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The Four Horsemen of the Investment Apocalypse Pandemic, War, Corruption, and Climate Change

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"For every bad, there is a worse"

Thomas Hardy

Introduction

While the world continues to struggle with the impact of the coronavirus pandemic, investors need to remain cognizant that other thematic effects can be vastly influential on investment outcomes in both the near term and the long term. Of our four themes, pandemic and war are sufficiently violent and episodic (hopefully) as to dominate investor thinking in the moment. The other two themes, corruption and climate change affect investment outcomes in a slow acting, but persistent fashion that is often too subtle to be captured by a conventional risk assessment. Much like the fable of the "tortoise and the hare", it is unclear which of these thematic effects will ultimately win the race for greatest influence on global investment outcomes. *While focused on the coronavirus as the matter at hand, global investors must be prepared to address all four.*

We must consider two broad concepts about investment risk management. Different investors and investment agents (i.e. asset managers) do not agree how risk is defined. Some asset owners may consider risk in terms of absolute loss of the value of the portfolio assets. Pensions may view risk as the inability to earn sufficient long-run returns to meet their actuarial expectations. Most asset managers see risk as the potential to underperform some mandated benchmark index. Implicit in benchmark relative risk assessment may be *an unhelpful indifference* to absolute risk, as described in Roll (1992).

Whatever risk may be, *it is in the future.* While financial markets may have experienced period to period volatility in the past, economic risk can only exist in the future. Risks associated with either rare extreme events or slow persistent effects may not be foreseeable from measures of financial market volatility. Investors are really facing a situation akin to the residents of the ancient city of Pompeii where prosperity came to an abrupt halt in 79 AD, but even then the residents of Pompeii were not ignorant of the risk associated with the local volcano. The potential for *rare* extreme events of any kind is routinely ignored by financial institutions. How to address this critical omission was pointed out in *Why Getting Risk Right is Wrong* by diBartolomeo (2018).

A recent Bloomberg article citing Johannes Borgen[1] is an interesting example. The author discusses recent pronouncements by the Swiss Financial Market Authority, The essence of the FINMA position was that since the pandemic was not foreseeable in a traditional bank "Value at Risk" model, any realized losses which exceeded the model expectations for losses would be ignored for the purpose of ongoing bank capital requirements.

The perverse logic of this argument relies on the deficient mathematical properties of VaR as a risk measure. If you are measuring losses on a daily basis, the likelihood of an extreme negative event occurring *on a particular day* is extremely small, so it follows that at the 95% or 99% confidence interval such *massive potential losses can be ignored.* This is like Pompeii residents saying the risks are low because *it is unlikely that the volcano will erupt today.* Of course, what matters is not the daily likelihood of the event but *rather the cumulative likelihood for as long you are exposed to the source of danger.*

Let's consider the period from 1900 to 2020, a period of 120 years. During that period there were at least five global events which could have entirely destabilized financial markets (World War I [1914-1918], Spanish Flu epidemic [1918-1919], Great Crash and Depression [1929-1945], World War II [1941-1945], Global Financial Crisis [2007-2009]), yielding a probability of some kind of "large" event around 4% per annum. We assume that the investor holds a portfolio with volatility at 10% under typical conditions, but due to the potential for rare, large events there is a 2% annual probability of a "tail event" with a 90% loss. Using the method of the Cornish and Fisher expansion (1938), we obtain the economically equivalent annual portfolio volatility which *more than triples from 10% to over 33%.*

Regulators may choose to take the view that banking risk is really about what happens in the "ordinary course of business," and that extreme events will be separately addressed through the intervention of government. We would argue that it is ill advised for investors to assume a similar ignorance of tail risk and therefore must make the effort to incorporate the potential for rare but extreme events into risk assessments.

Investor Response to Information

Wars and pandemics represent massive flows of information to investors. A lot of research on financial markets has argued that financial markets are more volatile than is economically justified by real world events. This overreaction is often ascribed to human influences such as "fear," "greed" and "cognitive biases." While it is debatable whether investors do or do not overreact to actual events, *no one ever argued that investors are ignorant of real world events.*

The classic view assumes that investors formulate expectations about receiving returns on a future investment (i.e. cash flow) and then algebraically discount the expected future cash flows to present value. There are two parts to the exercise. The first is to formulate expectations of future cash flows. For some assets like Treasury bonds, the expected cash flows are essentially certain, while for another investment such as a "start-up" technology company, the future cash flows (earnings) expectation would be that earnings will grow in the future, but that expectation will be highly uncertain. Financial theory says that investors demand a higher return from risky investments so they use a higher discount rate in making their determination of present value.

A somewhat more sophisticated view of asset pricing is that in setting discount rates investors actually consider three components. The first is what rate of return they could get without risk (the time value of money). The second is that they demand an additional return (an increase in the discount rate) which is proportional to the risk of the investment. It should be noted that while there is only one true risk (uncertainty of future outcomes) for an investment, investors may disagree as to their perception of the degree of that risk, so different investors will have different discount rates and come to different conclusions about asset value even when there is no disagreement regarding future cash flows.

Brown, Harlow and Tinic (1988) argue for a third component to discount rates. This work asserts that investors set higher discount rates for investments they understand poorly and set lower discount rates for investments they feel are well understood. Under the extreme conditions of war or pandemic, the uncertainty of global circumstances implies that investors will demand very high returns on investments not judged to be risk free. For investors the old adage "*No News Is Good News*" has an economic basis.

Pandemics

The current coronavirus pandemic represents an unprecedented challenge to all investors. As of late May 2020, the global situation remains deeply uncertain and subject to change in conditions by the day. In the current atmosphere of ongoing crisis investors need a logical rather than emotional basis for their actions. Humanity has survived several incidents that were even more extreme (World War I, 1918 Spanish Flu Epidemic, World War II).

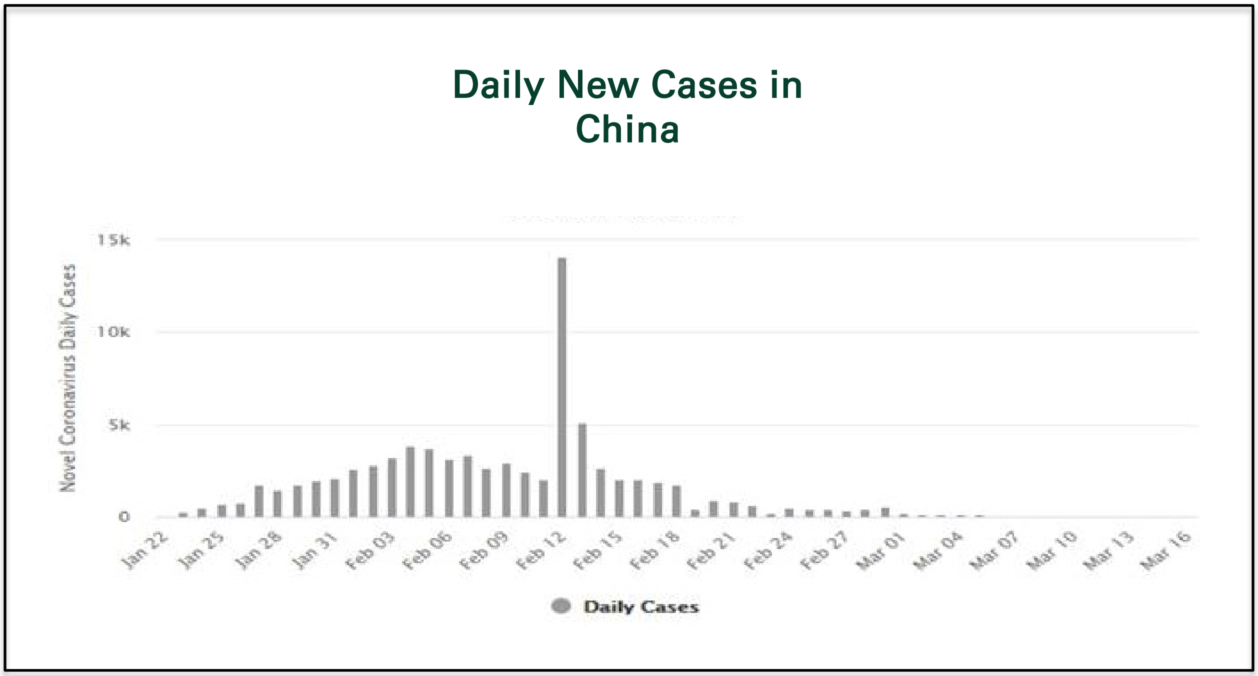
The worst-case scenarios for global coronavirus mortality are certainly unimaginable as a human tragedy. However, in the course of the twentieth century estimate of the worst case was that the entire world ignores the pandemic *in which everyone in the world becomes infected with the coronavirus,* leading to mass mortality of around 60 million.

The estimate of 60 million deaths reflects the fact that the 3.4% mortality rate (March 3, 2020 estimate of the World Health Organization) is highly skewed to an elder population which is large in the countries impacted to that date. For example, the United States is about 4.3% of the world population but about 12% of the world population over age 65. There are approximately 815 million people 65 and over in the world or about only 10.5% of the total population.

While terrifying, the 60 million casualty estimate is about .8% of the current world population. Although casualties of war are hard to tally with precision, that figure of .8% is around the higher end of the estimated range for *each* of the eight plus years of the World Wars. Adding in the massive toll (median estimate 35 million) from the Spanish Flu epidemic of 1918 the abnormal mortality for that year was about 1.9% of the then global population.

To summarize the developments subsequent to mid-March, we can simply say that the best-case scenarios have gotten much worse, but the worst-case scenarios have gotten much better. Put simply, the process of slowing the spread of infections in Western Europe and the United States has taken much longer than in the reported data on countries earliest to be affected, China and South Korea (see Exhibit 1).

Exhibit 1



Let's try to put the coronavirus emergency into context. *By early May 2020, the death toll stood at about 250,000, but we estimate the total number of deaths globally at about 26 million (old age, other illnesses, traffic accidents) over the same period.* The *current impact of the virus* on global mortality has been small at about 1% of all deaths, though the figure has exceeded 50% in a few cities at the respective local peaks of the crisis.

On the less negative side, *almost* all the countries where the pandemic has infected large numbers of people to date are now reporting declining numbers of new infections and stable or declining numbers of deaths. In some countries, sporadic spikes in new infections reflect increased rates of testing which results in a counterintuitive but positive sign. Finding persons who are infected implies there are fewer people "infected but unaware" (who are most likely to spread the infection).

Even stable numbers of new cases implies an end to an *exponential* growth process that could have created tens of millions of deaths if left unchecked. For example, a US Center for Disease Control estimate of the "worst case" for US mortality was 1.7 million deaths as of late February. This horrific number was later increased to 2.2 million in a separate analysis that assumed that only 50% of the American public would abide by "social distancing" orders. Luckily, the rate of US public compliance appears to be well over 90% nationally.

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In early May, many US states joined some European and Asian countries in loosening "lockdown" restrictions. Subsequently, the widely cited Institute for Health Metrics and Evaluation[2] model was updated to include an expected increase in infections associated with greater societal mobility. The upper bound for expected US mortality from this model has increased to 175,000, less than 12% of the CDC worst case of February.

From a human perspective, the vast majority of *risk* is how great the loss of life would be if the virus is left completely unchecked and how soon. At a geometric growth rate of 8% per day, the entire world population would be exposed in approximately four and a half months.

In **Appendix 1**, we present a simple "first order" model for tracking the pandemic. For a detailed discussion on estimation of the model parameters, see diBartolomeo (2020). This model is not intended to compete with forecasts arising from public health authorities, but rather to frame the problem in a way that is transparent to financial rather than medical professionals so that the output can be can easily integrated into their investment decision making. Many parameters of the pandemic model remain highly uncertain and the available body of statistical data[3] (as illustrated in **Exhibit 1** above and **Exhibit 2**) continues changing from hour to hour.

Exhibit 2

Financial Impact of "Rapid Risk" Events

Both pandemics and wars share the common theme of *widespread death*. If investors are similarly impacted by risk mortality in both cases, we can use the historical record to be informative of both. Our first hypothesis is that long term financial market returns will negatively correlated with periods of unusually high mortality. Our second hypothesis is that the effects of war on bond markets will be particularly acute. Wars are expensive driving up bond yields, losers in war can't pay, and there is no "upside" for lenders even if their borrowers win.

For financial market returns, we examine global value-weighted index values for equities and bonds calculated in US$ from the Dimson, Marsh, Staunton (2014) dataset. They include all countries with traded markets between 1900 and 2010. The data is not survivorship biased as countries that went to zero market value are included appropriately. For the measure of global geopolitical conflict, we created a proprietary data set. Our metric is "deaths by conflict" globally year by year as percentage of world population (32 major events). We included high/low and median estimates for each event. The events included all wars, civil wars, genocides and induced famine (deprivation of food aid) even in countries where there were no financial markets. For conflict events lasting longer than one year (e.g. World War II), we allocated linearly across the conflict years, so 20% of deaths would appear in each year for a five year event. We break our sample period into eleven- decade long periods (all statistics have been adjusted for small sample bias).

We start the analysis with a simple Ordinary Least Squares regression model where market returns are the dependent variable and our mortality metric is the independent variable. Depending on whether you use the "high," "median" or "low" estimate for conflict, the correlation to the global equity market is between negative 30% and negative 38%, but not statistically significant with only 11 data points. For global bond markets the simple correlation ranges from negative 63 to 71%, which is statistically significant despite the small sample of eleven data points. For a typical 60% equity /40% fixed income institutional portfolio, the correlation averaged around negative 45% which is significant at the 95% confidence interval.

Our death metric does not explicitly consider the financial costs of physical capital such as roads, bridges and buildings that are typically destroyed in armed conflict. We assumed that rate of destruction of capital stock would decline as conflicts proceeded, as "high value" targets would presumably be hit first. To incorporate this idea, we repeated the analysis using the log of the death rate. The rationale is that the rate of capital destruction relative to casualties would start high and decline as the magnitude of destruction increased, so a doubling of casualties would imply a less than doubling of the associated economic burden.

When we restated the independent variable as the log (base 10) of the conflict measure, the correlations rise to over negative 80%. The "best fit" is between bond market returns and the "maximum" conflict time series with a correlation of negative 86% (r-squared = .74). This is statistically significant at a greater than 99.9% level. We chose not to control for other effects (inflation, changes in rate of GDP growth) as they may also be outcomes of the real world events, not independent effects. A second benefit of considering the log relationship is to shed light on the possibility that the OLS results are being driven by two large events where casualty rates spiked, World War I and World War II. The small differences in the regression coefficients suggest that the World War decades are not dominant.

Given these empirical results, we can reject the null of our hypothesis that financial market returns will be negatively correlated to conflict mortality for both fixed income markets and the blended 60/40 portfolio. For equities alone, the result has the correct sign but is not significant on eleven observations. We can also confirm that fixed income markets are more acutely impacted. While we are making no formal claims about causality, it is far more intuitive to think of conflict impacting financial markets than financial market outcomes causing wars.

Pandemic Implications for Long Term Investors

Even if the implausible worst case of 60 million deaths were to come about, this would represent about a 9% increase in global total mortality over a ten-year investment time horizon (much smaller than multiple years of sustained large-scale war). We note above that the correlation of decade long global equity market returns with the variations in mortality rates was on the order of -.45 (mortality rates up, equity market returns down).
Let's walk through the financial algebra for a moment for a typical investor. Initial assumptions are:

a. Future equity returns would be 6% in an average year with a volatility of 15% (this is a geometric mean return of 4.875%) or a cumulative return of 59% over a decade
b. Future fixed interest returns would be 2% with a volatility of 7% (this a geometric mean return of 1.755% annually)
c. The correlation of equities and fixed interest returns is .3
d. The investor is 60% equities and 40% fixed interest by asset value
e. The total portfolio expected arithmetic return works out to 4.4% with a volatility of 10.67. This equates to a geometric mean return of 3.83% annually or a cumulative return of 45.6% over a decade

If an investor had a 10-year time horizon and the pandemic effects are similar to war, the expectation of the cumulative return of their portfolio would decline by -1.85%. This arises from the expected return of 45.6% over ten years, times the 9% total increase in mortality over the decade times the correlation coefficient of -.45. The expectation of cumulative return over a decade declines from 45.6% to 43.75% which is a net geometric mean return of 3.70%. The expectation of the geometric mean annual return on the investor's portfolio *has declined only by a very modest .13 % per annum,* conditional on an extremely grim scenario for mortality.

There are also other considerations at play which suggest this could be a pessimistic assessment in other ways as well. During World War II the US military budget reached 35% of GDP for a sustained period. Even the massive economic stimulus program just undertaken by the US government represents a one-time event of about 15% of GDP. War casualties are also skewed toward younger persons who would otherwise be the most productive members of an industrial society. The coronavirus mortality is skewed toward the elderly. As such, the economic impact of each death is smaller.

As Niels Bohr said, "It is always hard to forecast, especially about the future". However, it seems that the crashing of financial markets around the world early in the pandemic period cannot be explained by rational actions of long-term investors conditioned on the available data on large variations of mortality rates.

Our first speculation is that Investors are short sighted so that nobody is thinking logically about 10-year horizons right now. A worst-case scenario of 60 million dead over a span of a few months is *very scary*, as are the likely economic impacts of coronavirus mitigation efforts. Investors switching from risky assets to riskless assets (e.g. cash, sovereign debt) have a simple decision as they don't have to wonder what the risk-free asset is. Investors choosing to move from riskless assets to risky assets have to make decisions about what risky assets they believe are appropriate. This means that selling is always faster than buying which leads to crashes, which are eventually made up by long growth periods (e.g. the Global Financial Crisis was followed up by an eleven-year bull market in global equities). A similar long expansion was experienced in the "roaring 20's" after the Spanish flu pandemic in 1918 was roughly coincident with the end of World War I.

Significant research also suggests that investors are relatively indifferent to small changes in their wealth level but are extremely sensitive to larger changes in wealth so an amount of selling by investors may be logical. This effect has been defined in various ways by Wilcox (2003), Barro (2005) and Gabaix (2009). Alternatively we can apply the "behavioral" framework the "Cumulative Prospect Theory" advanced by Kahneman and Tversky (1992) which suggests that investors would be more distressed by a percentage loss in their wealth than they would be pleased by an equal magnitude percentage increase, particularly for large changes.

We can also understand investor behavior from the impact of "great anomalies". Much of the empirical literature on financial markets does not include rare but extreme events such as the collapses of Russian financial markets at the time of the Russian revolution, the German financial markets in the 1930s, and the expropriation of private enterprises at the Communist takeover in China in 1949. While rare, such collapses have a meaningful impact on how investors should view returns from various financial markets.

While there is always some non-zero chance that the spread of the virus could spin out of control in heavily populated countries like India and Brazil, we assert that long term investors should be minimally impacted by the pandemic if they are globally diversified.

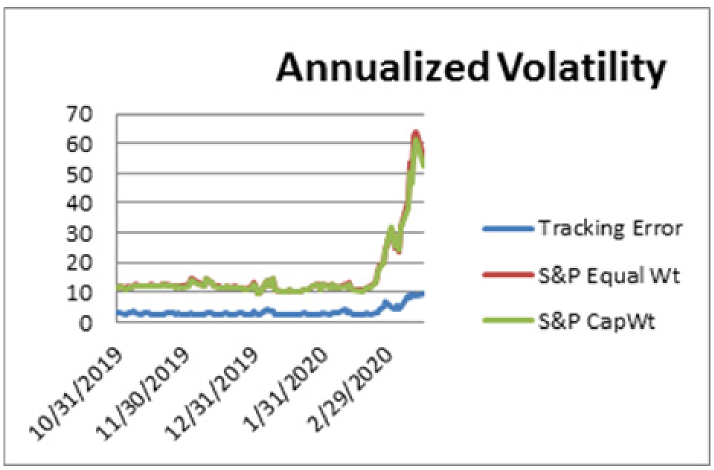
Pandemic Investor Risks in the Short Run

One explanation for the large recent decline and later recovery in equity markets is that investors are thinking about their portfolio assets in a "one day at a time" fashion. To assess investor beliefs about short-term risk we have maintained a short term risk model since 1997. In this approach, a statistical factor model is adjusted daily for changes in the implied volatility of options traded on equities in the US. A mathematical process then maps the day to day changes in security level volatility across the factors of covariance so that changes in market conditions are applied to all securities, not just equities in which options are traded. Security coverage includes all traded on US exchanges in ADR form, so the model does cover most large publicly traded firms globally. Mathematical details of the model are presented in diBartolomeo and Warrick (2005). Although volatility levels are presented in the usual annualized units, the intended time horizon for the risk forecast is the next trading day. Our estimate is different from the traded CBOE Volatility Index (VIX) contract because the volatility estimate for the S&P 500 is built from the estimated volatility and weights of the individual securities comprising the index.

Exhibit 3 shows the expected volatility of the S&P 500 on an equal weighted basis, the S&P 500 on the conventional capitalization weighted basis, and the tracking error of the two portfolios. The time period is from the end of October 2019 through to March 16th, 2020, at a daily frequency.

The chart shows that the volatility values for both series increased roughly five-fold over the sample period. Peak annualized volatility values of over 60% were observed on March 13th but decreased to 52% for cap weighted index and 55% on the equal weighted index by March 16th. As is common in crisis periods, correlations had increased with the *expected* correlation of the two portfolios going from .968 at the start to .984 at the end. On April 15th this value was 39.8% and has declined a bit more since.

Exhibit 3



Inference on the Length of the Pandemic Period

We can use the above information to make a useful inference about US equity investor's *expectations* of the persistence of heightened risk from the pandemic. Our intent to estimate this expectation from what investors are actually *doing* with their portfolios rather than what they might be *saying* (e.g. in a survey). Let's assume that at the start of the period (November 2019), investors believed the *expected* total return of the S&P 500 was 6% with a known dividend yield of 2%, implying a growth rate of 4%. We will also assume that the market was fairly valued implying that expected returns and required returns were equal.

Over the period of the sample, the expected volatility of the S&P 500 increased by roughly 40 percentage points, while the index level declined roughly 20% by mid-March We assert that rational investors would respond by increasing their required rate of return by 6.7% per annum (40/6) for the period of heightened risk.

The denominator scalar of six is derived from the implied risk boundary of an investor's original risk level. We start with a "growth optimal" investor whose *only objective* is to maximize their long term geometric mean return. The usual investor objective function from Markowitz and Levy (1979) is:

$$U = E [R - \lambda * \sigma^2]$$

For a growth optimal investor λ =.5 or ½ assuming all units are in decimals. See Messmore (1995) for a good discussion of "variance drain". My preference is to remove the potential for $\lambda = 0$ so I'll rewrite this with the tradeoff parameter (T) in the denominator and also convert to all values from decimals to percentages

$$U = E [R - \sigma^2 / T]$$

For the growth optimal case T = 200. The question is what is the appropriate_risk tolerance (T) for an investor less comfortable with volatility? We derive the value of T from an estimate of the "Maximum Loss Fraction".
Now let's work through a simple example, where our existing portfolio has expected return (R) = 8 and $\sigma = 12$. Implicit in choosing a portfolio of a particular risk (e.g. 12%) is the idea that I don't want to put all my money at risk, just some of it, as described in Wilcox (2003). A reasonable expectation for the **maximum loss fraction (M)** of the portfolio value would be:

$$M = (Z * \sigma) - R$$

Where Z is your choice Z-score of the worst case scenario under a normal distribution (e.g. 3.5)

$$M = 3.5 * 12 - 8 = 34$$

So the investors only willing to put 34% (.34) of the portfolio at risk (implicit T= 200), which means that the other part of the portfolio must be riskless (implicit T = 0)

$$T = .34 * 200 + (1 - .34) * 0 = 68$$

If we divide T through by σ, we obtain 68/12 = 5.67 (about six). So now we can express our objective as

$$U = E[R - \sigma^2 / (5.67 * \sigma)]$$

Simplifying we obtain:

$$U = E[R - (1/5.67) * \sigma]$$

Our tradeoff between return and standard deviation is therefore about 1/6. For a broad range of empirical cases, the 1/6 relationship holds rather nicely. For tracking error cases rather than absolute volatility, I prefer to use Z = 3, R = 0, which **renders exactly 1/6.**

We next utilize a simple Gordon dividend discount model (Gordon and Shapiro, 1956) for the pricing of a stream of $1 dividends.

$$P \text{ (November 2019)} = 1 / (.06 - .04) = \$50$$

This gives us a result $50 per $1 of dividends (2% yield). If we now add an increment to the required return for the heightened expected risk, we get:

$$P \text{ (March 2020)} = 1 / (.127 - .04) = \$11.49$$

If investors believed that the massively heighted risks would be permanent, the S&P 500 should have fallen by 78%, not the observed roughly 20% to mid-March 2020. To get the 20% drop to make sense, the *long term* required rate of annual return must increase from 6% to 6.5%, meaning that investors are pricing the market as if the long term expected volatility increased by 3% (e.g. from 12% to 15%). Updating our parameters to mid-April 2020, the expected decline of the S&P 500 should have been 58% for a permanent risk increase, while the observed decline was roughly 9%.

If we assume that the median survival time for a publicly traded firm in the USA is about twenty years as asserted in diBartolomeo (2010) we can infer how long investors expected the heightened risks to last. The underlying model in this paper is based on the contingent claims concept from Merton (1974). Essentially it argues that stockholders have two options that lenders don't have. One is a call option on the assets of the firm which can be exercised by paying off the firm's debt. The other option is a put option associated with the limited legal liability of shareholders. If the assets of a firm fall sufficiently, the shareholders can walk away transferring the assets to lenders. The "underlying" of these options is the assets of the firm, and the strike price is approximately the value of the firm's debt. Using option pricing models, we can solve the relationships for the expected expiration date of the options which is the median of the expected distribution of firm survival time.

Using the mathematical property that variances are additive, we obtain an *implied* length for the pandemic of approximately seven months as of mid-March, five months as of mid-April, about one month as of late May. Please note that this analysis ignores the small variations in the S&P dividend yield over the sample period, and the potential loss of a modest amount of total return over long horizons as previously discussed.

Corporate Credit Risk

An obvious area of investor concern during the "rapid risk" periods such as the current coronavirus pandemic is the ability of corporations to make timely payments on their bond debt and bank loans. We begin with a very familiar measure, the yield spread between investment grade corporate bonds denominated in US dollars, and US Treasury bonds of similar maturity as shown in **Exhibit 4**. This incremental yield is compensation to investors for both the risk of default and the lower liquidity of corporate bonds. The sample period is from the beginning of 1992 to near the current date.

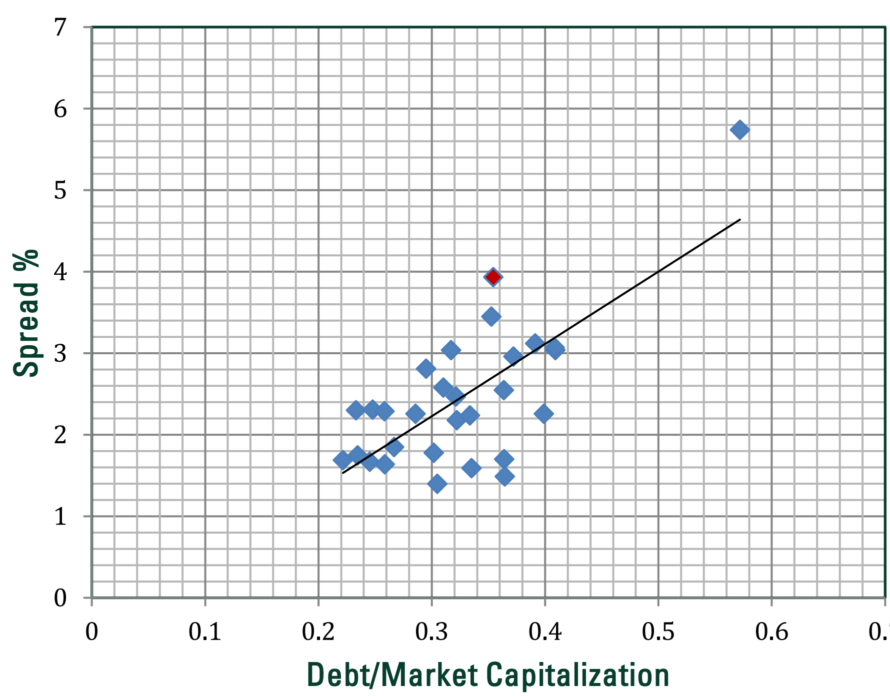
Exhibit 4

While the model in diBartolomeo (2010) is quite complex, we can illustrate the concept in a simple fashion. As long as shareholders can issue new equity to get cash to pay off debt, a firm should be able to survive and avoid default. Therefore, the ratio of the debt value to the market capitalization of a firm should be a crucial metric. If the debt is small compared to the market value of equity, it should be easy for a firm to avoid default. If the debt is large compared to the market value of equity, the firm may have difficulty raising enough cash to pay off the debt.

Exhibit 5 provides a scatter plot of the relationship between the debt/capitalization ratio for a universe of equities and corporate bond yield spreads. To avoid any seasonality issues, each data point is defined as of March 31st of a particular year, starting in 1992. The ratio is the simple average of all stocks publicly traded in the USA at each date (including ADRs) whose market capitalization was over $250 Million.

A significant portion of the data points lie to the right of the March 31, 2020 data, indicating that less favorable credit conditions have prevailed over material portions of the sample period. Although the stock market had come down a lot, this decline was from a high level so the month-end status of this measure is *better than about a quarter of previous observations.* The Pearson correlation of the two series is 72% (T>7) R-squared of .52.

Exhibit 5



The most recent month-end data for March 31st, 2020 is highlighted in red. This point is approximately 1.15% above a simple OLS trend line. One can rationalize this extra yield with two closely related but not identical explanations. The first rationale is that there is currently a heightened degree of uncertainty in terms of what future default rates and recoveries may be, and investors demand additional yield to compensate them for this uncertainty[4].

Alternatively, investors may believe that the coronavirus pandemic represents a circumstance where the correlation of likely defaults across many borrowers is likely to be very high for at least a short period. This means that the distribution of return outcomes on diversified portfolios will act more like a single bond and exhibit negative skew and positive excess kurtosis (i.e. a typical bond has a lot more room to go down in value than up). Again using the method of Cornish and Fisher the expectations of higher volatility would require higher returns (i.e. spreads).

We can integrate the above ratio analysis with updated data on corporate sustainability. For the twenty-six year sample from 1992-2017, the average of "expected half-life" (50% probability of surviving this long) is *seventeen* years across time for our full equity universe of US firms (including those under $250 Million in capitalization). This longevity value changes materially if firms are weighted by either market capitalization (higher) or by revenues (shorter). The latter effect can be interpreted as "too big to fail" firms taking on higher financial leverage.

This average longevity estimate corresponds to a market implied annual extinction rate of 4%. If we run an OLS regression of the debt/capitalization ratio series on the expected life data, we obtain an estimated half-life of around thirteen years, or an extinction rate of 5.2% as of March 31, 2020. In the first half of April, US equity market averages rose about 10%, decreasing the ratio of the value of debt to market capitalization to a ratio of .321 as of April 15th, *very close to the long-term sample period mean* of .325 with a corresponding implied extinction rate of 4.1%, just slightly above the historic average level. The further increase in equity market valuations in May moved our credit measures even closer to typical conditions.

There are several other items we should consider when assessing bond credit risks during the pandemic. The first one is the average maturity of the debt. If debt is only a fraction of the market value of equity, the interest payments are likely to be a very small fraction of market capitalization. As of March 31, 2020, the average maturity of debt across the nearly 32,000 global issuers covered in our internal database is almost exactly five years.

At the 5.2% extinction rate about 76% of bonds would not default within five years. The long-term average spread for the sample period is 2.45%, so the current spread provides about a 1.5% annual yield increment or about 8% extra return cumulatively over five years. At the 4% long term extinction rate, about 81% of firms are expected to survive at least five years. Investors are being compensated 8% over five years for the risk of having an incremental 5% of firms default. There must be a risk premium involved as even if we experienced 5% incremental defaults with zero recoveries the *incremental cumulative loss of principal* could not be greater than 5%. If we assumed recoveries averaging 40% on corporate bonds (a typical assumption) the incremental loss of principal would be 3% of our portfolio. This additional return (8 > 3) is therefore consistent with our risk premium hypothesis for the very high yield spread as of the end of March.

It should also be considered that while yield spreads have increased, the overall interest rate being paid by borrowers on new debt has not changed very much. The spread values used herein are increments in yield over US Treasury 10-year bond rates which have fallen to historically low levels of around 1%, compared to a long-term average of 4.2%. Some yields have actually fallen, particularly on corporate bank loans (where recoveries average around 80%). The net effect may be that the long-term expectation of corporate sustainability would *perversely improve somewhat* as the annual carrying cost of debt capital declines thereby improving corporate profits in the future.

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Economic Recovery from the Current Pandemic

The severity of the pandemic ***appears*** to have peaked in many countries including the US and most of Western Europe. As such, there is extensive debate about how and when to reduce various forms of "lockdown" restrictions on their populations so as to minimize the already great damage to their respective economies. We will ***assume*** *that no country would undertake to reduce restrictions unless they believed the worst was over and that the number of future infections would be manageable* within their health care systems.

To address the issue of "assumption dependence" we will consider two metrics of readiness for a range of nations. The first is the number of coronavirus tests performed to date as a percentage of the population. The second is the percentage of tests that have given a positive result for infection. It should be noted that "tests given as a percentage of the population" does not imply that testing is that widespread (e.g. essential workers may have been tested multiple times).

We believe an even more important metric of readiness to return to normalcy is the percentage of positives among tests given. Given that the supply of tests is limited, medical authorities would naturally allocate tests to people most likely to need testing (those showing relevant symptoms), where a high percentage of positives is to be expected. Testing of random samples of the general population is likely to show much lower percentages of positive outcomes.

As of mid-April the worst percentage was France with more than 44% positives, followed by Brazil at 40.7%. The US state of New York was also over 40%. The lowest was the UAE with just .7% of tests given producing positives. Of the fourteen nations with more than 20,000 infections, the average national rate was 20.75%, with the US and UK at 19.75% and 26.2% respectively. Many of the more rural US states have also reported lower percentages of positives (e.g. Vermont = 7.1%). By early May the rate of testing in the United States has increased significantly to about 300,000 tests daily and the percentage of positive tests was about 16% of the total.

Given the high coefficient of variation across neighboring countries and regions, the process of coordinating a gradual return to normalcy may be prolonged as a matter of the "lowest common denominator." A further increase in the production of testing kits will be a key determinant of the date at which the world can declare the battle with coronavirus is at least a stalemate, if not a victory.

The Cross-Section of Corruption

Unlike pandemics and wars, the impact of societal corruption may be imperceptible on a short term basis. However, we can assess the cumulative differential effects across asset classes and geographic regions. Let us consider the relationship between financial markets and the perception of corruption across countries. Corrupt practices in government and economic affairs are widely believed to contribute to slow economic growth and the instability of sovereign states.

The seminal study is Shleifer and Vishny (1993). They found GDP growth is slower in countries perceived to be corrupt. They also found the value of traded equity markets as a fraction of GDP to be smaller in corrupt countries. We updated to 2012, and discuss 2002, 2007 and 2012 as representatives. Our hypothesis is that the ratio of equity market valuation divided by GDP will be lower for countries with a high perceived degree of corruption. Our intuition is that in countries with low corruption, investors are willing to participate in "arms-length" transactions over a stock exchange, confident that legal and regulatory oversight will protect their interests. In countries with high corruption, investor confidence is lacking, creating bias toward a culture of "face to face" transactions. With today's widespread accusations of "fake news" investors will demand higher return premiums for information uncertainty, consistent with the aforementioned study of Brown, et. al.

As data for our analysis of corruption, we obtained country level GDP and total market value of equity markets reported as year-end values in the World Bank online database. Corruption levels were measured by the Transparency International Corruption Perceptions Index[5]. This index is compiled by an annual survey of business and government officials, with data being collected on essentially every country on earth. Annual data begins in 1995.

Our empirical investigation began by calculating the ratio of equity market cap to GDP for a sample of about 100 countries for 2012. The correlation of market cap/GDP to the corruption index was negative 45% (r-squared = .21) which is highly statistically significant (T > 5). We repeated the analysis annually starting with 2002. In this case, the number of countries with functional equity markets was only 82, but the correlation of the market cap/GDP ratio was even higher at 48% (r-squared = .23) which is also highly significant (T > 5). We can clearly reject the null that equity valuation is unrelated to perceived corruption and confirm our hypothesis for every year tested.

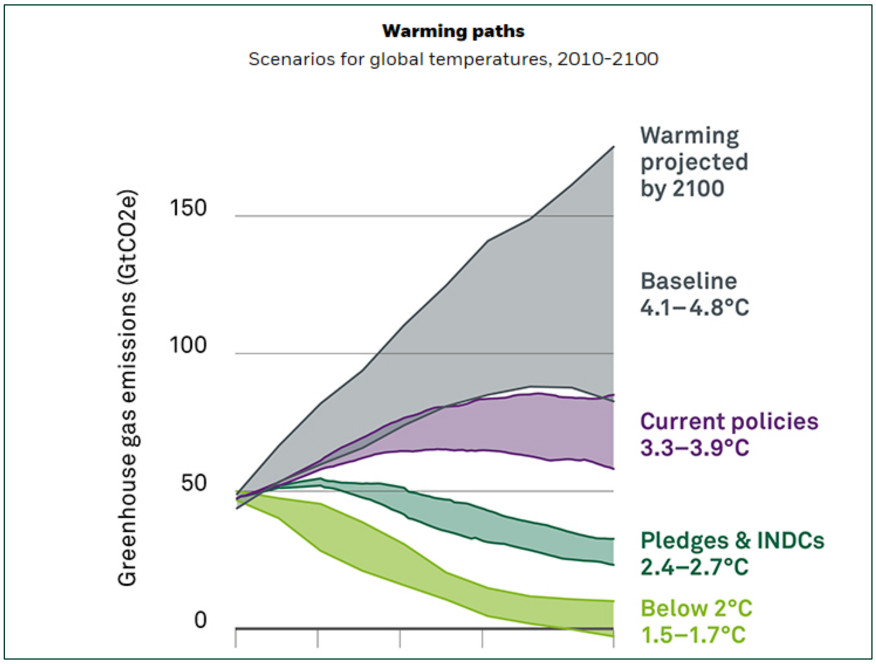
Mitigating Climate Change on Portfolio Assets

Unlike societal corruption which we can study country by country, climate change is a truly global effect. However, some asset classes and geographic areas are more likely to be affected than others, so investors can act to mitigate potential risks of climate effects on their portfolio.

In some ways, the phrasing of "climate change risk" is a misnomer. In financial markets, the word risk is often used as a proxy for uncertainty. There is little uncertainty about the direction of what is happening in climate. The "risk" is in what the economic effects will be. Against a background of natural variation in temperatures over centuries, the increasing existence of greenhouse gases in the atmosphere has biased the process of global temperature variation toward increases rather than decreases. *The world is being made hotter by some amount,* and the increased energy levels associated with this greater heat is manifesting in various ways including higher intensity and frequency of extreme weather events. While it will take hundreds or thousands of years to prove to a statistical certainty that the recent changes in average temperatures are the result of human activity, the increasing concern of investors with respect to the environment is clear.

Exhibit 6 is a chart from a 2016 Blackrock report[6] on climate change illustrating their range of projections for future increases in temperatures. If one assumes that these projections are a sensible baseline, asset owners must now consider what to do about it.

Exhibit 6



The most obvious question facing investors is the future of fossil fuel production and consumption which is widely accepted as the single largest cause of global warming. The most basic question is whether to reduce or eliminate investment in oil, coal, natural gas, and other fossil fuel related enterprises. The first research on this point *was published nearly a quarter-century ago.* In diBartolomeo and Kurtz (1996) a detailed analysis is done to attribute performance differences in an equity index which had been "screened" for environmental effects against a similar but unscreened equity index (the S&P 500). At the time, approximately 80% the variation in relative performance could be attributed to the inclusion or exclusion of fossil fuel related firms. This study was subsequently updated in diBartolomeo and Kurtz (2011) with similar conclusions. Both papers also illustrate how investors could change company level weights in their portfolios so as to minimize the variations in relative performance over time.

While many models of equity risk explicitly consider membership in the energy sector, not all directly measure the statistical relationship of all firms to oil prices (which have recently collapsed). Doing so ensures that the impacts of energy are captured for consumption as well as production. For example, it can be shown that the earnings of "big box" retail companies (e.g. Walmart, Home Depot) are particularly sensitive to energy costs both in direct operations and in terms of impact on consumer behavior. Risk assessments that rely solely on industry classifications to capture energy sensitivity are insufficient in this regard. There are also deficiencies in equity benchmark index construction. With particular respect to climate change, one such deficiency is the fact that in many nations, energy resources such as oil have been nationalized and hence are under-represented in equity market indices in terms of the impact of the energy sector on the local economies of many countries.

The aforementioned use of a Merton style analysis for credit risk means that all of the information described above for equities flows directly to the consideration corporate credit risk, and the aggregation of corporate credit risk, equity risk, and tenant credit risk in real estate at the enterprise level of an asset owner. Belev and diBartolomeo (2019) address how dependence on the energy sector of the economy may influence the creditworthiness of sovereign debt. De Jong and Nguyen (2016) illustrates how to mitigate climate risk in fixed income portfolio fixed income portfolio construction conditional on the expectation of rapid climate change.

Many asset owners are large investors in geographically bound assets such as real estate and the financing of public infrastructure. Baldwin, Belev, diBartolomeo and Gold (2005) provides a detailed approach to evaluating the risk of real estate and similar assets. A key fact is *knowing exactly where that asset is located, down to a specific neighborhood or even street address.* A major part of climate change risk is the expectation that sea levels and weather patterns will be changing and these changes will naturally impact some locations more than others (e.g. waterfront cities).

Investors should also consider the potential for climate related changes in sea levels and weather patterns directly on the risk levels of the equity securities in their portfolio companies. In a recent study, Kruttli, Tran, and Watugala (2019) show that option implied volatility values for equities increase during periods of extreme weather events (e.g. hurricanes). This effect is unsurprisingly stronger for firms whose operating facilities or headquarters are associated with coastal locations and hence are more likely to be harmed by such events.

Conclusions

Like all four of our thematic influences on investing, it should be clear that the current coronavirus pandemic is a profoundly serious matter. Allowed to spread entirely without limit the death toll would be massive in number and comparable to the peak year of World War I or World War II as percentage of the population. Unfortunately, neither of the "war to end all wars" was sufficient in scope to remove the possibility of future apocalyptic conflict accomplishing this final task. While corruption and climate change are slower acting, the cumulative influences on society over time are apt to be profound.

While we do not take a position on the matters of morality, ethics, or public policy associated with pandemic, war, corruption or climate change, it is clear investors should be undertaking policies that mitigate the likelihood of negative outcomes. For the coronavirus pandemic the more immediate risk to investors and the world economy at large comes from clumsy handling of the societal response than from the virus itself. Of greatest concern is that many organizations, companies, and governments have been engaged in an undesirable game of managing the "optics" of the situation. The actions of many entities are being driven by a desire to be perceived as managing risk as opposed to actually managing risk in response to factual information and analysis.

Endnotes

1. Bloomberg April 16, 2020, https://www.bloomberg.com/news/newsletters/2020-04-16/money-stuff-banks-pretend-2020-never-happened
2. Refer to http://covid19.healthdata.org/united-states-of-america
3. Unless otherwise noted, all statistical data on the coronavirus pandemic is drawn from the Worldometers website, https://www.worldometers.info/coronavirus/.

4. See slide 15, diBartolomeo (2018). https://www.northinfo.com/documents/923.pdf
5. See https://www.transparency.org/
6. See https://www.blackrock.com/corporate/literature/whitepaper/bii-climate-change-2016-us.pdf

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Appendix I: A First Order Model of the Pandemic

$$S_t = U_t + C * A_t$$

$$A_t = T_t - L_t - D_t$$

$$U_t = U_{t-14} * (1 + E)^{14} - (T_t - T_{t-14})$$

Where

S_t = the count of people currently spreading the virus as of day t

U_t = the count of people who are infected but don't know it as of day t

D_t = the cumulative number of deaths up to day t

T_t = the total number of cases diagnosed up to day t

L_t = the total number of infected persons who have recovered by day t

A_t = the active number of cases (i.e. persons infected but alive, presumably in treatment) on day t

E = the decimal rate of exponential growth of the number of infected persons who continued to spread the coronavirus since 14 days ago

M = the decimal mortality rate

C = the decimal rate of "cheating of quarantine"

Values for T_t, L_t, D_t and A_t are being published in "near real time" on various websites.