allocation Strategy



As of September 30, 2014

Note: The information used in Exhibit 1 is based on a representative account in the Strategy selected because it has the fewest restrictions and best represents the implementation of the Strategy.

¹ In the interest of full disclosure, Grantham Foundation has tilted toward the Presidential Cycle by using out-of-the-money calls. But, caveat emptor.

² See Ben Inker, "Free Lunches and the Food Truck Revolution," July 2014 and James Montier, "The Purgatory of Low Returns," July 2013. Each of these publications is available with registration at www.gmo.com.

My personal fond hope and expectation is still for a market that runs deep into bubble territory (which starts, as mentioned earlier, at 2250 on the S&P 500 on our data) before crashing as it always does. Hopefully by then, but depending on what the rest of the world's equities do, our holdings of global equities will be down to 20% or less. Usually the bubble excitement – which seems inevitably to be led by U.S. markets – starts about now, entering the sweet spot of the Presidential Cycle's year three, but occasionally, as you have probably discovered the hard way already, history can be a snare and not a help.

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The Beginning of the End of the Fossil Fuel Revolution (From Golden Goose to Cooked Goose)

Jeremy Grantham

General Thesis

The quality of modern life owes almost everything to the existence of fossil fuels, a massive store of dense energy that for 200 years had become steadily cheaper as a fraction of income. Under that stimulus, the global economy grew ever larger, more complex, more inter-related and, I believe, more fragile. Then around the year 2000 the costs of finding oil start to rise at over 10% a year, and with the global economy growing at only 4% oil starts to fall behind in affordability. Oil has a leading role in the cost structure of agriculture and extractive industries, including coal, and dominates transportation. Because of that its affordability seems to determine economic progress far more than coal or natural gas. As its cost of extraction rises, other parts of the complex economic system have to be sacrificed to retain the ability to acquire sufficient oil. In those conditions, economic growth rates have to fall, and if oil costs continue to rise the trade-offs become more and more painful. Our complex system has been trained by experience to deal with steady growth. Now it must deal with slowing growth and one day it may face contraction. In this changed world we can only guess how robust the stressed system will be. We may hope it will be tough but quite possibly it will be brittle. At the extreme it might even threaten the viability of our current economic system.

It is vital therefore, if we want to reduce these stresses, to emphasize fuel efficiency, reduce wastage of all kind, and encourage the rapid development of sustainable “alternative” forms of energy, particularly those that displace oil. These alternatives are competitive today with only very high-cost fossil fuels but in 20 to 30 years, if encouraged, may replace \$40 or \$50 barrels of oil, at which price the global economic system may muddle through. Unfortunately, this target is hindered by the fossil fuel industries, which actively oppose incentives for alternatives.

As a sign of the immediacy of this problem, we have never spent more money developing new oil supplies than we did last year (nearly \$700 billion) nor, despite U.S. fracking, found less – replacing in the last 12 months only 4½ months’ worth of current production! Clearly, the writing is on the wall. It is now up to our leadership and to us as individuals to read it and act accordingly.

Discussion

The Historical Importance of Coal and Oil

The epic spurt of growth that began for Europe and the U.S. around 1800 (before which global growth had been negligible for thousands of years¹), was fueled by coal and then oil. The driver of this growth was the massive gap between what the energy was worth in terms of horsepower and human power equivalents and the much lower cost of digging or drilling the fuels out of the ground. Just imagine, for example, that you had to cut your winter wood supply in a hurry and you had to choose between paying your local labor a respectable minimum wage of, say, \$15 an hour or filling your empty chainsaw with a gallon of gas. One of my sons, a forester, tells me he could cut all day, 8 to 12 hours, with a single gallon of gasoline and be at least 20 times faster than strong men with axes and saws, or a total of 160 to 240 man hours of labor. For one gallon! So for this task an estimate of value of \$2,400 to \$3,600 a gallon would be about right. But with gasoline at \$3 a gallon we trade way down to trivial tasks with little labor equivalent value because we can, squandering the great potential value that oil has for really important jobs. That's how we do it. We assume the oil or coal, our finite and amazing inheritance, is free and price it just at its extraction cost plus a profit margin. So at the important end of the spectrum gasoline or oil is worth, say, \$3,000 a gallon and at the wasteful, trivial end is worth \$3. This example used gasoline, an expensively processed part of a barrel of crude oil, but the same principle of a large gap between value and cost of course also applies to crude. Let's work with that assumption for a moment. In 1998 the price of oil hit a 20-year low of below \$14 a barrel and I assume the average cost was about \$10 given there was still quite a bit of very cheap Middle Eastern oil in the mix. But the value might well have been as high as \$250² in which case a "massive surplus" – or beneficial gap between cost and value – of \$240 would have existed, or 24 times the cost of extraction.

This surplus goes in part to governments as taxes, in some oil-producing countries virtually carrying the budget on its back. It goes as pay to oil workers and their support infrastructure. It goes as profits to oil companies and from them out to dividends. But above all, its greatest benefit is in those uses that have a far higher value than the cost of the fuel, as is the case with my son's chainsaw. The great size of this surplus, first for coal and then oil and gas, drove the industrial revolution. The giant leap in wealth facilitated a massive increase in the science and engineering worlds. If you doubt the driving force of this surplus, revisit for a moment my earlier effort at imagining a world without fossil fuels ("Time to Wake Up," April 2011 Quarterly Letter, page three). Somewhere around 1850 we would have rapidly run out of wood, the predecessor fuel to coal. Wood was used for ships, homes, tables, and wagons but above all it had two irreplaceable and vital uses: charcoal for making steel and power for steam engines and heating. By 1900 wars would have been fought over forests, and the population – without oil-intensive agriculture, both for growing and transportation – would have peaked out probably well under two billion and our species would indeed have had its nose pushed up against the limits of food. (Those who assume the key factor in our growth was the steam engine miss the point: without coal, the steam engine would have just hurtled us toward the depletion of wood far faster than was already happening. The Industrial Revolution was based on coal as the source of energy and the steam engine as the original way to exploit that energy as the efficiency level rose from 1% to 35% over the steam engine's first 100 years.)

Thus we owe almost everything we have had in the way of scientific and economic progress and the growth of the world's food supplies and population to fossil fuels. And not simply to the availability of these fuels, but more precisely to the availability of those fossil resources that could be captured extremely cheaply. From 1870

¹ The Maddison Project estimates that U.K. growth from year 1 to 1800 was just .07% a year, with most of the world significantly lower.

² This estimate is made by guessing what percentages of oil use are very high-value, low-value, and so on. From my rough work I believe the range is unlikely to be outside \$200 to \$400 a barrel.

to 1970 technological improvements in finding oil offset the naturally rising marginal cost effect that you drill the best and cheapest prospects first. The price was always volatile but stayed around a trend of \$16 a barrel in today's currency. During this time, though, Americans became six times richer so that they could afford very substantial increases in energy, which drove the size and complexity of the economic system.

Rising Oil Costs Begin To Squeeze the Economy

Starting around the year 2000 a remarkable change in the relationship between oil and the economy began: the growing demand for oil started to outrun the supplies of cheap reserves and the economy had to adjust by bringing in the higher and higher cost reserve so that marginal costs compounded at over 10% a year. Why the price of oil inflected around the year 2000 so sharply, from stable to rising, is not clear but certainly owes a lot to a growing world population and perhaps a lot more to rapid Chinese growth. Marginal costs, which usually determine price, rose from \$15/bbl or so in 1998 to around \$70 to \$90/bbl today. (And average costs rose from about \$10 to \$60/bbl.) This has subtracted about \$50 from our invaluable surplus. On my numbers – and it is the principle here that is more important than the accuracy of the numbers, which in any case can only be guessed at – the surplus dropped from \$240/bbl to \$190/bbl. This 21% drop in surplus has no effect at all on high value uses like my son's, but it drives out of business a \$50/bbl band of less valuable uses of oil, which acts as an important drag on economic activity. (On a less abstract basis, a \$50/bbl loss amounts very roughly to \$1,000 per person per year in the U.S.) The price of oil is such an important input into the cost of all other resources that as oil more than quintupled between 1999 and today, the price of almost all other resources doubled and, for a while up to 2011, tripled (all adjusted for inflation). If it's true that oil's economic surplus has accounted for so much of our growth, then what we should have seen since about 2004 as the price of oil began to break out way over its long-term trend was some grinding of the economy's gears: a persistent seeming reluctance on the part of the economy to live up to expectations. And this, in my opinion, is precisely what we have seen: a broad and increasing tendency for all countries to disappoint compared to their earlier growth rates. This should be no surprise, for every previous example of surges in oil price had the same effect. What is different this time, though, is that the damaging effects of the rapid price rises in oil and other resources up to 2008 in the U.S. have been misascribed as solely the result of the financial collapse. Being a believer in real things – people, education, training, motivation, and machines and buildings – and considering oil and its energy to be very real indeed, I believe that the financial paper losses are much less consequential than others do and that the resource squeeze on the economy is much more important. The apparent value of paper can disappear into thin air easily enough, as we have seen, but people do not, nor do machines. But the same worker, with only half a gallon of gasoline in his chainsaw because of increased cost will simply have a lower output. The efficiency of energy usage increases at about 1.5% a year, but if the price of finding and delivering oil continues to rise at a faster rate than that, then the squeeze on global growth rates will continue to tighten.

Consequently, I think that the old growth rates in productivity will not come back, at least until we have had a transition away from fossil fuels. Even that transition is not in itself enough. The latest solar and wind are indeed competitive already in ideal locations, but with what are they competitive? They are not replacing our old oil that cost \$10/bbl on average 15 years ago. They are at the moment only outcompeting the highest cost fossil fuels so that the new energy sources are absolutely not remedying the painful loss to our energy surplus. What is needed is a continuing steady drop in the cost of alternatives for another 20 or more years before the surplus they offer has any chance of equaling our old, 1950-2000 fossil fuel surplus. Fortunately, a continued steady decline in the cost of wind power is likely, and a rapid decline in solar and energy storage costs is almost a certainty.

The challenge for our economy is to speed up this energy transition and to try and minimize, in the interim, the damage to our global economy and, possibly more importantly, to the actual viability of several poor countries, which suffer under the combined impact of rising fuel costs and their associated rising food costs. In some critical cases like Syria and Sudan, these cost increases are exacerbated by rapidly worsening climate extremes.

Even if we can make the transition to renewable electric power smoothly, other challenges to reducing carbon emissions remain, especially in transportation, which is where the great majority of the rest of oil goes.

Because of oil's dominant role in the cost structure of agriculture, mining, and, particularly, transportation, cheaper coal and gas have historically not materially blunted the pain from increases in the affordability of oil in developed countries. Only in some emerging countries with large coal reserves is there some reprieve, and even there as their economies mature and transportation takes on a larger share, as in China today, their sensitivity to oil increases.

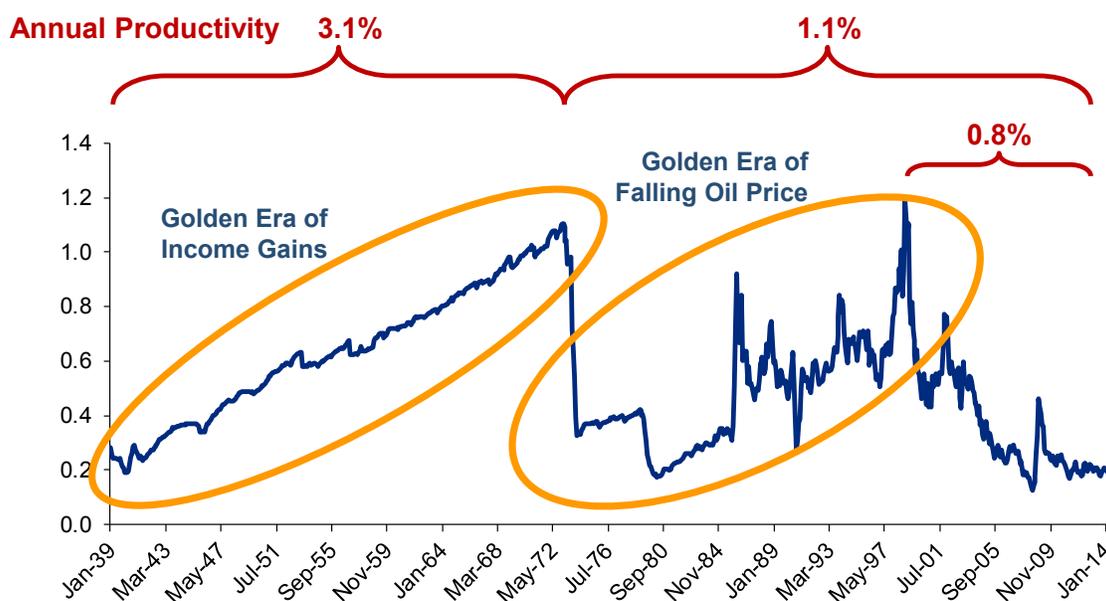
U.S. Fracking: the Largest Red Herring in the History of Oil

First, let us quickly admit that U.S. fracking is a very large herring. Its development has been remarkable. It will surely be seen in the future as a real testimonial to the sheer energy of American engineering at its best, employing rapid trials and errors – with all of the risk-taking that approach involves – that the rest of the world finds so hard to emulate. Similarly, it will always stand out as remarkable proof that, so late in the realization of the risks of climate change and environmental damage, the U.S. could expressly deregulate such a rapidly growing and potentially dangerous activity. There are few if any constraints, for example, on what chemicals and in what amounts, can be pumped into a fracking well. Nor is the leakage of methane (natural gas) from the drilling and pipeline operations seriously monitored despite the fact that methane is over 86 times as potent a greenhouse gas, at a 20-year horizon, as CO₂ is. This has given the U.S. industry a second spectacular advantage over more regulated fracking efforts elsewhere and demonstrated once again the remarkable influence of the energy industry over the U.S. governmental process, if “process” is not too dignified a word. Be that as it may, U.S. fracking produced – in addition to a lot of natural gas – almost four million barrels of incremental oil per day, not a barrel of which was in the official oil estimates eight years ago! This is very close to 100% of all the increase in global oil production in this time period and without it oil prices would obviously have been substantially higher than the recent Brent peak of around \$115/bbl. Equally remarkable, U.S. oil production from fracking continues to rise and it seems likely to rise another two to three million barrels a day before topping out. Already today, partly because of continued very disappointing global economic growth, U.S. production is temporarily glutting the world market – storage is up and prices are falling. It is one of the ironies of this complex oil system that despite this unexpected gush of U.S. oil and the ensuing impressive current drop in oil prices, nothing that really matters in the long term is changed by U.S. fracking. Yes, it has produced most of the short-term kick to the U.S. economy that makes the U.S. look superior to others (although despite this help the U.S. economy, too, has been persistently below earlier estimates, including this year). It has also created a temporary oil glut and pushed down world oil prices. Yet what it has not done is more important, and that is what makes it a red herring. It has not prevented the underlying costs of traditional oil from continuing to rise rapidly or the cash flow available to oil-producing countries like Saudi Arabia, Iran, and especially Venezuela from getting squeezed from both ends (rising costs and falling prices) with potential political consequences that I will leave to others to speculate about. The same pressures will of course also expose those oil operators that have been borrowing amounts close to the total of their cash flows for, strangely indeed, the fracking sub industry in total does not clearly show much positive cash flow despite considerably higher prices over the last two years than exist today. Yes, they have been drilling more wells that chew up money, but not that many more, and good operations have lowered the costs per well by over a third. On the

other hand, they have drilled, as always the best parts of the best fields first, and because the first two years of flow are basically all we get in fracking, we should have expected considerably better financial results by now. The aggregate financial results allow for the possibility that fracking costs have been underestimated by corporations and understated in the press.

Because fracking reserves basically run off in two years and can be exploited very quickly indeed by the enterprising U.S. industry, such reserves could be viewed as much closer to oil storage reserves than a good, traditional field that flows for 30 to 60 years. Fracking oil reserves could consequently be treated as our emergency reserve. In real life we are using it up as fast as we can. Let us hope that there will not come a time in 10 to 20 years when we will regret the absence of reserves that could be developed in a hurry. Meanwhile, cheap traditional oil, in contrast, becomes increasingly difficult to find both in the U.S. and globally. Last year for example, despite spending nearly \$700 billion globally – up from \$250 billion in 2005 – the oil industry found just 4½ months’ worth of current oil production levels, a 50-year low! Despite currently falling prices from a temporary glut that has exceeded storage capabilities, rising costs of finding and pumping traditional oil continues to put pressure longer term on resource prices. Because of this the global growth trend will be lucky to be over 3.5% with the developed world closer to 1.5% and both may well be less. The continued run of disappointing economic growth seems likely therefore to continue. Indeed, it is quite likely, although hard to prove, that any oil price over \$40 or so has been putting sustained underlying pressure on global growth and that it did not take the spikes to \$150 in 2008 and \$115 recently to throw some sand in the works: the sand has been there since 2006 and is likely to stay there indefinitely or at least until alternatives provide very cheap energy under a \$50 per barrel or so equivalent.

Exhibit 1: U.S. Average Hourly Manufacturing Earnings / Oil Price per Barrel



As of September 30, 2014
 Source: GMO, Global Financial Data
 % number = productivity measured as GDP per capita deflated by CPI

This is a good time to take a look at my solitary exhibit which is like a summary of the story so far. In 1940 as the Great Depression was ending, one hour’s work for an American engaged in manufacturing could buy 20%

of a barrel of oil, or approximately eight gallons. Bearing in mind that a single gallon has the equivalent energy of 200 to 300 man hours of labor, this already seems like a small fortune, but in what I am calling “The Golden Age of Income” the affordability of oil increased so steadily that by the end of 1972, just before OPEC and the troubles in the Middle East began, one hour’s work controlled 1.1 barrels, over a five-fold increase, the greatest surge of real wealth in U.S. history. By the second oil shock of 1979, however, oil affordability was back at a new low. Next began a quite different leg up, far less smooth and this time driven by declining oil prices and despite increasingly modest increases in income per hour. A new high in affordability was reached at 1.2 barrels per hour worked at the astonishingly low price of \$16 a barrel in 1999 at today’s dollar equivalent. The final leg that I have been obsessing about now for six years was the great decline in affordability from 1999 until today that took affordability of oil back precisely to where we began in 1940! This has been a remarkable round trip and what a lot it says about the preeminence of oil in our economy. When oil was becoming more affordable up to 1972 and oil intensity per person was still increasing, productivity per man hour grew at an unprecedented rate of 3.1% a year. From then until now as affordability fell and oil usage per person fell, productivity per man hour fell with it to 1.1%. This is not a small shift! 3.1% will take \$1 to \$21 in 100 years, where 1.1% will make it to barely \$3. But to rub this point in, the productivity from 2000 to now has fallen to 0.8% a year at which rate \$1 just about doubles in 100 years. (All calculations were done using GDP in nominal dollars deflated by the CPI, a number calculated by a government that always has a strong incentive to shave inflation down a bit here and there.) This data surely raises a strong likelihood that falling affordability of oil dominates our energy equation and poses a serious threat to income and wealth generation. At the very least the data is compatible with the thesis.

The Demise of Oil-burning Engines

Working in exactly the opposite direction to the rising costs of finding new oil is the accelerating progress in oil replacement technologies. Progress in electric vehicles (see January 2014 Quarterly Letter) seems to move faster by the month. Last November, a colleague and I personally witnessed a two-minute recharging of electric batteries (without any damage to the life of the battery). Interestingly, this was described to us a week later by a leading battery expert as being “against

Oil Costs vs. Oil Prices (or Oil Profits get Crushed!)

In the long run, when the costs of producing oil rise, the prices will rise. But in the short run it is not always the case, and in such occurrences it is easy to confuse the effects of changes in costs with changes in prices. When global oil costs rise, as they are currently doing, global growth must suffer as we are forced to use more of our capital per unit of oil discovered and thus limit our capital investments in other growth opportunities. This is true even if prices simultaneously fall due to a temporary supply/demand imbalance. The current fall in price does nothing to offset the squeeze on the total economy from rising costs. It merely transfers massive amounts of income from one subgroup (oil producers) to another (oil consumers), in a largely zero-sum game. Oil consumers tend to spend more and save less than oil companies so short-term impacts are favorable. But we should not be carried away with enthusiasm because the declining investment from the oil industry will lower future growth. When, as now, oil costs are still rising even as prices fall there is of course a particularly savage effect on the profits of oil companies, squeezed from both ends. They must and will rapidly adapt by reducing expenditures and therefore oil production with the fairly obvious result that prices will rise again.

The only longer-term price relief and net benefit to the economy will come when either we reverse recent history and start to find more oil more cheaply, which will be like waiting for pigs to fly, or when cheaper sources of energy displace oil.

the laws of physics.” Considerably perplexed, we checked with the engineers who had achieved this two-minute recharge to find that they themselves were not so sure of the physical principles involved. They had reached their goal by many thousands of intelligent trials and errors as engineers have probably done since the Stone Age, leaving it to future Nobel Prize winners to notice what had happened and then produce a theory. And more recently scientists have indeed theorized the possibility of rapidly charging electric batteries. (This is a field of research moving so fast that apparently even the laws of physics can’t keep up!) Then, in the spring of this year, a Japanese company, Power Japan Plus, announced similar rapid-charging capabilities, plus some attractive features that offer great potential cost reduction. There have also been several important breakthroughs announced in both the cost and efficiency of large-scale energy storage, notably in liquid metal batteries. If not unprecedented, this progress is definitely remarkable. We also heard from experts of automobile redesign from the ground up to produce ultra-lightweight “people movers,” and we followed the rapid progress of “autonomous” or self-driving vehicles. All in all it seems likely that in 10 to 15 years the gasoline engine will be in its death throes, and we can absolutely count on China riding the new technologies to the limit even while the vested interests in the U.S. fossil fuel and utility industries throw their usual wrenches into the machinery to try to buy themselves some time at society’s expense. But we will, I’m sure, eventually remove oil demand for surface transportation. As we do so, it will give our environment some breathing room – some more time for us to deal with the remaining important uses for oil and gas such as chemical feedstock, air and sea transportation, and road surfacing, which uses will take many decades to completely replace.

The Immovable Object and the Irresistible Force

What I’m trying to describe here is on one hand a remorseless and historically unprecedented rise in the costs of delivering oil to the marketplace, which is sapping economic strength globally, and on the other hand (and simultaneously) what will be the beginning of an accelerating transference of demand away from oil under the impact of surprising technological progress in alternative energy. When we add the further complexity of a temporary surge in oil from U.S. fracking, I am willing to concede that the outlook for oil and energy is the most complicated puzzle I have ever come across: it is wheels within wheels, but with each spinning in a different time frame. As Spock would say, “Fascinating!” How this ultra-complicated tug of war plays out in the next 10 years or so is anyone’s guess. My guess is that oil prices will bounce around for most or all of the next 10 to 15 years as first one side of this tug of war moves ahead and then the other, with perhaps another 2008-type spike (or two) in the price of oil, after which prices will plateau and decline as electric vehicles take over and, one by one, oil’s remaining uses are slowly replaced.

The story for coal is much simpler. Coal for coking in the steel business may last for decades (although very recent announcements out of MIT suggest that the need for coal may one day be bypassed), but steam coal, used almost exclusively for electric power, is already in a rapid and certain absolute decline in the U.S. and in a steady decline in its growth rate elsewhere. In China, which astonishingly accounts for over half of all current global coal consumption, it is unlikely that any material number of new coal plants will be built after 20 years and, quite possibly, 10 years. China is moving faster than most realize in this area and should be, given the extensive health damage from air pollution there. If this problem continues or worsens, it is likely to threaten the social contract between the Chinese people and their government, which seems well aware of this possibility. Natural gas, a fuel that is potentially much cleaner and potentially less environmentally threatening if leakage can be controlled, will last longer than coal in utilities, but not much longer. That said, as with oil, some other uses for natural gas, fortunately much smaller, such as feedstock for nitrogen fertilizer, will continue for decades. How quickly and smoothly this tug of war is resolved will determine how prosperous and stable our global society will be. Possibly, it will determine whether our currently successful global economy will be viable at all in anything like its present form.

P.S.

As a parting shot let me emphasize once again how out-of-it mainstream economics has been for the last several decades. Not only did the mainstream absolutely not see the financial crisis approaching, but it marginalized the work of Hyman Minsky, who did. More to the point, the economic mainstream has totally missed the significance of the limits on growth posed by finite resources and again marginalized the work of Kenneth Boulding and Nicholas Georgescu-Roegen and the writers of the original The Limits to Growth,³ who did. As with inefficient and corrupt market players in finance, they simply assume such limits away, in disregard of at least one of the laws of physics⁴ (that entropy rules and everything runs downhill, becoming less useful). This neglect of resources, like their last failure in finance, is likely to end very badly. Meanwhile, they try to define all of our problems in monetary, debt, and interest rate language, ignoring the real world of people and things. The economic establishment is letting us down again. Their report card should read, “Could do better!” Which brings me to my main P.S.

P.S. Two: Hysterical Malthusians and Hubristic Cornucopians

On the principle that there is no such thing as bad publicity, I must thank *The Economist* for mentioning (October 3, 2014) that I had pointed out three and a half years ago that the previous world of cheap and available commodity prices had gone forever. Reading between the lines, though, the view of *The Economist* is that concern over long-term commodity prices and availability is more likely to reflect hysterical Malthusianism than real life as they point to the recent impressive fall in almost all commodity prices. I had suggested originally that temporary drops in commodity prices could be caused by China growing less than expected or by weather for farming improving after several monstrously bad years. Both of these events occurred this year. However it has always been oil that matters most, for oil is half the value of traded commodities and almost half the cost structure of the rest. Oil, as described in this quarter’s letter, is currently very complicated but the key for the long term is the remorseless rise in the cost of producing the marginal, or extra barrel, that continues to rise even as U.S. fracking oil gluts the global market for a minute or two. Oil was \$14 a barrel in 1998 and has now dropped to \$83 from \$115 (Brent). With costs of production at \$60 or \$70 a barrel, oil prices are not going back to \$14 or even \$40 (at least until renewables displace it more or less completely in a few decades). The weather for growing grain is of course mean reverting, but it is now unfortunately doing so around a steadily deteriorating trend. Rising grain prices are one of the greatest threats to global stability and it would be wonderful if there were a magic cure for the declining growth rate in the productivity of grain, soil erosion, water availability, and deteriorating long-term weather patterns but it just ain’t so.

As discussed in earlier quarterlies, three important commodities are really quite common in the earth’s crust: iron ore, bauxite, and potash. All other industrial metals and the critical phosphorus added together do not equal the least of those three! They are simply scarce and are being depleted, as is cheap oil.

The Economist is not a flamboyant, cowboy member of the Cornucopians – those who have the hubris to believe that the infinite human brain will always conquer all problems by divine right and will make all resources available forever, despite logic and the laws of nature – but they are part-time Cornucopians if you will. And they can still misuse the hoary old Simon-Ehrlich bet⁵, which extended to today is at worst a draw for Ehrlich and the last time I checked all the details it was a clear victory for him. (See Appendix A, attached, from GMO’s

³ Donella H. Meadows, Dennis L. Meadows, Jorgen Randers and William W. Behrens III, The Limits to Growth, 1972.

⁴ The Second Law of Thermodynamics.

⁵ The classic wager between Ehrlich (the Malthusian) who believed shortages would push up finite resource prices and Simon (the Cato Institute Cornucopian) who believed Technology would push their prices down forever.

July 2011 Quarterly Letter.) It comes down to understanding the impossibility of sustained compound growth in finite resources and a finite planet and reminds me of one of my favorite quotes from one of my favorite economists (a very small group), Kenneth Boulding, who said, “Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist.”

Stop Press! The End of Normal by James Galbraith

Having labored over the eighth draft of this quarter’s letter on oil and energy in which I insult economists for their lack of interest in resource limitations, a new book appears that amazes me by doing the opposite, and by an increasingly well-known economist no less (although clearly not mainstream, thank heavens). It is entirely sensible from start to finish. Which is code for I agree with almost everything he writes. Galbraith claims, for example, that the resource price rise to 2008, especially for oil, played an important role in the economic setback and deplores the fact that nobody mentions this. Sadly, he is not a reader of my quarterly letters but, hey, nobody is perfect. Let me leave you with the advice to buy and read this book, along with this quote from page 104 (underlining added):

“There is no reason to believe that the democratic decision made by the living in the face of their present needs and desires will be the decision that would maximize the chance of long-term system survival. The unpleasant conclusion is that it is possible for a society to *choose* economic collapse.”

Disclaimer: The views expressed are the views of Jeremy Grantham through the period ending November 2014, and are subject to change at any time based on market and other conditions. This is not an offer or solicitation for the purchase or sale of any security and should not be construed as such. References to specific securities and issuers are for illustrative purposes only and are not intended to be, and should not be interpreted as, recommendations to purchase or sell such securities.

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Appendix A: Malthusians and Cornucopians: the Ehrlich-Simon Bet

While still on the topic of resources, there are a few points I'd like to make on the subject of the famous bet made between Paul Ehrlich and Julian Simon in 1980, which is so often mentioned by opponents of any ideas regarding resource limits. They have been called Cornucopians, which I think is a great term for them. Ehrlich believed that we were beginning to run out of resources; we might call him a Malthusian. He reflected the Club of Rome's thinking and the famous book entitled *The Limits to Growth*.¹ Simon on the other hand, who worked at the Cato Institute for many years, was a classic super-Cornucopian: everything will always be fine because of our species' boundless resourcefulness; population increases are to be welcomed because they cause growth, which in turn stimulates invention so that there will always be plenty. The Cato Institute generally supports any theory that will result in less government and fewer restraints on corporations. (They were grubstaked by the Koch family, they of the hydrocarbon empire, who, not surprisingly, profoundly agree with those beliefs.) The argument that mankind might seriously endanger the long-term productivity of the planet by wasteful overconsumption or by unnecessarily large emissions of carbon dioxide is a dangerous "idea" for libertarians and Cornucopians (we might, I think, reasonably call such things "facts") that might open the door to regulation. Ergo, the facts must be disputed. And every argument along the way, large or small, must be grimly defended, especially the ideal of limitless growth.

And defend it Mr. Simon did, and very effectively. He engaged Ehrlich in a bet on this topic, which he famously won, and the Cornucopians have never let anyone in this field forget it. The essence of the bet was that Ehrlich believed that compound growth could not be sustained in a world of finite resources, and therefore the real price of raw materials would rise. Simon argued that, regardless of the rate of growth, real prices would fall. Of course, the spirit of this bet has no time limit – 40 years is better than 10, and 100 is better than 40. But a bet like this between humans of middle age is one that both would like to collect on. So, the bet was set at 10 years and five commodities² were chosen by mutual agreement. Here again, all commodities would have represented the spirit of the bet better than five, but five was easier to monitor. Simon won all five separate bets fair and square at the 10-year horizon. But let's admit that this is a very unsatisfactory time period for the rest of us who are really interested in this contest of ideas. So, let's take an equally arbitrary but much more satisfactory bet: from then, 1980, until now, and include all of the most important commodities. Simon would have lost posthumously, and by a lot! (Even of the original five, he is only one for five, having won the least significant of the five: tin.) So, please "Cornucopians," let's not hear any more of the Ehrlich-Simon bet, which proves, in fact, both that man is mortal and must make short-term bets, and, more importantly, that Ehrlich's argument was right (so far).

¹ Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, and William W. Behrens, III, *The Limits to Growth*, Universe Books, New York, 1972.

² Copper, chromium, nickel, tin, and tungsten.