

2021

2ND QUARTER

QUARTERLY COMMENTARY



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All in the Stars

Concrete has been used as a building material since the Roman Empire 2,000 years ago. It has high compressive strength (it doesn't crack under heavy loads) but low tensile strength (it breaks easily when pulled), and its use waned in the centuries after the Roman Empire fell. But in the late 19th century, scientists began experimenting with ways to enhance tensile strength by reinforcing concrete, first with iron, then with steel. Among the leading authorities of the day was a Serbian engineer, Milutin Milanković.

Milutin was schooled at home by his father, private tutors and relatives, some of whom were prominent in their fields. He graduated from university in Vienna as valedictorian and earned his Ph.D. a few years later with his dissertation topic on pressure curves, useful in curved construction, such as bridges and cupolas. He joined the leading engineering firm in Vienna and soon became the most sought-after civil engineer in the Austro-Hungarian Empire. He earned six patents, including a new type of reinforced concrete ribbed ceiling. His talents as an engineer made him famous and rich.

In 1909 Milanković left engineering and Vienna to accept a chair in applied mathematics at the University of Belgrade, turning his attention to research. A Viennese friend, Julius von Hann, mentioned to him that he

¹ Image of the spiral galaxy NGC 2841 courtesy Hubble Space Telescope, NASA.

was trying to uncover the explanation for the emergence of ice ages. Some scientists² had suggested astronomical forces were behind glacial emergence and recession, but no one had proven this or even attempted to construct a mathematical theory for such events. Milanković tried to do exactly that, by painstakingly creating a model for calculating solar radiation in the northern latitudes at various times throughout the year. His paper, *Distribution of the Sun radiation on the Earth's Surface*, published in 1913, presented a theoretical model that matched closely with empirical observations.

Milanković married in the summer of 1914, and honeymooned in his hometown of Dalj, along the banks of the Danube. Unfortunately for him, Dalj is on the Croatian side of the river, and he was arrested and detained by the Austro-Hungarian army as a Serbian (enemy) citizen. He was held in detention for the four years of the war.

After the war he returned to Belgrade to extend his model of solar radiation far back in time. His calculations, literally hundreds of thousands of them, all written out by hand, took years to complete, but Milanković believed he had constructed the first mathematical model of the effects of astronomical cycles on the Earth's climate.

For more than two decades Milanković assembled his data, made his calculations, and refined his theories. He completed his 600-page manuscript, by hand, on 2 April 1941 and brought it to the printers. Four days later, the Nazis bombed Belgrade, and the publishing house, where the only copy of his manuscript was awaiting printing, was destroyed.

This was a small catastrophe in the larger context of the war. But Milanković's work on astronomical cycles prods us to consider some more earthly ones.

C OVID-19 abruptly shifted the world economy into reverse last year. The US economy shrank 3 ½% in 2020, the sharpest contraction since the depths of the Great Depression in the early 1930s.³ This year should see growth of 6 ½%, the strongest since 1984.⁴ Some of this growth is simply a rebound from the self-imposed pandemic shutdown, but a good part of the surge is due to unprecedented fiscal and monetary expansion.

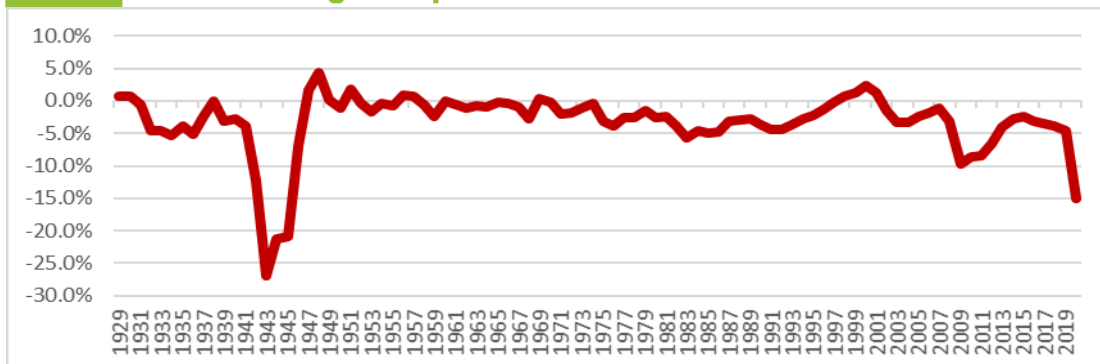
The federal budget deficit is (currently) projected at around \$3 trillion (and counting), or about 15% of GDP. That is the largest since the Second World War (Chart 1). Federal debt amounts to 127% of GDP, also the highest since the war. Likewise, the Federal Reserve's balance sheet, which doubled during the 2008-09 crisis, from \$1 trillion to \$2 trillion, kept expanding in the subsequent years to \$4 trillion. Over the past year, it doubled again to more than \$8 trillion (Chart 2).

Unlike previous recessions where incomes fall, the massive fiscal stimulus contributed to incomes rising 5% to record levels during the pandemic (Chart 3).

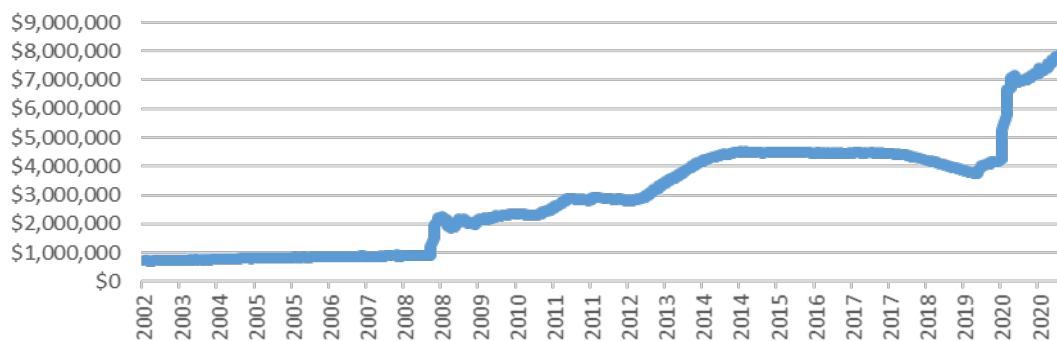
² Astronomer John Herschel, geologist Louis Agassiz, and geophysicist Alfred Wegener, for example.

³ The exception was 1946, which saw an 11.6% fall in output as the economy transitioned from war production.

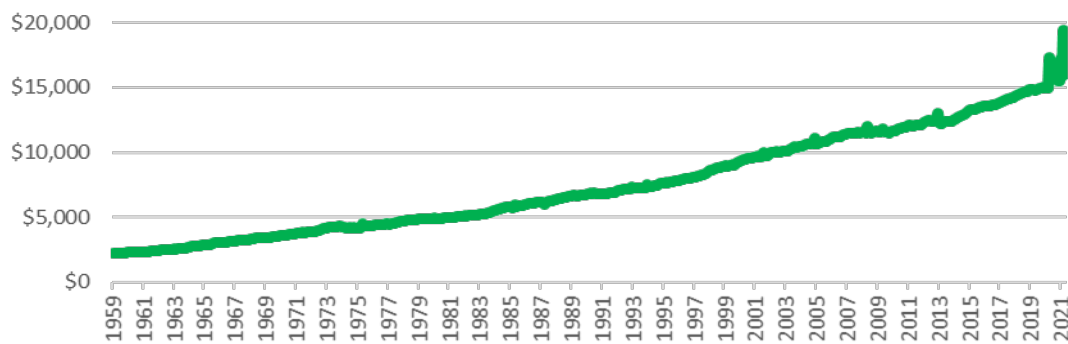
⁴ GDP grew 7.2% in 1984

Chart 1 Federal Budget Surplus/Deficit as % of GDP, 1929-2021

Source: U.S. Office of Management and Budget

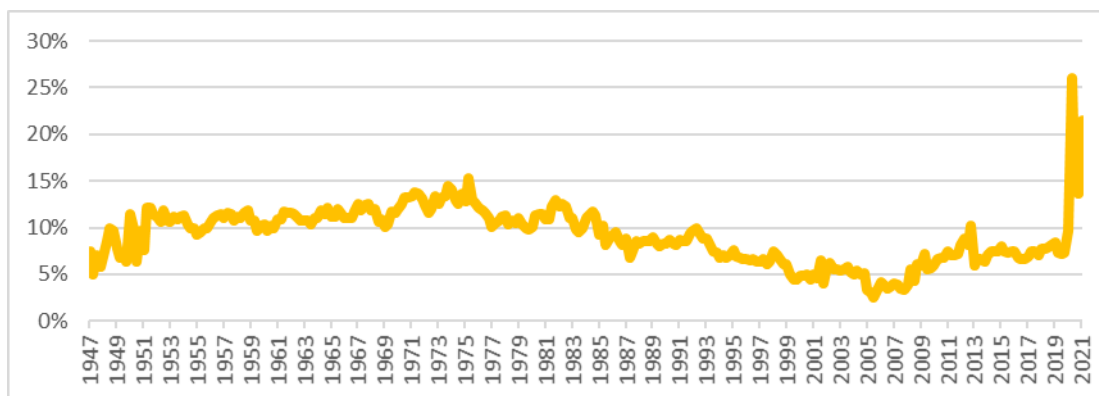
Chart 2 Federal Reserve Assets, \$MM, 2002-2021

Source: Federal Reserve System

Chart 3 Real Disposable Personal Income, Chained 2012 Dollars, SAAR, in Billions 1959-2021

Source: U.S. Bureau of Economic Analysis

Chart 4 Personal Saving as a % of Disposable Personal Income, SAAR, 1947-2021



Source: U.S. Bureau of Economic Analysis

A large portion (>20%) of this rising disposable income went to savings, the highest percentage since records began in 1947 (Chart 4).

This enormous expansion of monetary and fiscal policy is not only unprecedented, it represents a paradigmatic shift in the macroeconomic regime established forty years ago. Historically, debt and inflation have been the biggest constraints on fiscal and monetary policies; no longer. In a year that will see the strongest economic growth in over a generation, the federal government has unleashed more than \$3 trillion of additional spending, with trillions more planned. This spending goes way beyond helping the economy recover from the pandemic; it is a fundamental shift in policy goals to redistribute generational wealth in order to expand access to social services and promote greater equality and inclusion in income and wealth.

The other principal constraint on policy, inflation, is assumed by policymakers and investors alike to be transitory, a function of measuring from a low base a year ago and temporary supply constraints caused by the swift re-opening of economies. Higher inflation may (or may not) prove transitory, but the Federal

Reserve has articulated a new monetary framework that re-interprets and greatly expands its mission beyond broad macroeconomic stability to one that prioritizes economic equality and inclusion. Practically, this means that the Fed will de-emphasize maintaining low and stable inflation in order to see the broadest measurement of economic inclusion, specifically, full employment for the marginally employed. The current spike in inflation is assumed to be temporary, and since we are still far from this newly expanded definition of full employment, the Fed will not change its highly accommodative monetary posture anytime soon. Should higher inflation persist, the Fed has pledged to be patient in tightening policy until its broadest definition of full employment is achieved.

Broader economic inclusion and equality are laudable, even necessary, goals. Fiscal policies, traditionally the mechanism by which sociopolitical objectives are prioritized, are shifting in this direction, but there are questions about the effectiveness of monetary policy in achieving sociopolitical goals, and questions about how the Fed will balance these new objectives with its traditional mandate of maintaining macroeconomic stability.

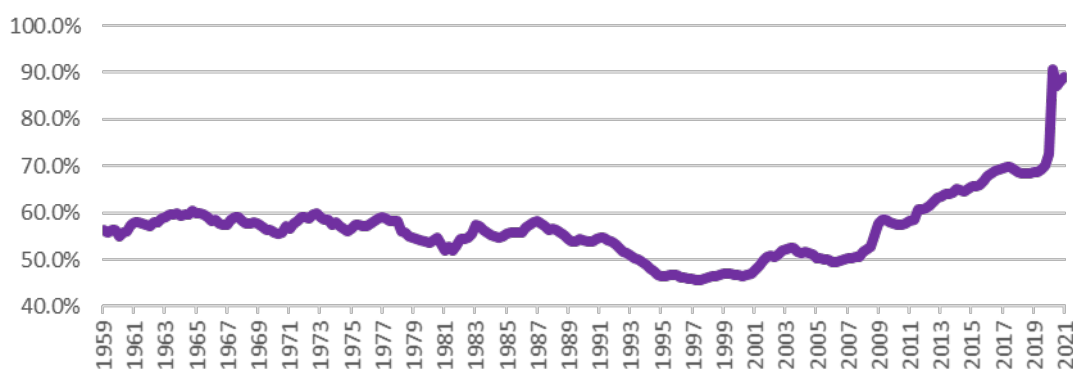
Inflation is the decline in the value of money, usually expressed conversely as the general (aggregate) increase in prices of goods and services. Inflation is not caused by OPEC restricting the supply of oil or by a shortage of toilet paper or semiconductor chips. Inflation is the price of money, and like any other good, its price is determined by supply and demand. When the supply of anything exceeds the demand for it, the price falls. When the supply of money exceeds the demand for money, the price of money falls (and the costs of goods and services rises). That's inflation. The job of the central bank is to supply the amount of money the public wants to hold. If the central bank offers fewer dollars than is demanded, the price of money rises (inflation falls). If it provides more dollars than is demanded, the price of money falls (inflation rises).

In prosperous times, the demand for money typically falls: people have more money that they happily spend. Central bankers need to restrict the supply of money in these good times lest inflation rise. Likewise, when the economy falters or economic uncertainty is high, the demand for money rises, and central bankers need to increase the supply of money to meet this growing demand.

The massive increase in the Fed's balance sheet over the past twelve years was not inflationary because it simply mirrored the huge demand by the public to hold money (Chart 5).⁵⁶ We can speculate on why the demand for money has been so high—perhaps it has been caused by the rise in economic uncertainty, understandably, in the wake of a global financial crisis and a global pandemic that each brought the world economy to brink of collapse, or perhaps driven by widening political polarization and growing social unrest. Regardless of why the demand for money has been so strong, by ensuring an adequate supply of dollars, the Fed has been able to keep supply and demand in balance, and inflation has averaged less than 2%⁷ annually for the past decade.

Inflation is simply the reflection of an excess in the supply of money relative to its demand and can occur when the economy is strong or when the economy is weak. Economic conditions certainly affect the demand for money, and central bankers must adjust the supply of money accordingly. A low and stable rate of inflation is proof that monetary policy is in balance; deflation signals policy is too tight, inflation indicates it is too loose.

Chart 5 M2 Money Stock as Percentage of Nominal GDP, 1959-2021



Source: Federal Reserve Bank and U.S. Bureau of Economic Analysis

⁵ Technically, the Federal Reserve does not create money. It creates reserves that banks can convert into money through lending.

⁶ M2 Money Stock is a broad measurement of cash and cash-equivalents. Expressed as a percentage of GDP, it represents the demand to hold money.

⁷ 1.8% p.a.

Inflation is up 5.0% over the past year. This spike may prove transitory, as most investors (and the Fed) believe, but should the demand for money fall, the Fed will need to withdraw its ample accommodation lest inflation take root and become more difficult to control in the future. The goals of economic inclusion and equality are desirable. But monetary policy can best contribute to a more equitable society through macroeconomic stability.⁸ Mismanaging monetary policy, resulting in either deflation or inflation, disproportionately harms those at the margins of our economy.

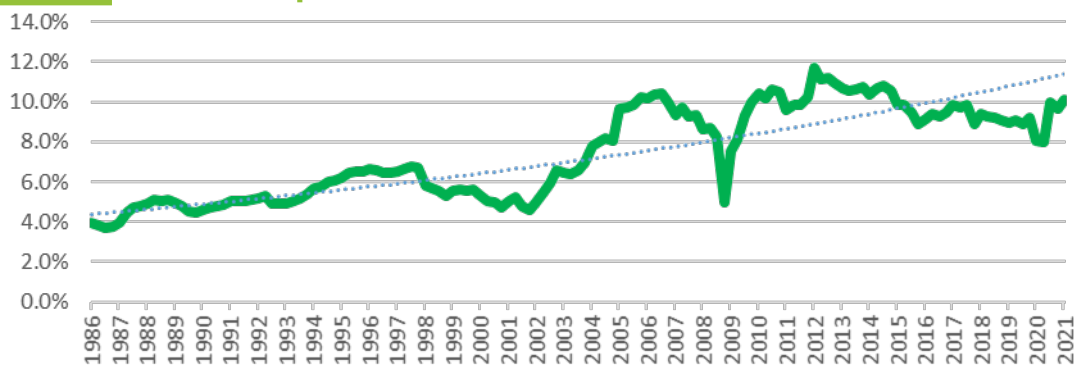
Cyclical factors pushing inflation higher now will abate; the issue for investors is discerning those structural forces that will determine the investment landscape in the coming years. The dominant drivers of the past few decades have been ever lower inflation (disinflation), stagnant real wages and weaker economic growth rates.

The shift in the monetary approach introduced by Fed chair Paul Volker in the early 1980s to combat high inflation persisted throughout the subsequent decades, whether the Fed was led by Alan Greenspan, Ben Bernanke or Janet Yellen. The monetary regime of the past forty years was designed to keep inflation low, and it succeeded consistently well.

Wage growth stagnated in developed economies as the global labor pool expanded massively, first with the collapse of the Soviet Union and its Eastern European subject states in the early 1990s, and then with the entry of China into the World Trade Organization in 2001. Manufacturing jobs disappeared in advanced economies only to resurface in these newly developing countries. Technological advances—in automation, transportation and supply chain management—also reduced manufacturing jobs and wages in developed countries. More than a billion people around the world were lifted out of poverty in the past two decades, an extraordinary achievement. But it came partly at the expense of millions of blue-collar workers in the developed world.

For investors, this has been a golden age. The successful fight against inflation reduced (eliminated) the inflation premium of bonds, and yields around the world have fallen to the lowest levels in the thousands of years of recorded history. The global labor arbitrage benefitted workers in developing economies and companies in advanced economies, which have accrued ever higher levels of profits (Chart 6). Long duration assets—equities, especially growth equities, and long-term bonds—have been the big winners in the past decades.

Chart 6 Ratio of Corporate Profits to GDP, 1986-2021



Source: U.S. Bureau of Economic Analysis

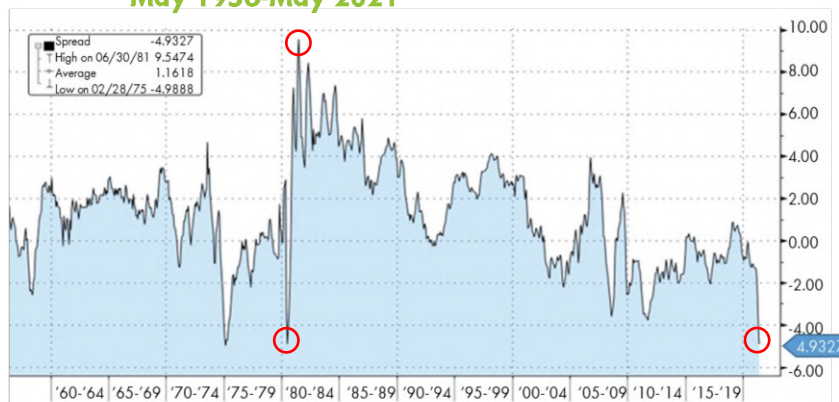
⁸ Annual Economic Report, Bank for International Settlements, June 2021.

**Chart 7 U.S. Consumer Price-Index, YoY, NSA, Monthly
May 1956-May 2021**



Source: U.S. Bureau of Labor Statistics, Bloomberg, LP

**Chart 8 Spread Between Fed Fund Rate
& U.S. Consumer Price Index Monthly
May 1956-May 2021**



Source: Federal Reserve Bank, U.S. Bureau of Labor Statistics, Bloomberg, LP

Investors have been right to see inflation spikes as transitory for the past forty years. There was a jump to 6.3% in October 1990⁹ and to 5.6% in July 2008,¹⁰ but both times inflation fell shortly thereafter (Chart 7). Perhaps this latest leap in inflation will follow a similar, transitory pattern.

Going back a little further in history, investors thought the rise of inflation in the 1970s was also due to transitory factors. They were slow to push interest rates higher until inflation had taken root. Similarly, investors also missed the secular decline in inflation begin-

ning in the 1980s, doubting it would be sustained, and interest rates remained elevated even as inflation fell.

President Nixon imposed wage and price controls in August 1971 as inflation shot above 5%. These measures temporarily reduced the official inflation data, at the expense of widespread shortages, and most of these measures were lifted in 1974. Prices then soared to above 10%. The Fed did raise the Fed Funds rate to over 12%, but as inflation fell, the Fed relaxed policy, letting the Fed Funds rate fall to below 5% in 1976, just as inflation was on its way up to 15% by 1980. The Fed, and investors, were slow to recognize the jump in inflation, and suffered through the late 1970s with negative real yields (yields below the rate of inflation).

In June 1980, Paul Volker took the Fed Funds rate from 9% to 19%, from 5% below the inflation rate to 10% above it (Chart 8). Investors were slow to realize that this marked the peak of inflation and the beginning of forty years of ever lower inflation rates (and yields).

The monetary regime established by Paul Volker has been in place for four decades. It was designed for one purpose, to bring inflation down to a low and stable level. The spikes we saw in inflation over the past forty years were rightly seen as transitory given the Fed's framework and commitment to lower inflation.

⁹ Iraq invaded Kuwait in August 1990, and oil prices soared as the US built toward the first Gulf War.

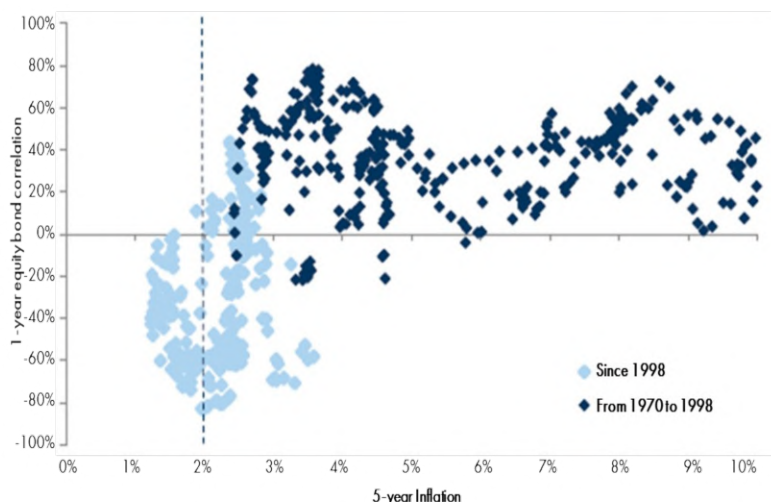
¹⁰ The Fed tolerated this rise in inflation to combat the effects of the mortgage crisis.

This monetary regime is now over. The Fed has adopted a policy of encouraging higher inflation, of reacting to, instead of preempting, inflation. The powerful disinflationary forces of the past few decades, tight monetary policies and an expanding global labor pool, are also over. For investors, the playbook that worked so well for the past few decades will need to be scrapped. The new playbook will be a lot more challenging to master.

High valuations translate to low expected returns. That's just one challenge for investors, but the math behind it is pretty simple. The more complex issue is how to diversify a portfolio against myriad risks. Earlier this year, we discussed how low nominal yields on government bonds reduced their ability to hedge equity risk.¹¹ A period of rising inflation, should that transpire, would make hedging equity risk that much more difficult. This is because the equity/bond correlation tends to be positive in a high inflation regime (Chart 9). The positive correlation thus adds to, instead of reduces, equity risk.

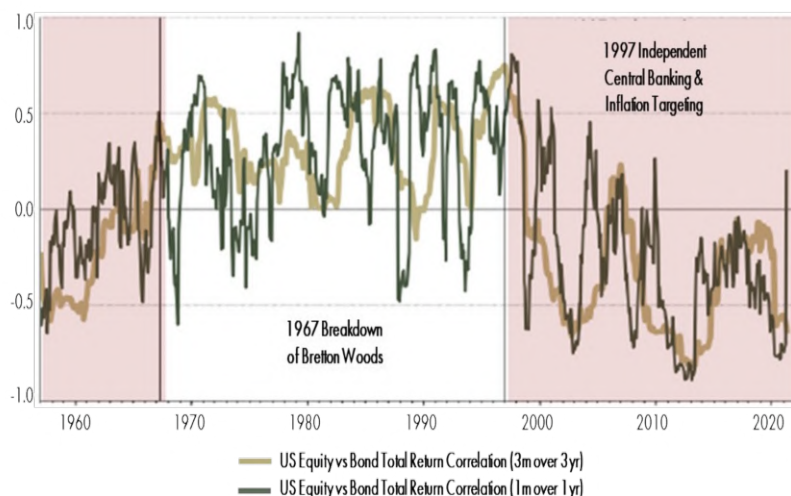
A positive correlation between equities and bonds can thus be interpreted as a concern about rising inflation. In the 1960s, the equity/bond correlation was negative, but as inflation risks grew, the correlation turned positive in the 1970s, and stayed positive into the 1990s, when eventually inflation risks abated. For the past twenty years, the equity/bond correlation has been negative, reflecting low and stable inflation. But recently, that correlation has turned positive again (Chart 10).

Chart 9 Equity/Bond Correlation vs. Realized CPI 1990-2021



Source: Goldman Sachs

Chart 10 U.S. Equity/Bond Correlation, 1958-2021



Source: ASR Ltd. And Refinitiv Datastream

¹¹ https://www.angelesinvestments.com/insights/video_pdf_presentations/webinar-replay-a-solutions-oriented-framework-to-strategic-asset-allocation.

We are at a moment when multiple cycles appear to be ending: the monetary regime of fighting inflation, the fiscal framework that approached debt with caution, the expanding global labor pool, the negative correlation between equities and bonds. All these forces favored investors in financial assets. What replaces each of these cycles is unclear. But it is the nature of cycles to take back what has been given, and reasonable to expect a more challenging time ahead for investors.

Following the bombing of Belgrade, Nazi troops occupied the city. The next month, two German army officers, who had been students of the famed paleontologist Wolfgang Soergel at the University of Freiburg, visited Milanković with greetings from Professor Soergel. Miraculously, Milanković had retrieved his manuscript from the bombed-out building with only a few pages missing. He recreated

the missing parts and entrusted his only copy with these officers to deliver it to Professor Soergel to see if he could get it printed in Germany. It was published later that year.

There are three distinct orbital movements of the Earth around the Sun:

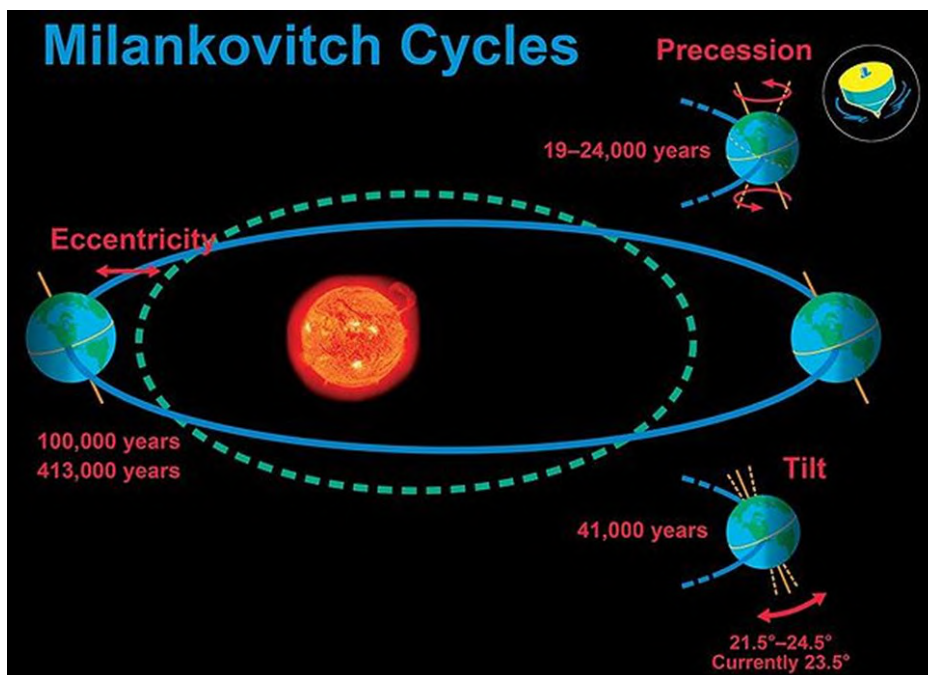
Eccentricity: the shape of the Earth's orbit around the Sun.

Obliquity: the angle of the Earth's axis relative to Earth's orbital plane.

Precession: the direction in which Earth's axis is pointed.

Eccentricity: the earth's orbit around the Sun is elliptical. Gravity from the largest gas planets, Jupiter and Saturn, pull the Earth's solar orbit away from the perfectly circular. This explains why our seasons are not of equal length: in the Northern Hemisphere, summer is currently 4.5 days longer than winter and spring is 3 days longer than autumn. Today, the Earth's orbit is near its most circular (least elliptical) in a cycle that spans about 100,000 years. Variations in Earth's eccentricity are small and are a minor factor in climate variations.

Obliquity: the tilt of the Earth's axis explains why we have seasons at all. Over the past one million years, the axis of rotation has shifted between 22.1 and 24.5 degrees perpendicular to the Earth's orbital plane over a cycle of 41,000 years. We are



Source: universitytoday.com

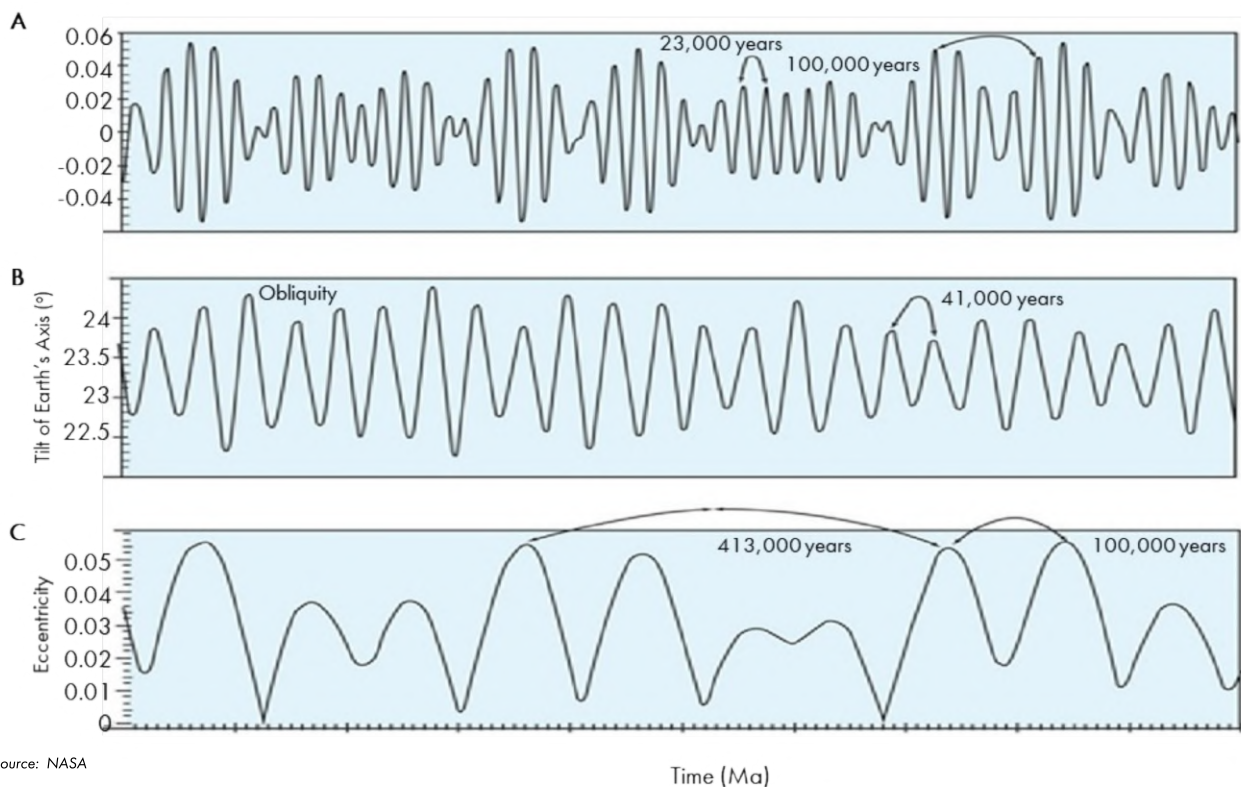
currently at 23.5 degrees, about halfway into the cycle, and the angle of tilt is decreasing. A lower angle over the next 9,800 years will make our seasons milder. These cooler summers and warmer winters will allow polar ice to build up and another ice age will occur.¹²

Precession: the Earth wobbles as it rotates due to the gravitational pull of the Moon and the Sun. This currently makes seasons in the Northern Hemisphere milder than in the Southern Hemisphere. We are also close to halfway in this 25,000-year cycle, and in about 13,000 years this will flip, and the seasons will be more extreme in the Northern Hemisphere than in the Southern.

Milanković spent decades calculating the variation in solar radiation as the Earth travels through these three different cycles. He then overlaid each of these cycles to add up the net effects of each cycle on solar radiation (Chart 11). He determined that the *obliquity* cycle was the most powerful of the three cycles in explaining variations in solar radiation, and he concluded that ice ages occurred with regularity every 41,000 years, coincident with the *obliquity* cycle.

Milanković established astronomical explanations for climate variations. Levels of carbon dioxide (CO₂) were thought to be coincident with, not causes of, climate variation by scientists of his day. For at least

Chart 11 Earth's Three Orbital Movements and Cycles



Source: NASA

¹² Unless interrupted; see below:

the past 800,000 years, CO₂ levels have fluctuated in a cyclical pattern. Until, that is, the mid-twentieth century, when levels shot higher by an order of magnitude (Chart 12). Since the Earth's temperature rises and falls with CO₂ levels, without a drastic reduction now, we could see a 10° F (6° C) increase in global temperatures (Chart 13). Astronomical cycles be damned, we are changing our climate.

Milanković's *magnus opus* was received with skepticism. Scientists doubted that his predicted temperature changes were large enough to explain glacial cycles. Some of the glacial deposits he analyzed to support his theory turned out not to be glacial deposits at all, throwing doubt on his entire work.

Chart 12 CO₂ Levels Past 800,000 Years

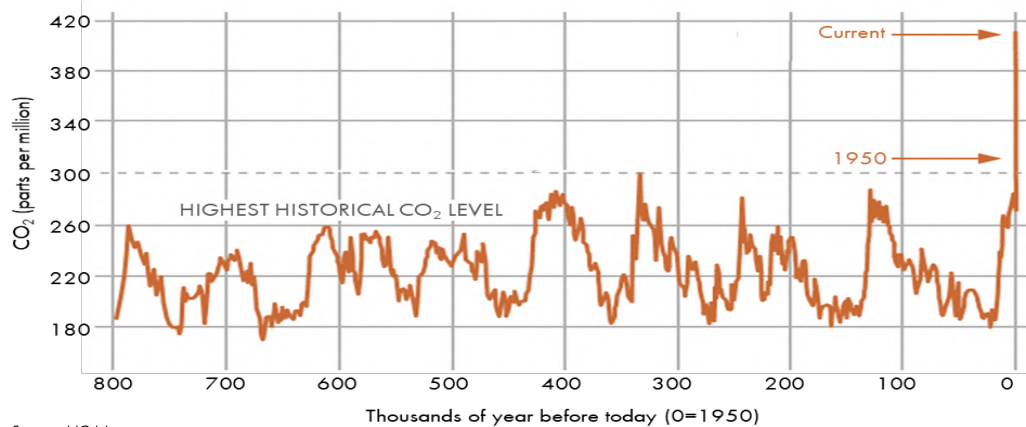
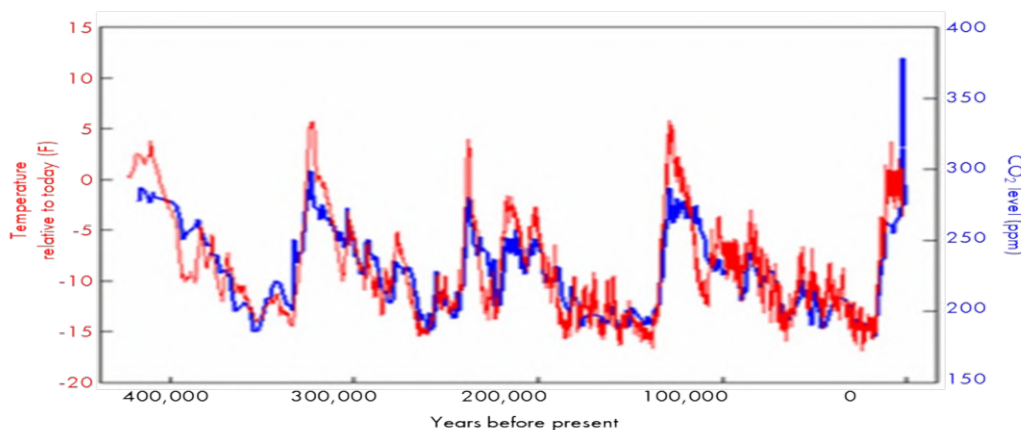


Chart 13 Global Temperature and CO₂ Past 400,000 Years



In 1955, the prominent geologist Cesare Emiliani discovered that Milanković's cycles aligned with the ratio of oxygen-16 and oxygen-18 isotopes in ocean sediment cores, and these isotopes were known to be markers of temperature. Still, the scientific community dismissed this discovery as coincidence and Milanković's work was forgotten. Milanković died in Belgrade in 1958, unheralded and obscure.

In 1976, a study¹³ of deep-sea sediment cores going back 450,000 years found that the Earth's orbital variations corresponded perfectly to evidence of glacial change. Ice ages have indeed occurred every 41,000 years, exactly as Milanković predicted. Subsequent data from ice cores in Greenland and Antarctica have confirmed that Milanković's framework explains the glacial cycles.

Milutin Milanković offered definitive evidence that variations in solar radiation caused by astronomical cycles determine changes in the Earth's climate. His work is accepted today as established fact. Astronomical cycles are determined by the laws of gravity, which are beyond our control. But the massive increase in the emission of greenhouse gases that began in earnest 200 years ago and has accelerated geometrically (astronomically?) in recent decades represents a man-made existential threat to our climate. Our environment has been altered (permanently) by our actions.

Economic cycles are less predictable, and on a much shorter time scale, than astronomical ones. For many reasons, we are at a moment of inflection, as the old regimes of fiscal and monetary frameworks fade, to be replaced by new ones. COVID-19 did more than merely disrupt supply chains, it has accelerated structural shifts in business models, consumption patterns, how and where we work, the size and role of government.



Milanković showed us the impact of astronomical cycles on our climate, helping us to see the symbiosis between our actions and our environment, be it ecological or economic. Our social landscape has been altered by the pandemic, much as the natural world has been changed by our industrial actions. For all of us, the future will be more demanding, less forgiving, more complex.

Unlike astronomical cycles, much of our future is in our control. We just need to make the right decisions.

¹³ Hays, James, John Imbrie and Nicholas Shackleton, "Variations in the Earth's Orbit: Pacemaker of the Ice Ages," *Science*, 1976.

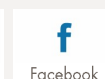


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July 2021

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