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THE BELL HAS BEEN RUNG

Table of Contents

The Bell Has Been Rung: The Contrarian Power of Magazine Covers
Energy Demand Has Never Been Stronger, Yet Investors Are Giving Assets Away
2019 Q1 Natural Resources Market Commentary
Oil Markets: Major Developments on All Fronts; Aramco Releases Reserve Details
Precious Metals Markets: The Impact of Central Banks
Agricultural Markets: What Sunspots Mean for Global Growing Conditions

The Bell Has Been Rung : The Contrarian Power of Magazine Covers

Businessweek has done it again. In an echo of the historic, oh-so-wrong- cover piece of August 1979, “Death of Equities,” the April 2019 cover of *Bloomberg Businessweek* proclaims “The Death of Inflation”. If that’s not a screaming warning of inflation’s return, and buy signal for inflation sensitive assets, we don’t know what is.

Magazine covers have a long history of proclaiming erroneous predictions at critical turning points in financial markets. Sometimes it takes decades, but bullish or bearish trends often persist long enough to convince everyone, even the most senior and wizened editors of well-respected business magazines, to publish ill-conceived cover stories arguing that well-established trends will continue forever.

One of the most famous examples of contrarian messaging on a magazine cover occurred back in August 1979 when *Businessweek* published its “Death of Equities” cover story. Written after stocks had posted 20 years of substandard returns (including four bear markets -- one of which saw the market decline by almost 50%), the August 13th cover story explained how future equity returns would remain substandard for the foreseeable future. Although not quite the bottom in stocks (the bear market didn’t end until August 1982), investors should have used the strong contrarian signal issued by the *Businessweek* cover to literally “back-up-the truck” and invest as much as they could. If an investor had bought the Dow Jones Industrial Average then (with the index at 870) and held it until today (with the index now at 26,500), he would have compounded his money by 12.3% per year over 40 years - by far the longest and strongest bull market surge in U.S. history.



THEN
8/13/79



NOW
4/20/19

What made the editors of *Businessweek* so bearish on stocks? While everyone remembers the cover, few people recall the subtitle: “How inflation is destroying the stock market.” By the late 1970s, intractable inflation, which was distorting the returns of almost all investments, had become an universally accepted problems by all investors. The cover story related the firmly entrenched consensus investment opinion:

“The masses long ago switched from stocks to investments having high yields and more protection from inflation. Now the pension funds - the market’s last hope - have won permission to quit stocks and bonds for real estate, futures, gold, and even diamonds. The death of equities looks like an almost permanent condition – reversible someday, but not soon.”

Everyone including the editors of *Businessweek* believed future equity returns would be severely and permanently impaired by inflationary problems that would only get worse. For investors without gray hair, it is hard to believe how different the investment landscape looked 40 years ago and how bearish investors had become. Ever-rising inflationary expectations had convinced investors that neither bonds nor stocks should be bought at any price. The U.S. inflation rate hit 14% in the summer of 1980 while the Fed Funds rate peaked in the summer of 1981 at over 22% and 30-year U.S. Treasury yields peaked in October at 15.2%. By 1980 bonds, dubbed “certificates of confiscation,” had replaced stocks as the most hated financial investment. By the late 1970’s, hard assets had become the most popular and recommended investment class. It is not surprising that precious metals, the best performing asset class of the preceding decade, had become the asset with “must-own” status. Cocktail party banter often centered around how many Krugerrands “smart investors” had stuffed into their safe-deposit boxes. By late 1979, oil hit \$25 per barrel; an eight-fold increase in 10 years. After two energy crises, everyone firmly believed we were running out. OPEC would continue to control world oil markets and it was only a matter of time before oil breached \$100 per barrel, or so went conventional wisdom.

The Dow Jones Industrial Average hit 1,000 for the first time in 1966. 13 years later, in the summer of 1979, the index traded as low as 850. At these levels, the Dow yielded over 6% and traded at a slight discount to its book value. Surging inflationary expectations and collapsing bond prices had produced the cheapest stock market in over 45 years. Despite its radical undervaluation, few investors outside of Warren Buffett owned it. No wonder *Businessweek* decided to published its now infamous “Death of Equities” cover.

In retrospect, we know how wrong *Businessweek’s* prediction was. A contrarian investor would have spotted huge changes in Federal Reserve monetary policy by 1979 which monumentally altered the investment landscape almost overnight. The commodity bull market broke in January

1980 when silver (the best 1970s best performing asset), spiked briefly to \$50 per ounce and then promptly crashed, taking the Hunt Brothers with it. Inflation, as measured by the Consumer Price Index, spiked six months later and interest rates peaked in the summer of 1981.

The bear market in stocks ended in spectacular fashion. By August 1982, the U.S. stock market literally blew off the bottom and proceeded to surge almost 40% in the next four months alone. The August 1979 *Businessweek* cover did nothing more than express an opinion that had been cemented by trends that persisted for decades: inflation problems would never be solved, hard assets and commodities were the great beneficiaries of an inflation problem that could only get worse, and bonds and stocks should not be bought at any price. The 1979 *Businessweek* cover gave investors the strongest sign imaginable that inflation was about to significantly slow, that commodities would become terrible investments, and that financial assets were the buy of a lifetime.

How different the investment landscape looks today. The expectations of rising inflationary 40 years ago have been replaced by a strongly-held belief that inflation will continue to fall -- a trend that has been in place now for nearly two generations. Because of lingering fears from the 2008 global financial panic, investors continue to favor "risk-off" investments in general and bonds in particular. After experiencing a massive 38-year bull market, investors clamor for bonds: the riskier the credit and longer the maturity, the greater the demand. Even more absurd, nearly \$10 trillion of government bonds now trade with negative yields -- a first in 3,000 years of financial history. Even though governments continue to set new records for peacetime indebtedness, investor demand for their debt remains unwavering. Japan and Argentina are poster children for this absurdity. Japanese government bonds are issued by a country which has racked up debt approaching 250% of GDP, a level never seen in peacetime by any industrialized country. Argentina, one of the world's great "serial defaulters," issued a 100-year bond only one year after its most recent default. Demand for the bond was extremely strong and the issue quickly traded above par.

In the stock market, investors continue to clamor for high-quality technology growth stocks (the so-called "FAANG" stocks), several of which command near trillion-dollar market capitalizations. Investor interest in "risky" hard assets, commodities, and their related equities has approached zero, even though all three have never been cheaper relative to financial assets.

The reversal in investor preferences from hard assets to financial assets has been extreme. The trend started 40 years ago and has continued up to today with few interruptions. Despite its persistence, we believe this trend is nearing its completion and is about to reverse again in favor of hard assets. Why do we think this? Back in 1979, the "Death of Equities" *Businessweek* cover gave investors ample warning that inflation-sensitive hard assets (the most popular asset class at the time) had become radically over-owned and overvalued and, conversely, that financial assets (the asset class that no one wanted) had become radically undervalued and offered phenomenal returns.

What if investors are as wrong today about the pricing of "risk-off" assets as they were about the pricing of hard assets in 1979? Certainly much of the outperformance of "risk-off" assets over the last 10 years has been the result of falling inflationary expectations. What if the bet on constantly slowing inflation is about to be reversed and inflation begins to rapidly and unexpectedly accelerate over the next several years? Since 2008, the US, European, and Japanese central banks have conjured trillions of dollars of bank credit through quantita-

"IN 1979 EVERYONE BELIEVED INFLATION WOULD NEVER END, WHEREAS TODAY NO ONE BELIEVES INFLATION WILL EVER RETURN."

tive easing. Despite this massive new credit creation, investors (in a fit of extreme trend-following) have become more convinced than ever that inflationary expectations will continue to fall. Even talk of introducing a new, radical monetary policy such as Modern Monetary Theory (MMT) has been met with a continued rally in bond prices.

Back in 1979, with gold soon to spike to \$850 per ounce and bond prices collapsing, investors bet that inflation would follow its 30-year trend and continue to accelerate while financial assets would remain depressed. Today, investors have made a completely different bet: in 1979 everyone believed inflation would never end, whereas today no one believes inflation will ever return.

Given the historical significance of *Businessweek* covers, we believe the April 22, 2019 *Bloomberg Businessweek* cover, "Is Inflation Dead," will turn out to be as historic as the 1979 cover. Just as the earlier cover predicted inflationary problems would never go away, today's *Bloomberg Businessweek* cover story tells investors that inflation will never be a problem again. The article explains how the danger facing investors is not inflation but rather deflation. It has taken 40 years to vanquish the inflation monster (as depicted on the cover), but we have now come full circle regarding inflationary expectations. The inflationary monster is now dead.

With the publication of this current *Bloomberg Businessweek* cover story, we believe investors have once again been given an extremely strong contrarian indicator: inflation (which everyone thinks is now dead) is about to reemerge as a huge problem. Investors today have crowded into trades that are heavily dependent on inflation staying low. "Risk-off" financial assets have been the only source of market outperformance and profit. Tens of trillions of dollars worth of government bonds now sport negative interest rates and four tech companies command equity valuations approaching \$ 1 trillion each. Gold has languished with little interest and there is even talk that oil will eventually trade toward "worthlessness," according to a widely-followed newsletter writer.

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Although investors forget, the long-inflation/short-financial asset trade that *Businessweek* recommended in 1979 began to unravel shortly after the publication of its cover story. Although it took three years for the bull market in equities to begin, the commodity bull-market bubble (driven by ever-rising inflationary expectations) broke in spectacular fashion soon after the cover story was published. Silver prices (which led the commodity bull market and were the subject of a speculative craze) crashed five months after the *Businessweek* cover story, bankrupting two famous brothers in the process. Today, with investors crowded into tech stocks, bonds, and other "risk-off" assets, we are looking for signs that these trades are about to become seriously stressed. Conversely, the asset class that absolutely no one has wanted to own — commodities, natural resource equities, and related "risk-on" assets - should reverse as well. This new *Bloomberg Businessweek* cover signals to us that the 40-year trend of declining inflationary expectations is now fully incorporated in everyone's portfolio, and at risk of coming undone.

The unexpected return of inflation will have monumental effects on "risk-off" and "risk-on" asset classes. Investors have made the bet that inflation will stay low; few are positioned for its return. This month's *Bloomberg Businessweek* cover gives a strong warning that everyone has made the wrong bet and yet no one is paying attention. The fat lady has come on stage, she is singing, and bells are ringing. Readers, we beg you to seriously listen and position yourself accordingly.

Energy Demand Has Never Been Stronger, Yet Investors Have Never Been More Bearish

“We have seen an extraordinary increase in global energy demand in 2018, growing at its fastest pace this decade.” Dr. Fatih Birol, Executive Director of the International Energy Agency (IEA)

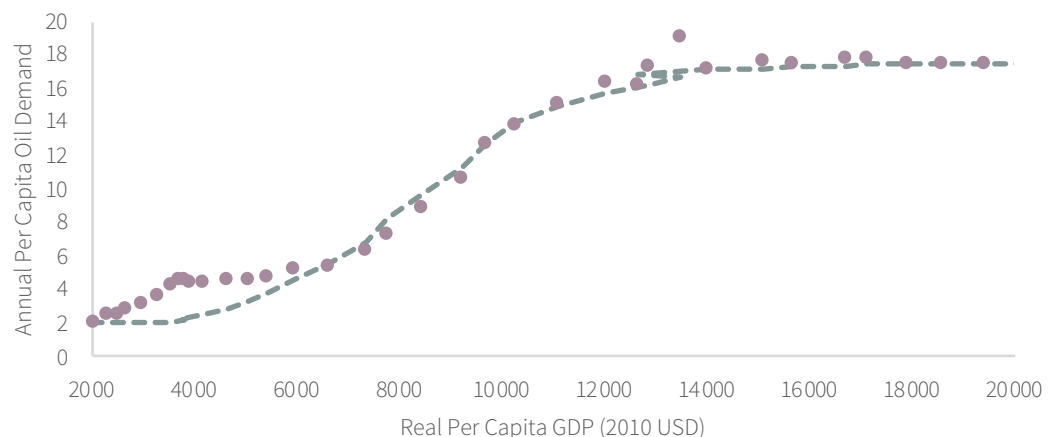
“Together, China, the United States, and India accounted for nearly 70% of the rise in energy demand around the world.” IEA Press Release 3/26/2019

Consensus opinion believes global energy consumption is in the process of slowing dramatically. Between 2003 and 2007, global energy consumption grew by an extremely strong 3.7% per year, driven by surging Chinese growth. In comparison, for the five-year period ending in 2017, global energy consumption growth slowed dramatically, averaging only 1.4% per year. Most investors believe downward pressure on all forms of energy consumption will continue as we progress into the coming decade. Fears of slowing Chinese economic growth coupled with increased energy efficiency will impair the future growth in energy demand. Given this backdrop, it came as a shock for many when the International Energy Agency (IEA) released its 2018 world energy consumption figures a few weeks ago, showing a large unexpected increase of 2.3%. This marked the biggest increase in 10 years, and eclipsed the 1.4% average increase over the last five years. As shocking as this headline figure was, we believe it will be revised higher. The oil section of this letter will explain why.

Our readers know we disagree with the prevailing view that global energy growth is slowing. Instead, we believe 2018’s strong energy consumption figure will be repeated over and over again in the coming decade. Based upon our research, all forms of energy consumption with the possible exception of coal will experience robust demand growth far exceeding consensus estimates.

Ten years ago, we put forth our demand thesis and concluded we would soon enter into “a golden age” of energy demand growth. Based on what we call the “S-Curve,” we discussed how rising income levels in many emerging markets had reached important “tipping points,” where total energy consumption begins to accelerate materially. This observable phenomenon has occurred repeatedly in many emerging markets in the post-World War II period. The most famous example of the “S-Curve” is oil consumption in South Korea between 1980 and 1997.

CHART 1 South Korea S-Curve

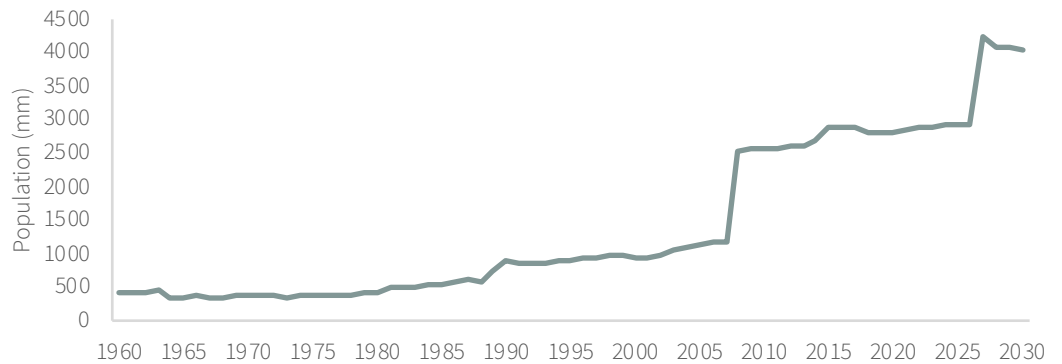


Source: BP Statistical Review, World Bank

During these 17 years, South Korean oil consumption grew 50% faster than real per capita GDP. The South Korean experience is now being experienced and replicated by a huge segment of the world's population. As you can see from the chart below, the population entering their period of increased commodity consumption (approximately \$5,000 per capita in today's dollars) held relatively steady between 1960 and 2000. During this time, approximately 500 to 700 mm people were in their period of accelerated commodity consumption at any given moment. However, beginning in the early 2000s, the number of people entering their period of rapidly accelerating commodity consumption exploded.

"NEVER IN HISTORY HAVE SO MANY PEOPLE ALL GONE THROUGH THEIR "S-CURVE TIPPING POINT" SIMULTANEOUSLY."

CHART 2 People Going Through S-Curve Tipping Point



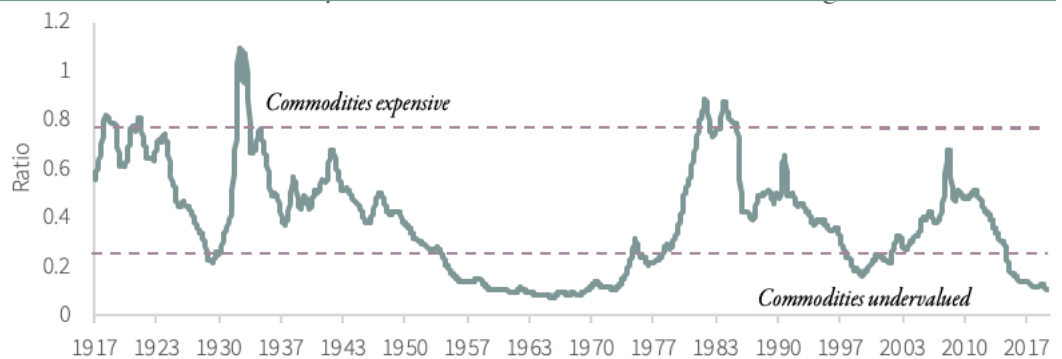
Source: World Bank

China passed its "tipping point" back in the early 2000s and has since been joined by Malaysia, Thailand, Indonesia, the Philippines, and Vietnam. And now, as we extensively wrote last year, India is in the process of joining this group. In just 20 years, the number of people going through their "S-Curve" period of intense commodity demand growth has jumped from 700 mm to over four billion. Never in history have so many people all gone through their "S-Curve Tipping Point" simultaneously. The result is that global demand for raw materials such as oil, natural gas, copper, and proteins will continue to surprise to the upside.

Just as we are entering a prolonged period of strong commodity demand, the value of commodities relative to financial assets grows more and more depressed. In one of our first Goehring & Rozenwajg letters, we printed a chart comparing the price of commodities to the Dow Jones Industrial Average going all the way back to 1917. For anyone interested, we used the Goldman Sachs' commodity index, available since 1970; for the years prior, we had to construct our own commodity price index using a similar methodology. The chart clearly showed that by 2017, commodities relative to financial assets, were as cheap as they had ever been.

"THE CHART CLEARLY SHOWED THAT BY 2017, COMMODITIES RELATIVE TO FINANCIAL ASSETS, WERE AS CHEAP AS THEY HAD EVER BEEN."

CHART 3 Commodity Index/Down Jones Industrial Average



Source: Bloomberg, Barron's, G&R Models

The chart generated intense interest from our readers, and we were frequently asked if we could also analyze commodity-related equities over the same time period. Although this task might seem relatively easy, it turns out that data on commodity-related equities is difficult to come by prior to 1980 (the exception being gold stocks which were widely followed). We have extensively researched the issue and, as far as we can tell, no one has tried to compare the price of commodity-related stocks to the general stock market throughout the whole twentieth century. Our ultimate goal is to construct a commodity-related stock index beginning in 1900 and to compare that with the broad market. We used the widely followed S&P North American Natural Resource Stock Index as our starting point and have worked to extend it back as far as possible. As of today, we have collected enough data to compare returns going back to 1937 and hope to reach 1900 within several months.

"FROM THE COMMODITY-CYCLE LOWS REACHED BACK IN BOTH 1970 AND 2000, NATURAL RESOURCE EQUITIES OUTPERFORMED THE BROAD STOCK MARKET FIVE-FOLD OVER THE FOLLOWING DECADE."

CHART 4 Commodity Stock Index vs. Dow Jones Industrial Average



Source: Bloomberg

The chart shows our Natural Resource Stock Index (which aligns with S&P North American Natural Resource Stock Index since 1997), divided by the Dow Jones Industrial Average. Commodity stocks clearly follow the direction and cyclicity of commodity prices, undergoing huge periods of relative outperformance and underperformance.

From the commodity-cycle lows reached back in both 1970 and 2000, natural resource equities outperformed the broad stock market five-fold over the following decade. Today, both commodity prices and natural resource-related equities have never been more depressed relative to the broad market. Considering the world is entering into a “golden age” of strong commodity demand, and given the massive amounts of money-printing over the latest decade by central banks (which will most likely wind up debasing global currencies), investors should be looking to resources as an extremely cheap potential hedge. As you can clearly see in the chart above, this is not the case: commodity-related stocks have never been more depressed and out of favor. Commodity related stocks are being “given away” today.

The greatest disconnect has taken place in the energy sector. Investors have become convinced that the E&P “model” is broken and that even energy companies with prime acreage positions in the best shale plays have become chronic value “destroyers.” Investors have lost faith in even the highest quality management teams with decades of experience.

The chart below plots the historical relationship between enterprise value and PV-10 (a standardized measure of discounted cash flow) for an index of a group of popular E&P companies.

CHART 5 Price / PV-10 per Debt Adjusted Share



Source: Company Filings, G&R Models

Although a company's PV-10 value is heavily dependent on oil and natural gas prices, you can easily see that investors are paying a smaller and smaller premium for oil and gas reserves of the North American E&P industry. In fact, valuations are almost as low as during the last great bottom in oil prices back in 1999-2000.

If the North American E&P industry was indeed destroying value over time, then it would make sense for investors to ascribe less and less value to oil and gas assets. In an extremely good piece in the January 2, 2019 edition of *The Wall Street Journal* entitled "Fracking's Secret Problem—Oil Wells Aren't Producing as Much as Forecast," the authors claim that oil and gas companies operating in all the shale basins have been far too optimistic in projecting their well performance over the last four years. The authors singled out two Permian companies, Pioneer Natural Resources and Parsley Energy as companies where well projections fell short of actual performance.

"ALSO, WE OBSERVED THAT MUCH OF THE DISAPPOINTMENT HAS TAKEN PLACE AMONG PRIVATELY HELD E&P COMPANIES, THE MAJORITY OF WHICH ARE MOST LIKELY OWNED AND MANAGED BY PRIVATE EQUITY FIRMS."

As we discuss extensively in the oil section of this newsletter, we have undertaken an extensive drilling productivity study across the three main shale basins (Bakken, Eagle Ford, and Permian) and we have come up with a slightly different take on The Wall Street Journal article. Our research indicates that while there has indeed been a drop in well productivity compared with expectations, these disappointments are not universally distributed among E&P companies. Some companies continue to drill excellent wells while some do not. Also, we observed that much of the disappointment has taken place among privately held E&P companies, the majority of which are most likely owned and managed by private equity firms.

We should point out that our models indicate both Pioneer and Parsley are drilling among the best wells in the United States today and that their wells are not underperforming. Regardless, the "value destroying" thesis is obviously being applied to their stocks and, as a result, the discount to our net asset value calculations is huge for both. As further proof of just how cheap these names have become, Anadarko Petroleum (a company with a large Permian position), has emerged as the object of a bidding war between Chevron and Occidental Petroleum. Even Mr. Buffett has entered the fray by pledging financing for Occidental's bid.

One of the most important characteristics in determining an oil company's ability to create value is the growth in net debt-adjusted proved developed reserves per share (converting net debt to equity at the prevailing share price). Despite being labeled value destroyers, both Parsley and Pioneer have realized stellar net debt-adjusted proved reserve growth

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per share between 2013 and 2018. Parsley ended 2012 with 0.49 barrels of oil equivalent (boe) of proved reserves per net debt-adjusted share. By 2018, this had grown to 1.17 boe per net-debt adjusted share, a compounded growth rate of 19%. Proved-developed reserves per debt adjusted share grew even faster. Parsley started the period with 0.21 boe per debt adjusted share and ended 2018 with 0.70 boe per debt adjusted share for a compounded growth rate of 30%.

Pioneer's performance was equally impressive. While total reserves did not grow materially between 2013 and 2018, a few adjustments need to be made. First, Pioneer sold 260 mm bbl of reserves between 2013 and 2018. Second, when Pioneer decided to proceed with horizontal Wolfcamp development, they suspended plans to develop their legacy Sprayberry assets and were forced to write-off 270 mm boe of associated reserves. After making those two adjustments, we calculate that Pioneer grew their proved reserves from 2.1 boe per debt-adjusted share in 2013 to 5.9 boe by 2018 for a compounded growth rate of 23%. Proved-developed reserves growth was even better, growing from 1.7 boe per debt-adjusted share in 2013 to 5.4 boe per debt-adjusted share by 2018 -- a compounded growth rate of 26%. Long-time followers of global oil markets will appreciate how difficult it is to achieve these levels of growth. More remarkable still, neither company has come anywhere near exhausting their inventory of high quality drilling locations. Based upon our analysis, both companies will continue compounding reserve growth for many years to come.

We compute price targets by projecting a company's reserves out five years and then estimating a PV-10 "standardized measure" under a variety of oil and natural gas prices. We do this for many E&P companies and use the results to determine overall market sentiment.

Based upon our calculations, investors today are as bearish as they have ever been. Let's look at both Pioneer and Parsley, two stocks that have been labelled as underperforming assets, to see how those values compare to the just announced transaction between Anadarko and Chevron. On April 12th, Chevron agreed to buy Anadarko in a cash and stock deal worth \$65 per share. This offer was subsequently "topped" by Occidental Petroleum on April 24th. Occidental offered \$76 per Anadarko share in a transaction consisting of half cash and half Occidental stock, with \$10 bn of financing pledged by Berkshire Hathaway.

According to our valuation methodology noted above, APC is worth approximately \$75 per share using an \$75 oil price and a \$3.50 gas price. Using similar oil and gas prices, Pioneer would be valued at \$320 per share, while Parsley would be valued at \$95 per share. Even after Friday's runup in share prices, Pioneer now trades at approximately \$170 per share and Parsley trades at \$20 per share. We now have a sense what big oil companies are willing to pay for companies with large high-quality acreage positions in the Permian basin.

Our research tells us that both Pioneer and Parsley have among the largest amount of remaining high-quality acreage in any shale play. Given the Anadarko transaction price, it is clear how radically investors are undervaluing these assets. In the case of Pioneer, we believe the stock is 45% undervalued and, in the case of Parsley, the market is undervaluing their assets by an amazing 79%.

We started this essay by saying the fundamental backdrop to the global oil and gas industry was as good as we have ever seen it. Never have so many people simultaneously been in their period of high commodity consumption. Despite such an extremely favorable backdrop,

"WE ARE ENTERING A "GOLDEN AGE" OF RESOURCE DEMAND AND YET THE WORLD'S BEST ASSETS ARE PRACTICALLY BEING GIVEN AWAY "

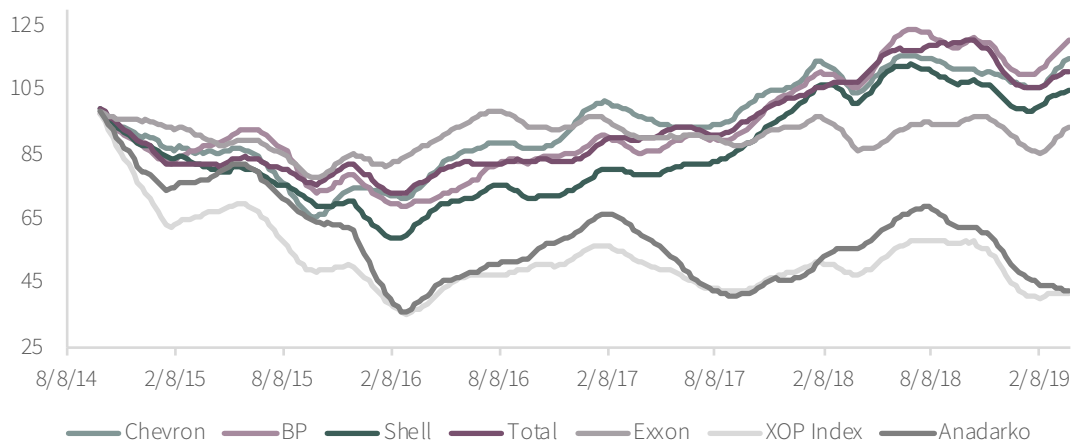
investors have never been more bearish. We just gave you two examples of extremely high-quality E&P names, with huge inventories of the best shale acreage in North America, and yet both today trade at discounts as large as we have ever seen. We are entering a "golden age" of resource demand and yet the world's best assets are practically being given away. These two companies are great examples of how bearish the investment community has become towards natural resources and commodities.

2019 Q1 Natural Resources Market Commentary

Most commodities and related equities rebounded from their lows reached at the end of Q4. Oil prices surged after being trounced in Q4. WTI prices advanced 32% while Brent prices advanced 24%. Continuing a trend that has lasted well over two years, oil-related stocks continued to lag the large advance in crude oil prices. For example, both the S&P Oil and Gas Exploration Index (XOP) and the XLE (one of the mostly popular energy related ETFs) advanced only 17%. Oil prices have now advanced by over 140%, since the bottom made in February of 2016. In stark comparison, the XOP has only advanced 40% while the XLE has only advanced 20%. As we wrote in the Introduction, the severe under-performance of energy-related equities has created incredible value in these stocks that we cannot remember ever seeing in our 30 years of natural resource investing.

We believe two things are going happen to oil-related equities in the next two years. First, either they will close the massive gaps in their valuations by surging in price, or else the industry will go through a period of massive consolidation. We believe that the takeover of Anadarko by Chevron or Occidental is just the start.

CHART 6 Outperformance of Oil Supermajors



Source: Bloomberg

Because of the huge distortion created by "risk-on / risk-off" capital flows, large-capitalization oil and gas companies have radically outperformed mid- and small-cap E&P stocks. As you can see over the last four years, Chevron has outperformed both the S&P E&P index and Anadarko by almost 20% per year compounded. Companies like Chevron, BP, Royal Dutch, and Total now trade at huge premiums to mid- and small-cap exploration and production stocks. For these large-cap energy names, using their stock to purchase grossly

undervalued companies with significant shale acreage positions makes a huge amount of financial sense. Chevron's proposed bid for Anadarko contemplates using 75% stock, while Occidental's proposed bid is 50% stock. We continue to believe energy names represent huge value, and recommend investors own significant positions in oil-related equities.

Oil markets have slipped back into deficit causing OECD inventories to contract counter-cyclically in Q1. We will discuss these balances and how they influence our thinking for the rest of 2019 in the oil section of this letter. Oil market balances will continue to tighten. In retrospect, the panic-selling low reached back at the end of December 2018 will have represented a significant bottom, similar to when oil bottomed in Q4 of 2001.

We have just completed a huge drilling productivity study of the Bakken, Eagle Ford, and Permian shale basins. In our analysis, we attempt to identify the drivers of drilling productivity to determine how much "Tier 1" acreage remains in each basin. As you shall see, we continue to believe that "Tier 1" acreage in both the Bakken and Eagle Ford shale basins is now almost 50% drilled and production from these fields has likely peaked. Regarding the Permian, we believe that we still have significant "Tier 1" acreage left to drill and production should continue to grow. For those interested in a detailed analysis of the sources of shale drilling productivity, we believe our essay is an extremely important read.

Also, there has been significant interest in the "child-parent" well problem which may have emerged in the Permian basin over the last year. For those unfamiliar with this phenomenon, it was first mentioned during Schlumberger's Q3 conference call last year and again by Centennial Resources CEO Mark Papa during his Q1 2019 conference call. They both observed that new wells drilled (child wells) near older well (parent wells) are not performing as well as originally projected. We have conducted an exhaustive analysis of this potential problem in the Permian and so far, our research is not pointing out a significant issue... yet. For those interested in the "parent-child" situation, please read our analysis in the oil section of this letter. We remain very bullish on oil prices and believe 2019 will see two major unexpected developments. First, demand for oil (which everyone believes will be weak) will for the seventh year in a row significantly exceed expectations. Second, non-OPEC supply outside of the United States will significantly disappoint.

After spiking to almost \$5 per million cubic feet (mcf) in mid-November and then promptly collapsing, North American natural gas markets continued to be weak in Q1. Even with winter weather that was 6% colder than normal, continued strong supply growth put downward pressure on prices. In total, 2.14 trillion cubic feet (tcf) of gas was withdrawn from storage this winter, which is about 100 billion cubic feet (bcf) less than the 10-year average. Increased weather-related demand was more than offset by surging supply. The 2018-2019 withdrawal season looks to have ended during the week of March 22nd with inventories at 1.107 tcf. Not since the "polar vortex" winter of 2013-2014 have storage levels been lower. Normally, we'd be bullish at such low inventory levels; however, as we enter the summer injection season, supply continues to surge. According to the latest data from the Energy Information Agency (EIA), U.S. natural gas production for the three months ending January surged by 13%, almost 10 bcf/day year-over-year. While 2019 demand will be helped by 5 bcf per day of new LNG demand, absent a much hotter-than-normal summer, we believe demand will continue to be exceeded by surging supply. We remain neutral regarding natural gas prices, even with today's low inventory levels.

Base metals were also strong during the quarter. Copper rose 11%, while zinc rose 19% and

nickel rose 21%. Our outlook on base metals has not changed. We believe copper has the best underlying fundamentals both in terms of demand and supply. On the demand side, India continues to aggressively push forward with its rural electrification efforts. As we have written extensively, Indian copper penetration is incredibly low. China has approximately 160 pounds of copper per person installed in their economy whereas India has only 15 pounds installed per person. Our research continues to suggest that India is approaching an important tipping point regarding its copper demand. We calculate that over the next 10 years, Indian copper consumption will surge, putting additional demand on an otherwise tight market. For those interested in a more detailed discussion regarding copper demand, please go to our website and listen to the recording that Adam Rozenwajg made for an O&M Partners “Town Hall” meeting on April 10th. In that presentation, he extensively outlined our viewpoint regarding future sources of copper demand.

Turning to the supply side of the copper market, we will be travelling to the Democratic Republic of Congo (DRC) in mid-May to visit the Kamao-Kakula copper project, being developed by Ivanhoe Mines. The high-grade Kamao-Kakula copper discovery is located on the western half of the DRC copper belt in an area previously thought to be devoid of copper mineralization. If Ivanhoe’s discovery proves that copper mineralization continues as the Congo copper belt tilts westward, this could very well be the most important copper project in the last 20 years. We will try to get a better understanding not only of the Kamao-Kakula discovery but of the potential for future exploration success in this new emerging copper region. Mining companies operating in the DRC are now negotiating with the government on the implementation of new royalties and taxes. Recent changes to both the royalty and tax code could wind up significantly delaying the development of the Kamao-Kakula project and we hope our trip will help us better understand all the issues surrounding these negotiations. Neither of us has visited the DRC since 2006 and we are very excited to be returning to the country. In our next letter, we will discuss all of our observations in great detail and provide an updated analysis of the copper market.

Precious metals had an upward bias during the quarter. Gold prices rose 8%, silver eked out a small gain of 0.3%, platinum rose 7%, and palladium rose 10%, driven by continued hedge-fund buying. Gold stocks continued their upward momentum from Q4, gaining an additional 6%. As we have covered extensively in these letters, we believe a huge precious metal bull market lies in the not-too-distant future. Gold has never been cheaper compared to the global money stock and sentiment indicators (covered in our Q3 letter) have reached levels only seen at the bottom of bear markets. For those investors with no performance constraints, we recommend aggressively accumulating physical gold and silver. For those with performance constraints, we suggest waiting for gold-oil ratio to flash a buy signal. The gold-oil ratio flashed a huge buy signal for oil back at the end of December and oil (and oil-related investments) have significantly outperformed precious metal investments since.

Agriculture markets were extremely quiet in Q1. Grain prices drifted down as the most recent World Agricultural Supply and Demand Estimates (WASDE) data from the USDA showed global grain markets to be in slight surplus. Global grain demand remains very strong except for some weakness in corn related to ethanol-based grain demand. Vastly improved growing conditions in Brazil and Argentina caused the USDA to raise their estimates for global corn and soybean production. As we have often discussed, the global grain bear market (now in its seventh year), is hugely dependent on continued excellent global growing conditions.

Except for the drought here in the U.S. in 2012, global growing conditions have been extremely good for the last 20 years. We have not suffered any sustained periods of adverse weather conditions in any of the world's largest grain growing regions. For example, while the U.S. Midwest suffered a severe drought back in 2012, it lasted only a single year and by 2013 conditions were once again excellent. Europe sustained a serious drought last year. While we don't know for certain if 2019 will see a repeat, as of today the duration of drought conditions has only been one year. By comparison, the great drought that gripped the U.S. Midwest in the 1930s leading to the famous "Dust Bowl" started in 1930 and continued with varying severity until 1940. At the peak of the drought years in 1934 and 1935, Washington DC was actually hit by two large dust storms that originated in the Mid-West, something that is difficult to imagine today. Since 1940, while the U.S. has experienced multiple droughts, they were all short-lived and localized and in no way approached the magnitude of what we saw in the 1930s.

In the agricultural section of this letter, we put forward our belief that we are on the cusp of a major change in weather patterns. We believe global weather patterns are influenced by solar activity and our research tells us we are entering into a long period of declining energy released by the sun. Although it is a controversial topic, we believe it may have huge implications over the coming decade. We discuss sunspots, the sun's magnetic energy, and the historical impact on the Earth's climate. If weather patterns are indeed changing and we are entering into a period of global cooling caused by lower sun-spot activity, then recent periods of extremely good growing conditions could very well come to an end. We disagree with the consensus view that gradually rising temperatures will negatively impact global harvests. In fact, we believe just the opposite: the 70-year rise in global temperatures has been a huge boom for the surge in global grain production. If our research is right, global cooling will produce weather-related problems that could severely impact global grain production.

Today, weather conditions in most grain growing regions are slightly stressed. Here in the United States, the upper Midwest has had excessive rain and snow (Chicago just experienced a record-late snowfall), delaying the planting season; something we will monitor closely. Europe remains extremely dry, and we will monitor whether last year's drought is the beginning of a new long-term trend. If we are indeed entering a cooling phase in global weather, some of the things we should expect to see would be longer winters, later springs, and much earlier fall frosts, as well as periods of excessive moisture followed by period of extreme drought. If weather patterns are changing and the climate is cooling, a huge bull-market in agriculture sits directly in front of us and we plan to aggressively participate.

Uranium prices, which advanced 20% in 2018, pulled back 12% during Q1. Cameco, in their Q4 conference call, informed investors that they had purchased 8 mm pounds of uranium in the open market to cover their forward-sale commitments. They announced they would have to purchase an additional 14 mm pounds throughout 2019 to cover further commitments not met by production. We believe the pull-back in prices was most likely caused by Cameco stepping out of the spot market during Q1. We remain huge uranium bulls and believe a structural change is taking place in the attitude of the "green community" towards nuclear power and its relationship to renewables.

The current state of renewable power (i.e., large instillations of intermittent renewable-sourced power without a "clean" source of backup power) is anything but sustainable. Germany is the poster child for what a renewable world looks like: much higher electricity costs and

more CO2 production. We believe even the “greens” are beginning to understand this and realize that nuclear power must be part of the solution. We will not publish a dedicated uranium section in this letter, in the interest of space and time. Rest assured, we will resume our coverage in the next one.

Oil Markets: Major Developments on All Fronts; Aramco Releases Reserve Details

Oil prices surged during Q1, with WTI advancing by 32% to \$60 per barrel while Brent rallied 27% to \$68 per barrel. During Q4 sell-off, we explained how oil market fundamentals remained very strong despite the panic-selling taking place. Although few agreed with us, we predicted oil prices would recover quickly as we progressed into 2019. Our models told us that last year's rout was caused when the U.S. asked OPEC to boost production to mitigate the impact of looming sanctions against Iran. When President Trump unexpectedly waived Iranian sanctions in October, global oil markets responded with a sell-off not seen since the Global Financial Crisis. After peaking at \$86 per barrel in October, Brent prices sold off by 42%, ultimately bottoming at \$50 per barrel on Christmas Eve. Once OPEC realized they no longer needed to replace embargoed Iranian supply, they announced a roll-back of their production boost in November. Our models told us that the market would once again slip into a persistent deficit as we entered into 2019, inventories would once again resume their declines, and prices would rally. Since we made these predictions three months ago, this is exactly what has happened. During the first quarter, U.S. core inventories drew by nearly 300,000 b/d compared with seasonal-averages and have worked off 50% of the overhang accumulated last year after OPEC boosted production.

Despite the mounting evidence confirming our analysis, investors remain extremely bearish towards oil-related equities. While Brent and WTI rallied between 25 and 30% from their Christmas Eve-lows, oil-related stocks advanced by only half that amount. In our introduction, we explained how certain high-quality E&P companies (not all mind you) are generating real value like never before, despite the common wisdom that the oil and gas E&P “model” is broken” and some investors complain that the sector as a whole has become “un-investible.” While this line of thinking is pervasive, nothing could be further from the truth and we will explain why the fundamentals are more bullish today than we ever recall seeing them. Far from being broken, we think that Tier 1 E&Ps offer some of the best investments in the market today.

Our investment process consists of identifying sectors where investor interest is extremely bearish, valuations are depressed, and our original research tells us the fundamentals have turned positive. Today's oil market meets all of these criteria. The price action over the last several months has certainly been frustrating; however as contrarian investors we get very excited whenever we hear the pundits universally declare an industry “un-investible.” We believe we are nearing an inflection point. The positive fundamentals that have gripped the oil markets since early 2017 have now created value that can no longer be ignored. The recent bidding war that broke out between Chevron and Occidental (with funding provided by Mr. Buffett) for Anadarko is simply another example of this value gap trying to be forced shut.

In past letters, we explained the four pillars of our bullish outlook. First, demand was growing

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much faster than most people believed. Second, conventional non-OPEC production (those outside of the U.S. shale plays) risked slowing materially due to a dearth of new discoveries over the past 10 years. While the U.S. shales would continue to grow, we argued that early signs of exhaustion in both the Bakken and Eagle Ford would leave the shales unable to meet surging global demand on their own. Lastly, inventories would resume their sharp declines in 2019 putting upward pressure on oil prices, absent a rebound in OPEC production. There have been material developments in all four of these pillars over the last ninety days, each with extremely bullish consequences.

First, demand remains extremely strong. The IEA released its 2018 Global Energy & CO2 Status Report on March 26, 2019, stating that global primary energy demand surged last year. Despite the barrage of bearish headlines, total energy demand grew by 2.3% in 2018 – twice the average rate of the previous decade. Every country goes through a period of strong energy demand growth (the S-Curve). The number of people simultaneously going through this period has jumped from an average of 700 million between 1970 and 2010 to over four billion today. The importance of this shift cannot be overstated, and will persist for many years to come.

Furthermore, we believe global primary energy demand will be revised even higher, driven by adjustments to global crude demand. Global oil demand makes up approximately 35% of total primary energy demand. The IEA estimates that global oil demand grew by 1.3 mm b/d or approximately 1.3% last year. According to their latest report, demand softened during Q4 as global economic activity deteriorated. Even though this view was largely echoed in the press, the data suggests otherwise. The IEA estimates Q4 demand averaged 99.6 mm b/d while global supply averaged 101.9 mm b/d implying inventories should have grown by a very large 2.3 mm b/d (consistent with a global economic slow-down). Instead, inventories actually declined during Q4 by 100,000 b/d. Even factoring in “floating storage” (which in our experience usually ends up being revised away as understated demand), missing barrels still reached a record 1.8 m b/d, based on the IEA’s figures during Q4. Longtime readers know we believe these “missing barrels” are actually understated emerging market S-Curve-related demand. For 2018 as a whole, the “missing barrels” averaged 900,000 b/d. If our models are correct and these missing barrels are actually understated demand, then 2018 global oil consumption actually grew by 2.2% to reach 101.1 mm b/d, implying global primary energy grew by 3.0% or nearly two-and-a-half times the average of the past decade. Far from reaching “peak demand,” the world is now entering into a period of sustained accelerating consumption – a period we are calling the “golden age of demand.”

Complicating matters, the dearth of conventional oil discoveries over the last two decades has now started to seriously impact supply. In our past letters, we explained how slowing conventional non-OPEC supply would surprise market watchers as soon as this year. As we first reported back in Q4 of 2017, large conventional oil discoveries have become more and more elusive. Conventional discoveries have lagged production by 170 bn bbl over the past six years, leaving the non-OPEC world susceptible to a more pronounced production shortfall. While “Hubbert’s Peak” is widely viewed as debunked, due to the U.S. shale plays, conventional oil production in the rest of non-OPEC has actually been declining for the past decade. In the spring of 2018, we stated that conventional non-OPEC crude production had declined by 175,000 b/d on average each year between 2010 and 2018 and that these declines were set to accelerate. We explained how both the size and number of new conven-

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tional projects would slow in 2019, making it difficult for conventional non-OPEC production to offset its base decline rate.

The world is still extremely dependent on conventional non-OPEC production, so any sharp decline would have a huge impact on global balances. Over the last six months, we believe we have seen the beginning of such a decline. According to the IEA, non-OPEC production outside of the U.S. and Russia peaked in June 2018 at 32.8 mm b/d and has since declined by 800,000 b/d. (Russia did boost production in 2018, but has since announced that they will curtail supply and so is not a likely source of growth in the near-term.) This decline rate is five times more severe than the average over the last eight years, and comes at precisely the same time as surging demand. Despite the importance of slowing conventional non-OPEC supply, we have not seen many reports referencing it. One of the only executives we have heard sound the alarm is Schlumberger's CEO, Paul Kibsgaard, who confirmed in his most recent quarterly conference call that non-OPEC production outside of the U.S. was slowing dramatically. Conventional non-OPEC production represents 35% of global oil supply and it is now facing substantial challenges after decades of lackluster exploration success. We have warned about this for many years and it is now coming through in the data.

Major depletion issues are now emerging in the OPEC world as well, particularly in Saudi Arabia. During the first quarter, Saudi Aramco came to market with its debut public bond offering, issuing \$12 bn of bonds at a blended interest-rate lower than that of the Saudi Arabian sovereign. While headlines focused on the fact that the deal was more than ten times over-subscribed, we were far more interested in the bond prospectus reserve disclosures. Since 1979, Aramco's reserve reports have been a closely held state secret. Throughout the 1980s, we believe Saudi Arabia reclassified its probable reserves into proved reserves and since then they have held this reported level flat at 260 bn bbl of crude oil despite having produced over 110 bn bbl during that period. We have long argued that Saudi Arabia's reserves were nowhere near the 260 bn bbl they reported. For those who would like to learn more, please read our Q3 and Q4 2018 letters.

In January 2019, Aramco summarized the results of an updated reserve report audited by the highly reputable Houston firm, DeGolyer & MacNaughton. In the summary, Aramco confirmed that Saudi crude oil reserves totaled 263 bn bbl. While this headline appeared on the surface to validate Saudi Arabia's claims, we explained in our last letter that we could not properly assess the reserve reconciliation between starting reserves, production, extensions, and ending reserves without seeing the full report.

After reading Aramco's bond prospectus in depth, we can - for the first time in forty years - begin to answer some of our biggest questions about the Kingdom's oil fields.

Most important, the prospectus confirmed our long-held view that Ghawar, Saudi Arabia's largest field, peaked and has been declining steadily for the past decade. Ghawar was discovered in the late 1940s and formed the foundation of the Saudi oil industry for decades. In 2005 (the last reliable data we have), Ghawar produced 5.0 mm b/d and had cumulatively produced ~55 bn bbl of crude. We fit a "Hubbert Linearization" and estimated that approximately 50% of the field's total recoverable reserves had already been produced by 2005. According to Hubbert's theories, a field peaks once it has produced half of its reserves and so we predicted Ghawar production was about to roll-over. Our initial estimates (made over a decade ago), predicted that production would fall from 5.0 m b/d in 2005 to approxi-

"GHAWAR WILL NOT BE ABLE TO INCREASE PRODUCTION FROM HERE, MAKING ITS 3.8 M B/D 'MAXIMUM SUSTAINED CAPACITY' FIGURE HIGHLY SUSPECT."

mately 3.0 m b/d by 2018. While the Aramco bond prospectus does not list historical production by field, it does disclose both the so-called "Maximum Sustained Capacity" and the remaining reserves for the major fields. Ghawar's maximum sustained capacity is 3.8 mm b/d. Last year, Aramco produced at 85% of its sustained capacity suggesting that Ghawar pumped approximately 3.3 mm b/d, down nearly 35% from its peak of 5.0 m b/d in 2005. This is remarkably close to our original prediction made back then.

We are more convinced than ever that Ghawar will not be able to increase production from here, making its 3.8 m b/d "maximum sustained capacity" figure highly suspect. Ghawar's remaining liquids reserves (including condensate and NGLs) are 48 bn bbl. Given that crude oil represents 85% of Aramco's total liquids reserves, crude-only reserves are likely 40 bn bbl. These reported Aramco reserves need to be adjusted slightly higher however, because they only cover the so-called "concession period" through 2077. Luckily the Aramco prospectus provides the data necessary to make the adjustment. Total "Kingdom" oil reserves (i.e., geological reserves) are 30% higher than Aramco's "Company" reserves (i.e., through the end of the concession period in 2077), suggesting that Ghawar's total remaining oil reserves are approximately 54 bn bbl. As we mentioned earlier, cumulative oil produced totaled 55 bn bbl in 2005 and we estimate that an incremental 25 bn bbl have been produced from the field over the last 14 years. Together, Ghawar's total recoverable reserves total 134 bn bbl of crude, of which 60% has already been produced. As we discussed, Hubbert claimed a field peaks once half its reserves have been produced. We now know this occurred at Ghawar between 2007 and 2010. Production appears to have peaked around that time as well.

Aramco's bond prospectus also confirmed that Saudi Arabia's reserves are concentrated in a very small number of (mostly aging) mega-fields. Five fields (Ghawar, Shaybah, Khurais, Safaniyah, and Zuluf) make up 65% of total liquids reserves. Moreover, three of these fields (Ghawar, Safaniyah, and Zuluf) have been producing for more than 72, 62, and 45 years, respectively. This makes Aramco's reserve base extremely concentrated and vulnerable to technical issues in any of these five fields.

The report also raises as many questions as it answers. For example, under the heading "Responsible and Sustainable Stewardship of Unique Fields," Aramco claims that only 10% of their reserves are more than 60% depleted. As we just discussed, Ghawar is approximately 60% depleted and that field alone accounts for over 22% of Aramco's reserves.

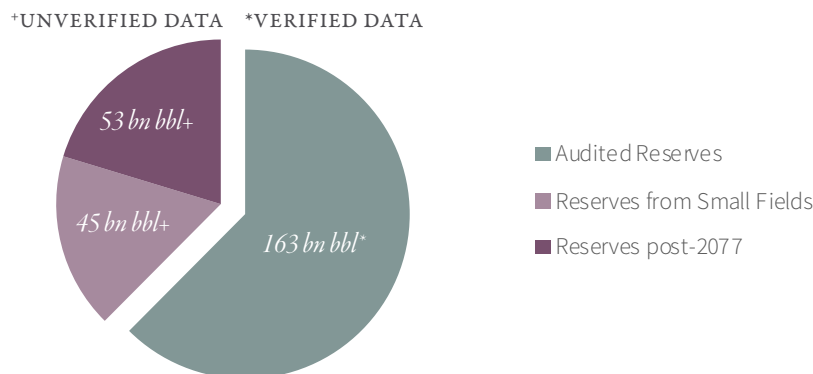
The most glaring anomaly in the Aramco prospectus revolves around the DeGolyer & MacNaughton audit itself. Back in January, Aramco announced that the Kingdom's crude oil reserves were in excess of 260 bn bbl and that this figure had been independently verified by DeGolyer & MacNaughton. In the bond prospectus, the Kingdom's proved crude reserves were in line with this figure at 257 bn bbl for the year ending 2017 as well. However, the DeGolyer & MacNaughton Certification Letter (presented in Appendix C), reveals that their independent evaluation only covered 162 bn bbl of Aramco's crude reserves. Two factors explain the difference between the 162 bn bbl of independently-evaluated reserves and the widely published 260 bn bbl figure.

The first factor is DeGolyer & MacNaughton's acknowledgment that 20% of Aramco's reserves are from fields too small and remote to be evaluated in less than several years. The second factor revolves around the "concession period" discussed briefly above. Aramco's concessions extend through 2077 and as a result DeGolyer & MacNaughton neither included

nor independently verified any reserves expected to be produced after the concession expires. According to Aramco, at the end of 2017 the company's crude reserves (i.e., within the concession period) totaled 202 bn bbl while the Kingdom's crude reserves (i.e., total reserves) total 258 bn bbl. Therefore, while the headlines all strongly suggested DeGolyer & MacNaughton independently verified 260 bn bbl of Saudi Arabian oil reserves, in truth they only verified 162 bn (or 60%) of that amount. An additional 55 bn bbl of reserves are expected (but never verified) to be produced after the concession ends in 2077, while the remaining 45 bn bbl of reserves are contained in fields too small to be independently verified according to disclosures in the Aramco bond prospectus.

"HEADLINES ALL STRONGLY SUGGESTED DEGOLYER & MACNAUGHTON INDEPENDENTLY VERIFIED 260 BN BBL OF SAUDI ARABIAN OIL RESERVES, IN TRUTH THEY ONLY VERIFIED 162 BN (OR 60%) OF THAT AMOUNT. "

CHART 7 Saudi Arabia Crude Oil Reserves



Source: Aramco Bond Prospectus

Even if we included all of the reserves post-2077, total "Kingdom" reserves only add up to 215 bn bbl, not 260 bn bbl. Why is this difference so important? Saudi Arabia has cumulatively produced 150 bn bbl of crude to date. If we assume the Kingdom has 260 bn bbl of remaining crude reserves, then total reserves would equal 410 bn bbl, of which 36% have already been produced. Therefore, if Saudi Arabia continues to produce at ~10 m b/d they will reach 50% depletion (and peak production) by 2034.

However, if we exclude the reserves contained in fields so small and remote they cannot even be counted (let alone developed and produced), then Saudi Arabia's ultimate recoverable reserves are only 365 bn bbl instead of 410 bn bbl. As a result, reserves are 41% produced instead of 36%. Using the same production forecast (10 mm b/d), Saudi Arabia will have produced half of their reserves and experience declining production in less than nine years. (If we remove all of the unverified post-concession reserves, then Saudi Arabia will have produced half of its reserves and see production peak in two years.)

It is important to remember that, according to Hubbert, production follows a bell-shaped curve. As a field approaches the halfway mark, production begins to flatten long before entering its period of outright decline. Given that Saudi Arabia is likely less than a decade away from having produced half of its reserves, we would not expect to see production increase dramatically from here. While we may see periodic production boosts from Saudi Arabia, any such episode will be immediately followed by a sharp curtailment to rest the aging fields as occurred in both 2016 and 2018. We have long argued that Saudi Arabia was exhausting their massive reserve base. With release of the Aramco bond prospectus, we now have several data points that confirm our view.

At the same time as serious supply issues have emerged in both Saudi Arabia and conventional non-OPEC production, the U.S. shales have also started to slow, something we have warned about over the last two years. Over the course of 2018, U.S. shale production grew by nearly 1.7 mm bbl/d or 140,000 b/d per month. For the first three months of 2019, U.S. shale production growth slowed to 42,000 b/d or less than 15,000 b/d per month. This 90% slowdown was widespread: the Permian saw monthly production growth slow 75% while the Bakken and Eagle Ford both saw production roll-over entirely. Furthermore, according to our models, this material shift occurred during a period of time where both rig counts and well completions were actually increasing. How can we explain the slowdown? Production from new wells disappointed and the wells became slightly gassier in the first three months of 2019 compared with 2018. As a result, new oil production per completed well fell by 15% in the Permian, 8% in the Eagle Ford, and 40% in the Bakken, according to data from the EIA's Drilling Productivity Report. Given the high decline rates associated with shale wells, any change in new drilling productivity has a large impact on total production, as we have observed so far in 2019.

In our Q2 2018 letter, we explained why we felt U.S. shale productivity would slow dramatically. Industry veterans such as Mark Papa of Centennial Development Corporation mentioned on various conference calls how the Eagle Ford and Bakken were running out of so-called Tier 1 wells. As operators moved into Tier 2 locations, productivity was expected to slow by upwards of 50%. We believed this trend was being obscured by two offsetting factors enhancing productivity: drilling of longer laterals and using of more proppant in the completion. We argued that as both of these techniques reached their limits, the underlying migration from Tier 1 to Tier 2 wells would come to the fore and productivity would slow.

Our models relied on a series of assumptions, including the impact of drilling longer and larger wells on productivity, as well as the difference between Tier 1 and Tier 2 wells. Furthermore, we relied on field-level completion data aggregated by various sell-side firms. Since we first wrote up our findings, we have embarked on a fascinating research project that we would like to share with you here. The importance of U.S. shale productivity cannot be overstated, so we made the decision to purchase a database of production and completion information covering over 150,000 shale wells. Instead of relying on industry observations and sell-side aggregated data, we could now drill down to the underlying well data itself. What we found confirmed some of our conclusions and challenged others and left us more convinced than ever that U.S. shale productivity will slow going forward.

A well's productivity depends on many features including shale thickness, organic content, pressure gradient, and completion techniques. These features can be grouped into two categories: where in the basin it is drilled (which covers the geological aspects) and how it is drilled (which covers the completion techniques, etc). For our purposes, we sought to build a model that predicted productivity, as measured by six-month cumulative oil production, using location data, lateral length and frac size. If we could successfully build such a model, we could answer countless questions regarding both historical and future productivity trends.

As you might expect, the relationship between these factors is incredibly complex. For example, basins exhibit irregularly shaped "sweet spots" based on changes to the sub-surface geology. Furthermore, different completion techniques have different impacts

depending on other variables such as lateral length and location. It was clear to us that traditional statistical techniques would not be suitable. Instead, we decided to build what is known as a “deep neural network.” While neural networks are excellent at modeling severe non-linearity in the underlying data, they require a large amount of data to be properly “trained,” something we did not have before acquiring our dataset from Shale-Profile. For those curious about the technical details, please reach out to us. We should point out that a few years ago we would not have been able to conduct a similar analysis. Google (among others) has placed its artificial intelligence software into the public domain which, along with the ability to rent high-performance computing power in the cloud, has enabled our research to go forward. As far as we can tell, we have not seen another investment firm do anything similar as it relates to shale productivity. This is all original research. We believe the investment uses are tremendous.

Our model was able to achieve an r-squared of 0.8, suggesting that we are now able to “explain” 80% of the variance in the underlying well results using our model. Our first conclusion was that, given a constant lateral length and completion size, there was a large difference in the underlying well quality in the Bakken, Eagle Ford, and Permian. If you split the results into two groups by quality, the average Tier 1 well was exactly 100% better than the average Tier 2 well in the Bakken, 130% better in the Eagle Ford, and 90% better in the Permian. These results were exactly in line with Mark Papa’s initial observation and a sign we were on the right track. Furthermore, the Tier 1 wells were broadly clustered in several counties that aligned well with what we believed were the basin “fairways.” We also confirmed that over the last five years, the productivity of the average Bakken, Eagle Ford, and Permian well advanced by 85%, 45% and 100% respectively – very much in line with the aggregated data released by the EIA. Lastly, we confirmed that over the last five years, proppant per lateral foot has grown by between 70 and 80% in the three basins, again in line with what we first reported last year.

However, other observations challenged some of our original assumptions. For example, we had based our original analysis on the assumption that a doubling of proppant loading per lateral foot would result in a 50% increase in well productivity. Armed with our new model, we were able to test that assumption and determined it was slightly too high. We now believe that a doubling of proppant loading only results in a 25% productivity improvement. Also, we had been assuming that doubling a well’s lateral length would double its productivity (constant productivity per lateral foot). However, according to our model, drilling productivity per lateral foot declines somewhat as the well gets longer. This makes some intuitive sense as it becomes more and more difficult to stay “in zone” as you drill substantially longer wells.

What surprised us the most revolved around the proportion of Tier 1 and Tier 2 wells being drilled. Our original analyses assumed we had gone from drilling all Tier 1 wells five years ago to drilling upwards of 30% Tier 2 wells today. Instead, we appear to actually be increasing the proportion of Tier 1 wells drilled today. Based on our new model, we now believe operators have gone from drilling 45% Tier 1 wells in the Eagle Ford five years ago to 56% Tier 1 today. In the Bakken, operators have gone from 43% to 67% Tier 1 wells over the last five years. In the Permian the proportion of Tier 1 wells being drilled has gone from 37% to 60%. We originally believed that well quality erosion was being masked by improved well completion techniques. We now believe that well productivity trends have been the result of extreme high-grading across the three basins. The impact of completion techniques is actually less than we originally predicted.

"67% OF WELLS DRILLED IN THE BAKKEN WERE TIER 1, BUT THE REMAINING WELL INVENTORY IS ONLY 48% TIER 1."

These findings are incredibly important because it will simply not be possible to drill the same proportion of Tier 1 wells going forward given the remaining inventory. Last year, 67% of wells drilled in the Bakken were Tier 1, but the remaining well inventory is only 48% Tier 1. In the Eagle Ford, 56% of last year's wells drilled were in Tier 1 locations, but going forward only 45% will be. Even the Permian is developing an issue. Last year in the Permian 62% of the wells drilled were Tier 1 but going forward that will drop to 50%. The net impact on basin productivity as operators are forced to drill their remaining inventory is expected to be 10-15%. While this does not sound like much, given the large embedded base decline rate, a 10% shift in new drilling productivity means the difference between growth and possible decline.

It is impossible to tell exactly how much longer operators will continue high-grading their remaining drilling inventory. While we expect that the more high-grading that takes place today the sharper the slowdown later, we cannot say with certainty when that will happen. However, looking at the Eagle Ford might provide some clues. Of the three basins, the Eagle Ford is the most developed. Between 2015 and 2017, as operators lay down rigs across all three basins, Eagle Ford production fell by 25% while the Bakken only fell by 10% and the Permian actually grew. Last year, Eagle Ford production grew by half the rate of the Bakken and one-quarter the rate of the Permian. We were fascinated to note that the Eagle Ford has also developed more of its Tier 1 drilling inventory than either the Bakken or Permian. Of all their Tier 1 locations, 45% have already been drilled in the Eagle Ford compared with only 20% in the Bakken and Permian. At current rates, we estimate 50% of the Bakken's Tier 1 inventory will be drilled within three years, at which point we would expect the basin will disappoint as seriously as the Eagle Ford does today.

We have also used our model to explore differences between various companies. As we had hoped, two thirds of our E&P investments are in the top quartile of historical drilling productivity. More importantly, they are even higher on the list when considering remaining drilling locations. Asset quality along with valuation are the key features of our investment process and we are now busy updating all of our company models with our productivity results.

Lastly, over the last eighteen months, there has been an extreme anomaly in the E&P investing universe that is very important for investors to understand. Last year, money continued to flow out of natural resource public equity funds at a very fast rate. At the same time however, energy private equity has seen much more favorable investor interest. We find this curious as the fundamental forces driving energy public equity ought to be the same as those driving energy private equity. The only reasons we can think of to explain why an investor would favor one over the other would be if the asset quality were better or the valuation were lower. With the help of our model, we can show that public energy companies are making much better wells than their private counterparts. Over the last three years, public companies' wells are on average 40% more productive than their private counterparts. Moreover, when looking at remaining drilling inventory, public companies maintain their advantage. This makes sense given the fact that the public companies tend to be larger and enjoy access to the best drilling and completion crews, are often better capitalized, and tend to be older thereby enjoying first-mover advantage. Furthermore, the public companies today are substantially cheaper than their private counterparts.

After the severe sell-off during Q4, many of the public E&Ps have not recovered nearly as much as the oil price, leaving them at near-record low valuations. The private companies,

meanwhile, were spared the volatility of the public market panic. We calculate that private equity energy assets are valued approximately 25% higher than public market assets. Given the lack of marketability, you would expect private assets to trade at a discount. We never recall seeing today's dynamic in the past. Unfortunately, energy private equity today is hard-pressed to take advantage of this discrepancy because they have already deployed the bulk of the capital they raised over the past several years. If anything, energy private equity is relying on the public companies to exit from their investments – something we believe will be difficult given the valuation dislocation. We do not think there is anything inherently “bad” about energy private equity per se, but think it is far too expensive today relative to public equities. As we wrote in the introduction, the best of the E&P companies today are compounding capital at a very healthy rate as they develop their best-in-class asset base. The fact that they are hated in the market creates an opportunity for value-minded investors.

Precious Metals: The Impact of Central Banks

As our readers know, we believe a huge bull market in precious metals sits directly in front of us. For proof, we look no further than the April 22, 2019 *Bloomberg Businessweek* cover, the significance of which we discussed in our Introduction. *Businessweek's* August 1979 cover story, “The “Death of Equities,” told how inflation would remain an intractable problem and hard assets would continue to outperform financial assets. While that *Businessweek* cover story is best remembered as a great contrarian signal to buy financial assets, it was also a great contrarian signal to sell those assets that benefitted from rising inflation. Only five months after that publication, gold and silver (having enjoyed huge bull markets for the previous nine years), both spiked in a spectacular parabolic blow-off and then crashed. Both metals entered into huge bear markets that ended some 22 years later.

On the flip side, a huge buy signal for precious metals occurred when the *Financial Times* ran its famous cover story “The Death of Gold” back in December 13, 1997. The subtitle read: “Gold has fallen from grace and is now a mere metal and a bad investment.” Although the cover story did not coincide with the exact bottom of the gold bear market (that occurred three years later), buying gold on the publication date, at \$285 per ounce, turned out to be an excellent entry point.

We believe the rally in gold that started back in the early 2000s, which took gold from \$260 to \$1,900 per ounce, was only the first of a multi-stage bull market. Although gold is thought of as an inflation hedge, the last bull move in gold from 2000 to 2011 occurred during a largely deflationary period. If the April 22, 2019 *Bloomberg Businessweek* cover story “Is Inflation Dead” is the contrarian signal that inflation is indeed about to return with a vengeance, then gold investors have another compelling reason to begin accumulating precious metal investments.

As opposed to the precious metal bull market of the 1970s, last decade's bull market took place with little in the way of speculator activity. While there was some hedge fund buying (through physical metal ETFs) between 2008 and 2011, most of the buying came from Indian and Chinese buyers, both of whom bought in an extremely orderly way. The 1970s precious metal bull market, in contrast, was driven by Western speculators (the most famous being the Hunt brothers) and was characterized by multiple periods of frenzied activity.

Why was the 1970s bull market characterized by huge speculative activity while the 2000s

saw relative speculator disinterest? We think the answer is simple: inflation. In the 1970s, inflation was a prime motivating factor. Ever-rising inflation created a huge urgency for investors to increase their precious metals holdings, The 2000s precious metal bull market, on the other hand, took place during a period of relatively benign inflation. We believe this lack of inflation explains why gold rose seven-fold last decade in such an orderly fashion. Given declining inflationary pressures, investors felt little rush to become involved with precious metals.

"IF WE ARE RIGHT THAT THE *BUSINESSWEEK* COVER STORY SIGNALS THAT INFLATION WILL ONCE AGAIN EMERGE AS A HUGE PROBLEM IN THE NEXT SEVERAL YEARS, THEN THE NEXT LEG OF THE PRECIOUS METAL BULL MARKET WILL BE CHARACTERIZED BY HUGE AMOUNTS OF SPECULATIVE ACTIVITY, JUST LIKE WHAT HAPPENED BACK IN THE 1970S. "

However, we believe that this is all about to change in the next several years. The famed newsletter writer Richard Russell would remind his readers that “there is no fever like gold fever.” If we are right that the April 22, 2019 *Bloomberg Businessweek* cover story signals that inflation will once again emerge as a huge problem in the next several years, then the next leg of the precious metal bull market will be characterized by huge amounts of speculative activity, just like what happened back in the 1970s.

In previous letters, we have spent considerable time outlining various valuation scenarios for gold that produce price targets often greater than \$10,000 per ounce. While today these price targets seem outlandish, if inflation were to reemerge as a problem in the U.S. economy in the next several years, we believe these price targets will be easily achieved.

The last remaining bearish data point continues to be the relationship between gold and oil. We have studied the relationship between gold and oil going back 160 years and observed an interesting relationship between the two (please review our 3Q 2018 Letter for extensive historical discussions of the “Gold-Oil” ratio). Whenever the gold-oil ratio approaches 30x (i.e., one ounce of gold buy 30 barrels of oil), oil is undervalued and should be bought. Whenever the gold-oil ratio approaches 10x (i.e., one ounce of gold only buys 10 barrels of oil), gold is undervalued and should be bought.

CHART 8 Gold-Oil Ratio



Source: Bloomberg

As you can see from the chart above, the gold-oil ratio fell below 16x last October for the first time in four years and gold began a three-month period of huge outperformance versus oil. However, with gold having advanced almost 15% and crude falling almost 45% in Q4, the gold-oil ratio hit 30x, once again suggesting that oil should outperform gold -- exactly what occurred in Q1. Today the ratio sits a little below 20x, signifying that neither gold nor oil is dramatically undervalued nor overvalued relative to each other.

"GIVEN THAT CENTRAL BANKS HAVE NOW TURNED FROM LARGE SELLERS OF GOLD INTO LARGE BUYERS OF GOLD, IT MAY BE IMPOSSIBLE FOR THE GOLD-OIL RATIO TO FALL ONCE AGAIN TO 10X"

In the past we said that we would like to wait for this ratio to approach 10x before significantly adding to our precious metal investments. Historically a ratio below 10x signaled an excellent time to make gold investments. However, we have been rethinking that stance. During the late 1990s and early 2000s, an ounce of gold bought 10 barrels of oil many times. However, this period was characterized by large-scale central bank selling which put huge downward pressure on the gold price.

Central banks turned into huge sellers of gold by the mid 1990s. From 1999 to 2008, central bank sales averaged almost 500 tonnes per year— a significant amount of gold considering global mine supply only averaged about 2,500 tonnes per year during that period. However, starting in 2009, central banks flipped in their behavior, and became large accumulators of gold. For example, between 2011 and 2017, central banks purchased over 500 tonnes of gold per year and in 2018 this accelerated to 650 tonnes.

Given that central banks have now turned from large sellers of gold into large buyers of gold, it may be impossible for the gold-oil ratio to fall once again to 10x -- the level that historically signaled gold undervaluation and a huge buying opportunity. Is a gold-oil ratio of 15x today equivalent to a ratio of 10x previously? The ratio hit 16x last October using WTI oil prices and 14x using Brent, before gold promptly rallied, lending some credence to this observation.

While there is no correct answer, given the huge gold bull market that sits in front of us and the incredibly strong contrarian signal provided by the *Bloomberg Businessweek* cover story regarding inflation, we are beginning to think we should raise our gold-oil “buy” signal up from 10x. Over the last four years, gold has been going through a massive corrective phase and we have largely sat on the sidelines as the gold price traded sideways. However, if the gold-oil ratio were to trade back to 15, we would be inclined to add to precious metals investments.

Overall interest in precious metals markets remains weak. Based on strong premiums to physical prices, gold demand from both China and India remains healthy. However, Western investment demand remains bearish. Physical gold ETFs liquidated gold in Q1, having now liquidated most of the gold they accumulated during Q4 of 2018. Physical silver ETFs did not follow the behavior of physical gold ETFs over the last six months. They persistently liquidated silver in Q4, and this behavior continued into January. Liquidations stopped at the end of January, but we have seen little accumulation take place since then. Western investment in silver remains extremely low. We have always believed any upcoming gold bull market will be foreshadowed by unusual behavior in the silver market - for example, a huge and persistent accumulations of physical silver in the ETFs. However, at this point, we see little activity in the silver markets that would indicate any sort of Western buying interest.

We recommend that investors with no performance constraints begin to accumulate precious metal investments. For those operating under performance constraints who wish to try to time the start of the upcoming gold bull market, we advise waiting until the gold-oil ratio (presently at 20x), approaches 15x.

Agricultural Markets: What Sunspots Mean for Global Growing Conditions

One of the great arguments put forth by a huge number of economists, prominent money

managers, scientists, and politicians is that global warming will massively disrupt global weather patterns and negatively impact global agricultural growing conditions. Rising temperatures, extreme droughts, extensive flooding, and rising sea levels are all expected to result in long stretches of failed harvests, ultimately leading to higher food prices, increased scarcity and, in some instances, even global famine and severe societal stress. Some prognostications go so far as to predict widespread food shortages that could very well undermine the future of humankind. One must often resist the urge to crawl back into bed after reading the editorial and op-sections of *The New York Times*.

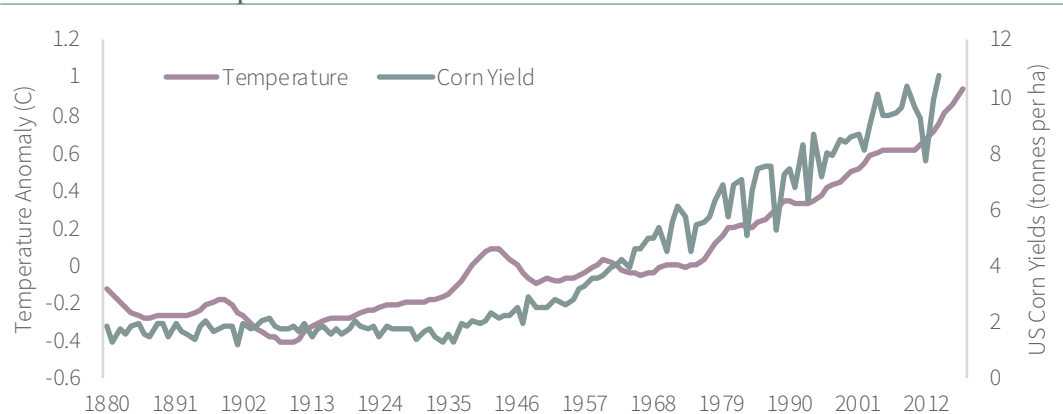
"AS THE WEATHER HAS BECOME WARMER AND WARMER OVER THE LAST 70 YEARS, THE GLOBAL GRAIN HARVEST HAS BECOME BIGGER AND BIGGER."

For all the talk of an impending global weather-related food apocalypse, a careful perusal of data over the last 70 years brings up a startling observation that almost no one has either noticed or chosen to point out. As the weather has become warmer and warmer over the last 70 years, the global grain harvest has become bigger and bigger. This trend has continued all the way up to the last five years, including last year's harvest.

As you can see in the chart below, the last 80 years have enjoyed an incredible bull market in U.S. corn yields. After stagnating at around 25 bushels per acre for almost 70 years, corn yields (and grain yields, in general) began a steady and consistent surge that continues today. After bottoming in the Dust Bowl during the Great Depression, corn yields in the United States have now risen an impressive seven-fold. The generally accepted explanations for the stupendous rise in yields are simple. The advancement of hybrid (and now genetically modified) seed genetics combined with large increases in fertilizer applications led to a global surge in grain production. This increase has allowed the world's surging population to be fed at ever-lower prices. While the impact of seed genetics and increased fertilizer applications cannot be overstated, what if another factor was at work helping to push up grain yields over the last 70 years?

"WHAT IF IT TURNS OUT THAT ONE OF THE MOST IMPORTANT TRENDS TO POSITIVELY AFFECT GLOBAL GROWING CONDITIONS OVER THE LAST 70 YEARS HAS ACTUALLY BEEN THE RISE IN GLOBAL TEMPERATURES"

CHART 9 Temperature & U.S. Corn Fields



Source: NASA, USDA, FAO

Although the relationship might be spurious, one cannot help but notice that the surge in U.S. corn yields began just as global temperatures began their 20th-century rise. Although it is impossible to disaggregate the impact of genetics, fertilizers, and weather on surging growing productivity, we want to at least put forward an idea that, while extremely controversial, might be an important variable in the surge in global yields. The consensus opinion is that global warming (a trend that you can clearly see in the chart below) will be extremely detrimental to the global growing conditions.

What if it turns out that one of the most important trends to positively affect global growing conditions over the last 70 years has actually been the rise in global temperatures? Perhaps

the warming of the global climate has actually helped to produce the most advantageous crop growing conditions the world has seen since the Medieval Warming Period one thousand years ago (a period warm enough for the Vikings to carry out an extensive farming existence on Greenland and on the northern tip of Newfoundland).

While it may sound unorthodox, we would like to point out that no one has even dared ponder what the effects of a global cooling period would have on crop conditions. If the warming of the past 70 years coincided with surging crop yields, could a period of cooling (however unexpected) have the opposite effect?

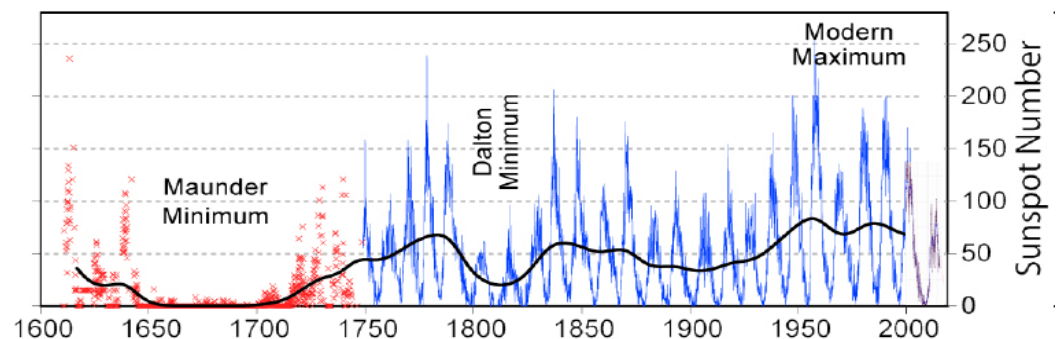
We are putting forth two very controversial ideas. Before we begin, we would like to state that we are not trying to weigh in on the impact of CO₂ to global warming. Instead, we would like to draw attention to a completely different factor impacting global temperatures. What's remarkable about this other factor is that no one has paid any attention to it whatsoever. We are contrarian investors and pride ourselves on trying to identify trends that few others have considered. While we admit that the science is far from certain, the implications of what we are about to discuss are important enough that we believe the investment community needs to, at the very least, consider it.

We believe changes are now taking place on the sun's surface that could ultimately usher in a significant shift in global weather patterns over the next 20 years. If the world were to enter a period of cooling for any reason, our research tells us that global growing conditions could become much more challenging and that the trend of relentlessly advancing crop yields we have experienced for almost four generations could reverse.

Scientists, astrophysicists, and meteorologists all carry on a vigorous debate regarding the impact on terrestrial weather of the sun's changing phases. There is no agreement on the subjects we are about to discuss, so please read to what we have to say with an open mind. All we ask is that you decide for yourself. Stories of the financial difficulties faced by farmers today abound. Low grain prices have reduced profits margins to zero while debt financing requirements continue to grow. If we are right about the upcoming change in global weather conditions, the seven-year bear market in grain prices could end in the not-too-distant future causing agricultural-related investments to surge.

Although common wisdom suggests the energy emitted from the sun is extremely stable, nothing could be further than the truth. For reasons not fully understood, the sun undergoes multiple cycles that are repeated over and over. The best-known cycle is the eleven-year sunspot cycle. In 1843 German astronomer Heinrich Schwabe published a paper describing how sunspots ebb and flow according to a cycle that repeats itself every eleven years.

CHART 10 400 Years of Sunspot Observations



Source: Wikipedia/ Robert A. Robde

What causes this eleven-year sunspot cycle? Most solar astronomers believe the sun's magnetic field reverses its polarity every eleven years, causing the development of sunspots to peak and trough in a repeatable cycle. Scholars have observed 24 cycles since 1750. As you can see from the chart above, the trends are easily discernible. The most notable period is the Maunder Minimum. This period was characterized by minimal sunspot activity and occurred between 1645 to 1715 in conjunction with the second half of the Little Ice Age, a period of intense cold which lasted from approximately 1300 to about 1850.

Sunspot activity rebounded in 1750 before exhibiting another period of weak activity between 1790 and 1830, a period known as the Dalton Minimum. Similar to the Maunder Minimum, the Dalton Minimum coincided with the last great surge of extreme cold temperatures that characterized the Little Ice Age. The last "Frost Fair" held in London on the frozen River Thames was in 1814, during the middle of the Dalton Minimum cycle.

The latest trough in sunspot activity occurred at the turn of the 20th century. Since then we have experienced an extended period of high sunspot activity, peaking first in the late 1950s and again in the 1990s. This period, now commonly referenced as the Modern Maximum, broadly coincides with the global warming cycle which also began at the turn of the 20 century and continues today.

The 24th sunspot cycle began in 2008, peaked in 2014 and has most likely ended as we write today. Sunspot activity has declined significantly over the previous two cycles. Although open to debate, many sunspot observers believe that sunspot-cycle 23 will have ended up being the last sunspot cycle of the Modern Maximum cycle.

For reasons that are not fully understood, it does seem that sunspots go through various repeating cycles (including nested cycles within cycles) of varying duration. For example, it is now commonly accepted that the sun produces a geomagnetic storm every 27 days that impacts short-term sunspot activity.

Scientists have gone back and studied ice cores and tree rings in an attempt to correlate them with sunspot activity. These scientists now believe the sun also exhibits much longer cycles which produce periods of high solar magnetic output (corresponding to many sunspots) and low solar magnetic output (corresponding with few or even no sunspots). The Modern Maximum and Maunder Minimum are examples of the former and latter, respectively. Some scientists now believe they have identified an approximately 85-year cycle (the Gleissberg Cycle), a 200-year cycle (the Suess-DeVries Cycle), and a 2,400-year cycle (the Hallstatt Cycle). There is mounting evidence indicating we are entering a potential period of very low sunspot activity, caused by a confluence of overlapping Gleissberg and Suess-DeVries Cycles. If this is indeed the case, the impact on the earth's climate and by extension growing conditions could be material.

What is a sunspot and how does it affect the earth's weather? A sunspot is an area on the sun's plasma surface that forms when intense magnetic activity is taking place. Why they form is still unclear, but we now know by using sophisticated measurement techniques that the areas surrounding a sunspot exhibit strong magnetic activity caused by huge magnetic storms known as "coronal mass ejections."

More sunspots on the sun's surface equates to more magnetic energy being released. One of the more intriguing phenomena noticed by scientists studying 700 years of data was first described by solar astronomer Jack Eddy in a 1976 paper in "Science." According to these

observations, periods of low (or even non-existent) sunspot activity have been associated with periods of global cooling. The most famous examples of this potential relationship were the Maunder and Dalton Minimums discussed earlier when decreased activity was associated with the coldest periods of the Little Ice Age. To this day scientists and climatologists debate the impact of solar cycles and magnetic energy on global weather patterns, although few deny that these minimums did indeed coincide with periods of intense terrestrial cooling. Although still only partially understood (and vastly complicated by the fact that both periods saw surges in volcanic activity -- another important factor contributing to periods of global cooling), it is a fascinating coincidence.

Scientists now believe that during periods of low sunspot activity when magnetic activity is low, the sun's shrunken magnetic field fails to deflect cosmic rays (high-energy radiation) coming from other parts of the galaxy. These rays not only produce carbon-14 (which can be identified through tree-ring analysis), but also ions which enhance the formation of aerosols and ultimately clouds in the earth's atmosphere. Conversely, periods of high sunspot activity and increased magnetic output serve to deflect cosmic rays, ultimately hindering the formation of clouds.

Thus, some scientists believe that periods of low sunspot activity will result in increased global cloud cover (which could have cooling effects) while periods of high sunspot activity could result in less global cloud cover (which could have warming effects). Scientists continue to vigorously debate the sun's influence on global weather patterns. While the theories we just described have become more accepted, the magnitude of their influence on global climate remains highly debated.

Confusing this whole issue has been the fact that the two most recent periods of reduced sunspot activity have also been associated with periods of significant volcanic activity. For example, during the Dalton Minimum, Mount Tambora erupted in 1815 which is believed to be the most powerful volcanic eruption in recorded history and cause of the famous "year without a summer" in 1816. Although not officially recorded, scientists also believe that the Long Island volcano in Papua New Guinea erupted spectacularly in approximately 1660, right in the middle of the Maunder Minimum. Through studying ice and sediment cores and dead vegetation, scientists also believe the world experienced four massive volcanic eruptions between 1275 and 1300, which coincided with the beginning of the Sporer Minimum (and first extremely cold spell of the Little Ice Age). This era marked another period of extremely low sunspot activity between 1400 and 1520, now confirmed by the carbon-14 testing of tree rings.

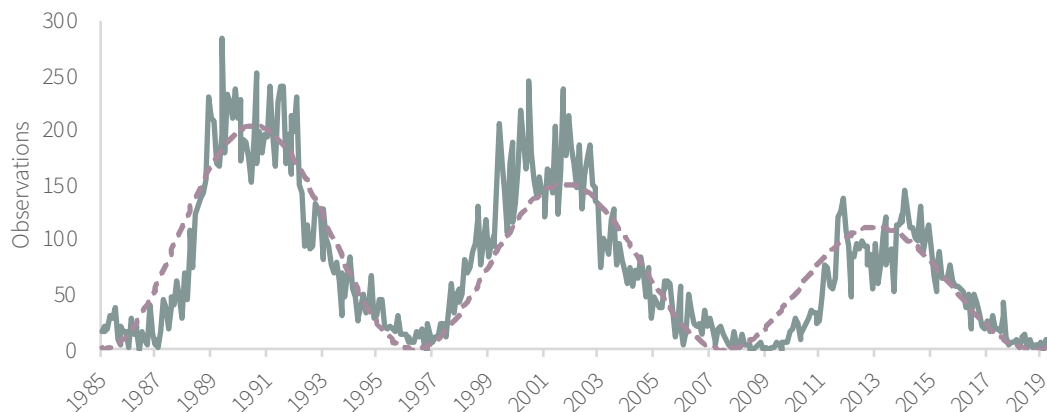
It now looks like the three coldest periods of the Little Ice Age occurred not only during periods of extremely low sunspot activity, but also extremely active volcanic activity. Is there a link between sunspot activity and volcanic events? Although we do not have enough time to discuss this subject (which is hotly debated among scientists), we want you to keep an open mind on the subject. There are many scientists that think a link might exist. If it does, we could see a potential surge in volcanic activity in the next 20 years which could add significantly to the forces at work to cool the global climate.

As you can see from Chart 10, the Modern Maximum solar cycle seems to have peaked during sunspot-cycle 22, which ended in 1996.

Sunspot cycle-23 and the just completed cycle-24 each had peak levels far below those of

the previous cycles. Cycle-24 was unique in other ways as well. The upswing in sunspot activity during cycle-24 occurred very late in its cycle and the activity was very weak. Although we do not have enough time in today's letter to discuss all the potential reasons for this weakness, there seems to be some consensus that the weakening of the sun's magnetic field is responsible for the most recent decrease in sunspot activity.

CHART 11 Sunspot Cycles 22-24



Source: SILCO, Royal Observatory of Belgium

Just as the sun goes through its observable 11-year sunspot cycle, it also goes through long periods of magnetic field strengthening and magnetic field weakening that is less well understood by the solar community. Over the last 20 years, many solar observers believe that we have seen a significant weakening of the sun's overall magnetic field strength. Given that sunspot cycles and related magnetic field strength seem to go through approximate 85-year and 200-year cycles, we are now almost right on schedule for a potential repeat of the Dalton and possibly the Maunder Minimum periods.

We believe we are potentially entering a significant period of decreased sunspot activity, with resulting severe weather implications.

We are just starting sunspot cycle-25. On November 19, 2018 a small sunspot appeared in the sun's northern hemisphere before quickly disappearing. Its magnetic field was reversed, suggesting that the 25th sunspot cycle had now started. If increases in the solar activity at the beginning of the 25th cycle appear slow, we will have confirmation we are entering into another cycle of weak sunspot activity that could last for decades.

The subject of sunspot activity is extremely complicated. Its impact on the earth's weather is even more so. Over the last 120 years, we have been in a period of extremely high sunspot activity which would very well have been contributing to the simultaneous warming of the climate. Although its impossible to separate the impacts from increases in both sunspot activity and atmospheric CO2 concentrations, one cannot help but notice that a large part of the warming trend over the last 120 years took place previous to 1950, a period where CO2 concentrations in the Earth's atmosphere remained relatively low. If we are now entering a lengthy period of reduced sunspot activity, it is possible that the global warming trends of the last 120 years could reverse as well.

Although never discussed in the popular or financial press, global cooling trends (as opposed to warming) have historically been associated with sub-optimal growing conditions -

something very different from what the world has experienced over the last 70 years. If we are right and the weakness of the last sunspot cycle (cycle-24) is the beginning of a long period of sunspot weakness, we could very well see many years of suboptimal growing conditions emerge as the global climate cools.

The end result will produce a massive bull market in agriculture markets as strong grain demand collides with weather-related constricted supply. The sunspot cycle and its potential impact on the earth's climate is a subject that is vigorously debated in the scientific and meteorological community. We will continue to monitor this fascinating subject and the debate that surrounds it, updating our readers as new observations, information and opinions emerge. If we are correct in our analysis, the great bear market in grains is about to end and a huge new bull market is about to start.