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The End of an Era

Have We Entered a Great Transition?

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The End of an Era

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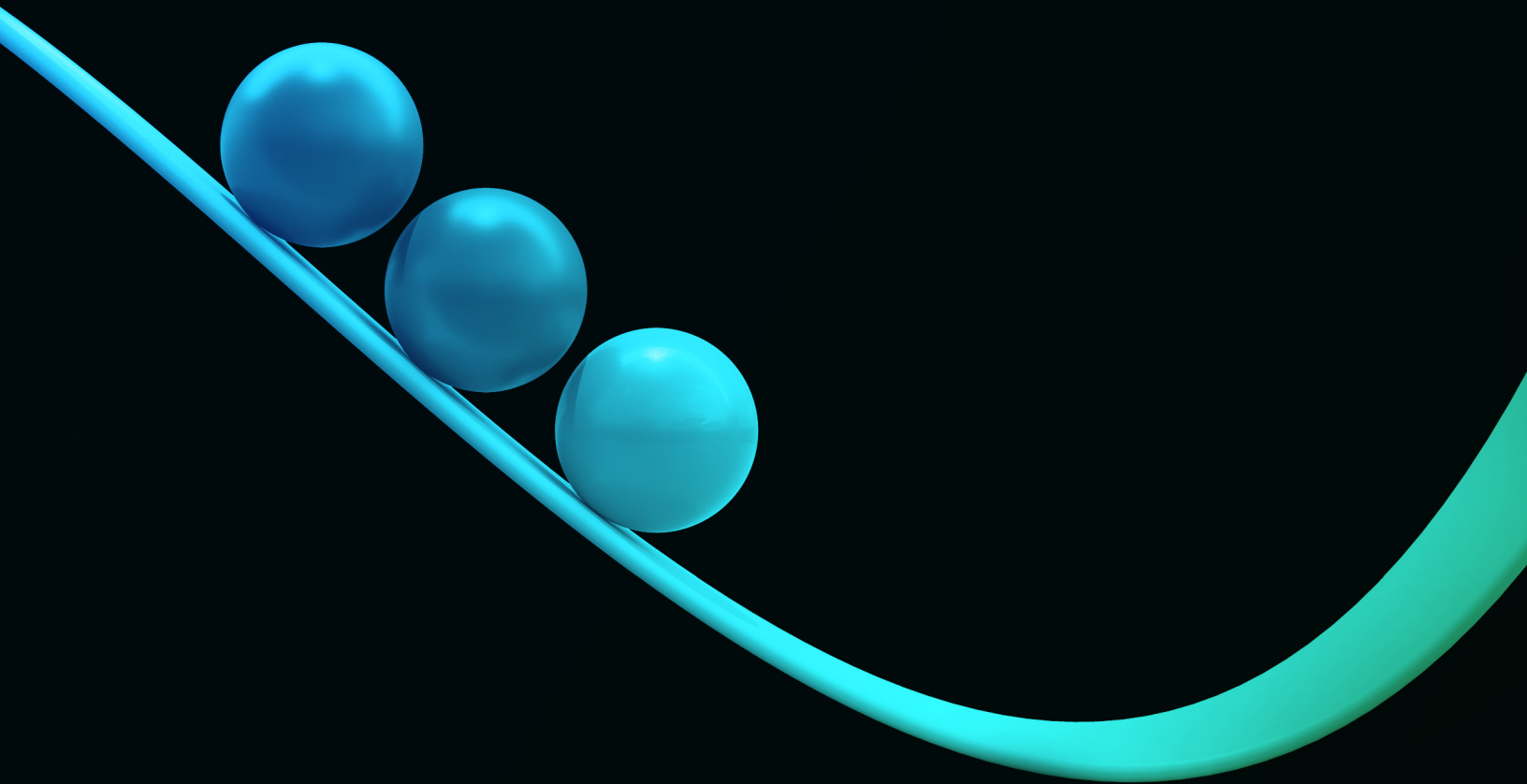
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Executive Summary



Global financial markets experienced a historic year in 2022, with record losses in both equities and bonds, and heightened risk aversion driven by multi-decade high inflation resulting in one of the fastest paced rise in policy rates by global central banks in recent history.

Much changed as bonds and traditional currency hedges failed as diversifiers of equity risk. Importantly, liquidity suffered on the back of risk aversion raising fragility risk. These developments have given rise to important questions about the future of financial markets – are we on the cusp of a “Great Transition” or are we likely to revert to the kind of markets seen prior to the onset of the COVID-19 pandemic?

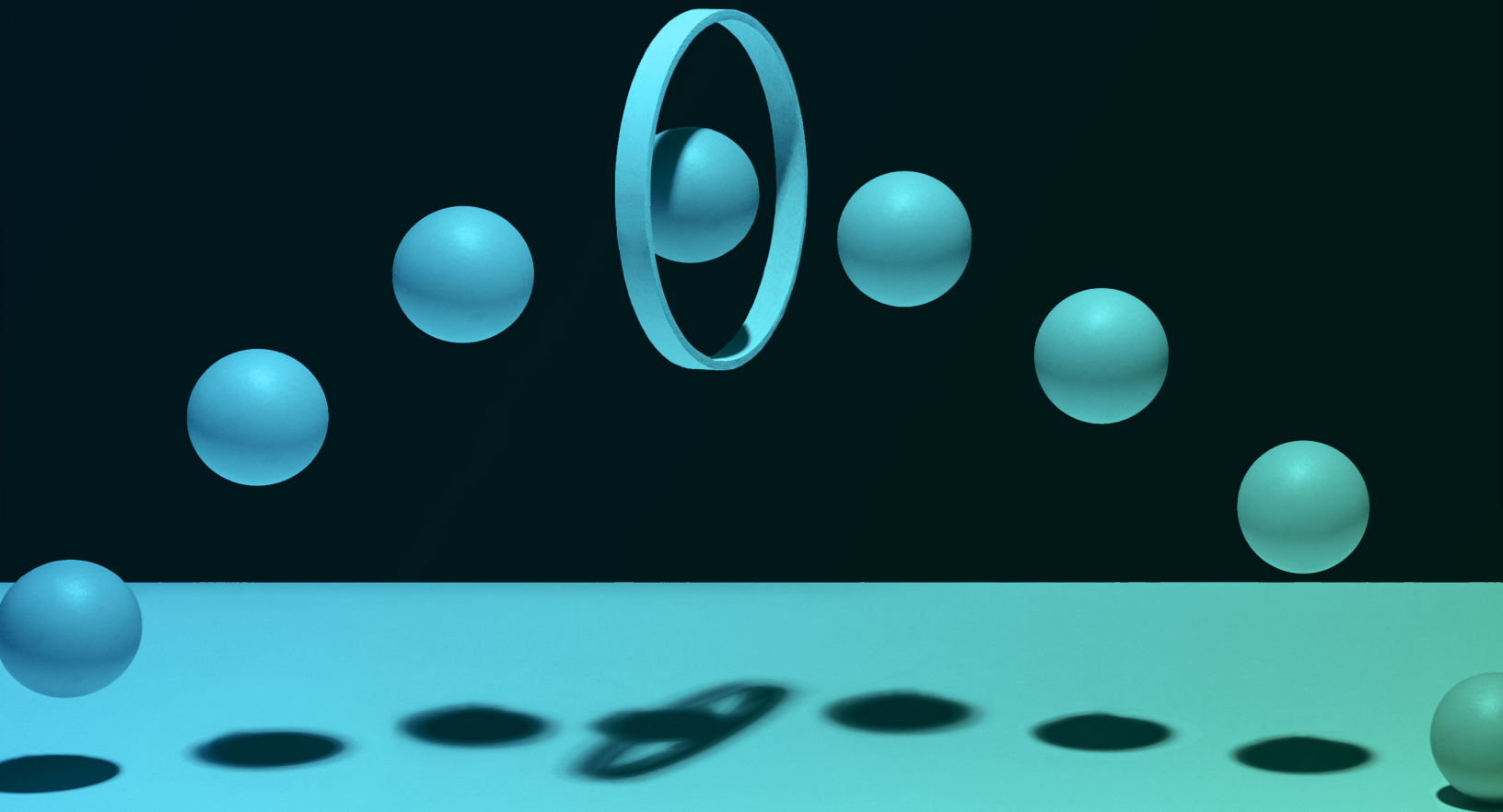
We explore challenges to monetary and fiscal policy as well as dynamics of portfolio construction in this new era. While these structural changes will likely exert inflationary pressures, increase market fragility and change the diversification dynamics across asset classes, we outline potential silver linings that may arise from the deflationary effects of technological innovation and productivity benefits from increased labor mobility due to the possible changes in immigration policy.

In this paper, we explore four structural triggers of this potential transition:

- 
- 1** Calls for strategic autonomy through initiatives such as friend-shoring
 - 2** Changes in China in a reversal of globalization
 - 3** Structural changes in labor market following the pandemic; and importantly
 - 4** Climate Transition

Chapter 1

Introduction



2022 was a historic year in global financial markets as both equities and bonds fell by record numbers¹, mortgage rates rose, growth cratered, inflation and volatility soared across all markets and traditional correlations reversed dramatically.

While geopolitical events since 2020 were an important driver of these record numbers, 2022 performance has given rise to important questions about the future of financial markets. For example, a recent position paper from the Australian Government Future Fund suggests that traditional portfolio construction is essentially dead in the wake of changes in global finance². In this paper, we primarily examine whether we are on the cusp of a Great Transition or likely to revert to the markets seen prior to COVID-19.

To address that question, it is helpful to have some historical context. The second part of the last century exhibited a great degree of time variation in global GDP volatility, particularly in the United States. The time period from 1965 to 1982 was characterized by a surge in volatility and inflation. The series of steps taken by then-Chair of the U.S. Federal Reserve, Paul Volcker, set forth the process of normalization that resulted in a sharp decline in inflation, followed by a decline in GDP volatility lasting well into the early 2000s. The former time period (1965-1982) was labeled the era of “Great Inflation” and the latter (1982-2000) the era of “Great Moderation”.

Much has been written about the era of Great Moderation by scholars including former Fed Chair, Ben Bernanke. Research has shown that the Great Moderation (as measured by the decline in GDP volatility) was driven by a decline in sectoral level volatility and factor productivity within each sector. Thus, things including globalization and evolution in technology and the energy sectors (such as digital payment and shale revolution) had important implications in shaping sectoral productivity and sectoral volatility (*Grazzini and Massaro, 2022*). Together, these factors contributed to temporal declines in GDP volatility as well as inflation volatility.³ All of this reversed in 2022.

Monetary policy was considerably more effective during the Great Moderation, as this period was characterized by lower inflation volatility. When inflation volatility is contained, macroeconomic shocks dissipate more quickly and have reduced spillover (*Borio, 2022*). This insulation from external shocks and spillovers enables monetary policy authorities to implement targeted solutions that are considerably more effective. The Great Financial Crisis (GFC) of 2007-2008 came as a true test of policy effectiveness during the era of Great Moderation.

Given the collapse in activity during the GFC, the primary goal of monetary policy was to find ways to stimulate the economy. Cutting policy rates to stimulate growth was constrained by zero lower bound.⁴ Thus, global central banks were compelled to use a combination of changes in policy rates as well as unconventional monetary policies (such as *Operation Twist*⁵ and *yield curve control*) to deal with the global macro shock of the GFC. The flood of liquidity from central banks lowered risk premia and volatility

across markets and asset classes globally. In effect, extraordinary monetary and fiscal stimuli further depressed inflation and GDP volatility in the years after the GFC.⁶ Thus, the GFC challenged, but did not curtail, the era of Great Moderation, which continued past the GFC.

Much of this pattern changed with the pandemic. Recently, the world has experienced a multiplicity of persistent shocks starting with the COVID-19 pandemic in early 2020.

In particular, economic activity has been impacted by four inter-linked shocks



the COVID-19 pandemic



the unprecedented global monetary response to the pandemic



supply chain challenges following the upsurge in demand post-abatement of pandemic



a persistent war in Ukraine causing massive disruption to energy and food supply chains

The rapidity and confluence of these shocks has taken most central banks by surprise. As is well-known, the unprecedented monetary and fiscal response to these shocks resulted in a surge in aggregate demand. A rapid resurgence of aggregate demand following the relative abatement of COVID-19 was met with shocks on the inflation front as supply chains weakened due to strict pandemic policy in places like China, Israel and India. As the world ambled back to some level of normalcy in early 2022, Russia's war on Ukraine had macroeconomic shocks scaling newer heights, starting with energy shocks that spilled over into other markets.

Today, inflation around the world is hitting multi-decade highs, government debt in most economies are at all-time highs, global supply chains are strained, and importantly, liquidity in financial markets is getting tighter than ever due to concerns of fragility and risk aversion stemming from aforementioned shocks. Moreover, structural factors such as changes in the labor market (*Mocuta and Le, 2022; International Monetary Fund, 2022*) and climate transition raise the specters of higher inflation structurally. This has created a huge increase in policy uncertainty.⁷

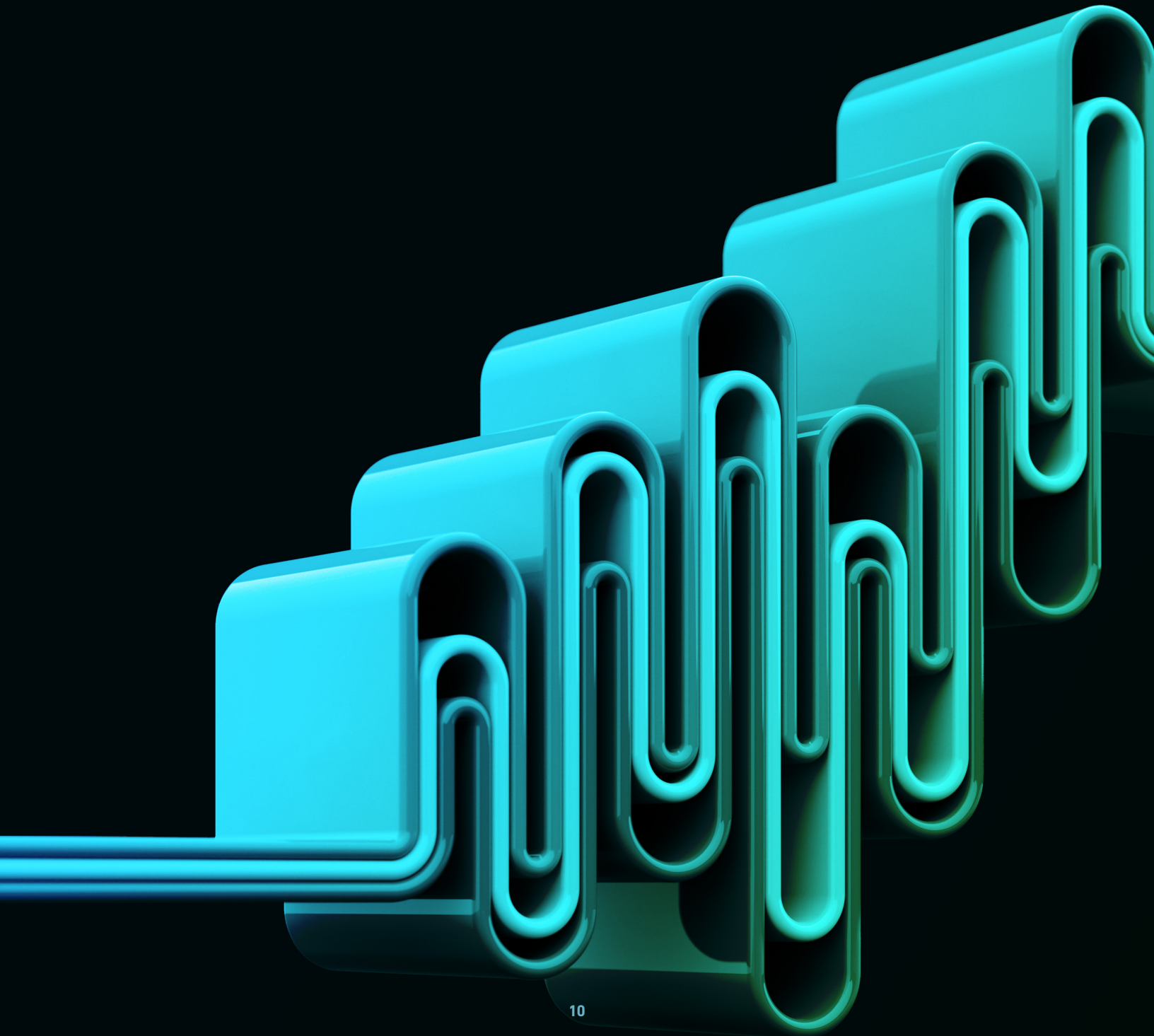
Against this backdrop, this paper asks a number of questions:

- a. Are we on the cusp of a new era of the Great Transition?
- b. Are we likely to see new, higher levels of inflation heralding a new era of higher volatility driven by structural factors?
- c. Is the upsurge in volatility in economic activity and related financial metrics likely to abate to previous levels anytime soon or likely to stay permanently higher? Related questions include, What does all of this mean for asset owners and asset managers? How does one navigate the era of higher volatility?

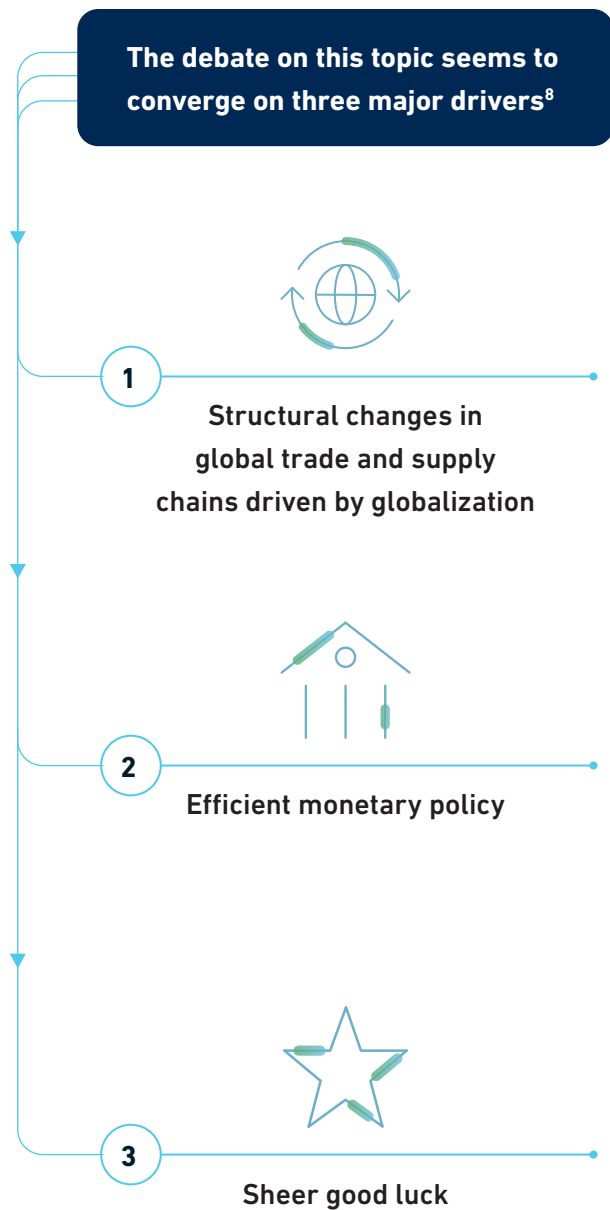
While we do not claim to have all the answers, this paper posits that what the world experienced during the era of Great Moderation is essentially over, and we are very unlikely to see a return of those times. This is because both labor and financial markets have undergone structural changes that make reversal difficult. An important expression of these changes in financial markets is heightened uncertainty and volatility. The new structural triggers of higher volatility cannot be ignored. We explore the monetary and fiscal policy challenges in this new era and suggest ways in which asset owners can navigate this new world.

Chapter 2

Why We Witnessed the Great Moderation



Much has been written about the reasons for the Great Moderation and the era of low volatility.



The easiest way to understand the role of the first two drivers would be to envision a simple canonical model of inflation. Inflation can be modeled as a function of stresses on input costs from economic activity (higher wages, etc.)⁹, inflation expectations and current levels of inflation that reflect the current regime to capture anchoring effects.

During the Great Moderation, inflation was subdued and so was inflation volatility. Why? The primary reason was globalization of supply chains. Throughout this period, stresses from economic activity did not ignite inflation impulses.¹⁰ Globalization, aided by a helpful immigration policy, ensured that abundant labor supply and production capacity kept prices and wages in check even during periods of strong economic activity.

As a result, swings in economic slack did not cause large fluctuations in inflation leading to the belief that inflationary shocks are largely transitory, which muted inflation volatility.

Given the weak link between economic slack and inflationary impulses, inflation became well anchored, as did inflation expectations. This, in turn, generated strong belief and trust in the efficacy of monetary policy.

The third driver of the Great Moderation was sheer good luck articulated by Ben Bernanke (*Bernanke, 2004*). During this era, aggregate supply conditions were well-behaved and predictable over the medium term, and supply shocks were limited. The subdued shocks in supply and aggregate demand were self-reinforcing, as the absence of severe supply shocks meant lower tail risk. As the effectiveness of monetary policy became more predictable, it led to the expectation that these shocks would respond well to monetary policy, giving rise to increased credibility of monetary policy (*Borio, 2022*).

Thus, everything fell into place during this period of benign growth – inflation was well anchored, expectations were muted, and economic stresses did not lead to inflation flares. Collectively, this built faith in the success of monetary policy and ex-post was designated as the era of “Great Moderation”.

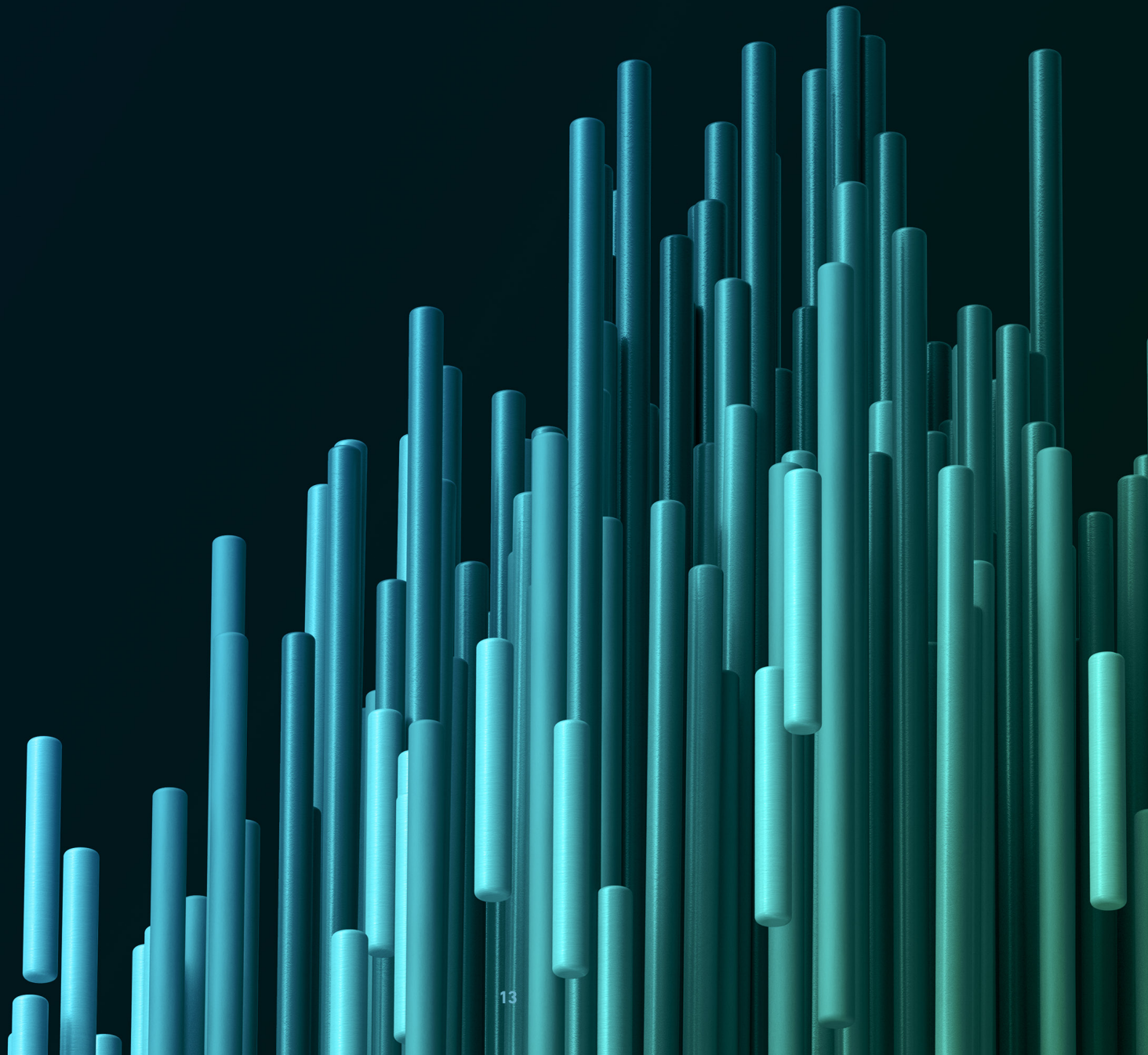
We believe that this era has ended, as the drivers of the Great Moderation have changed due to structural shifts post-GFC and particularly post-pandemic.

Today, we are witnessing a drastically different global economy that is characterized by a confluence of events such as surging inflation; globally fractured supply chains; shifting labor markets driven, in part, by changes in immigration policy; complicated energy supply dynamics; and climate transition – all of which can result in structurally higher inflation.

Accordingly, the belief that inflation will cyclically revert back to prior levels should be received with caution. The Fed has continued to view two percent inflation as its goal of monetary policy, however, we believe that getting to this level given structural changes in the market can be challenging without a prolonged period of rate hikes. Thus, we conclude that factors that drive inflation structurally higher warrant careful consideration, and there are good reasons to believe that inflation can be structurally higher than envisioned in the market. The result of this will likely mean a reconsideration of traditional portfolio construction and risk practices in the financial services industry.

Chapter 3

Changing Dynamics: Dawn of the Great Transition



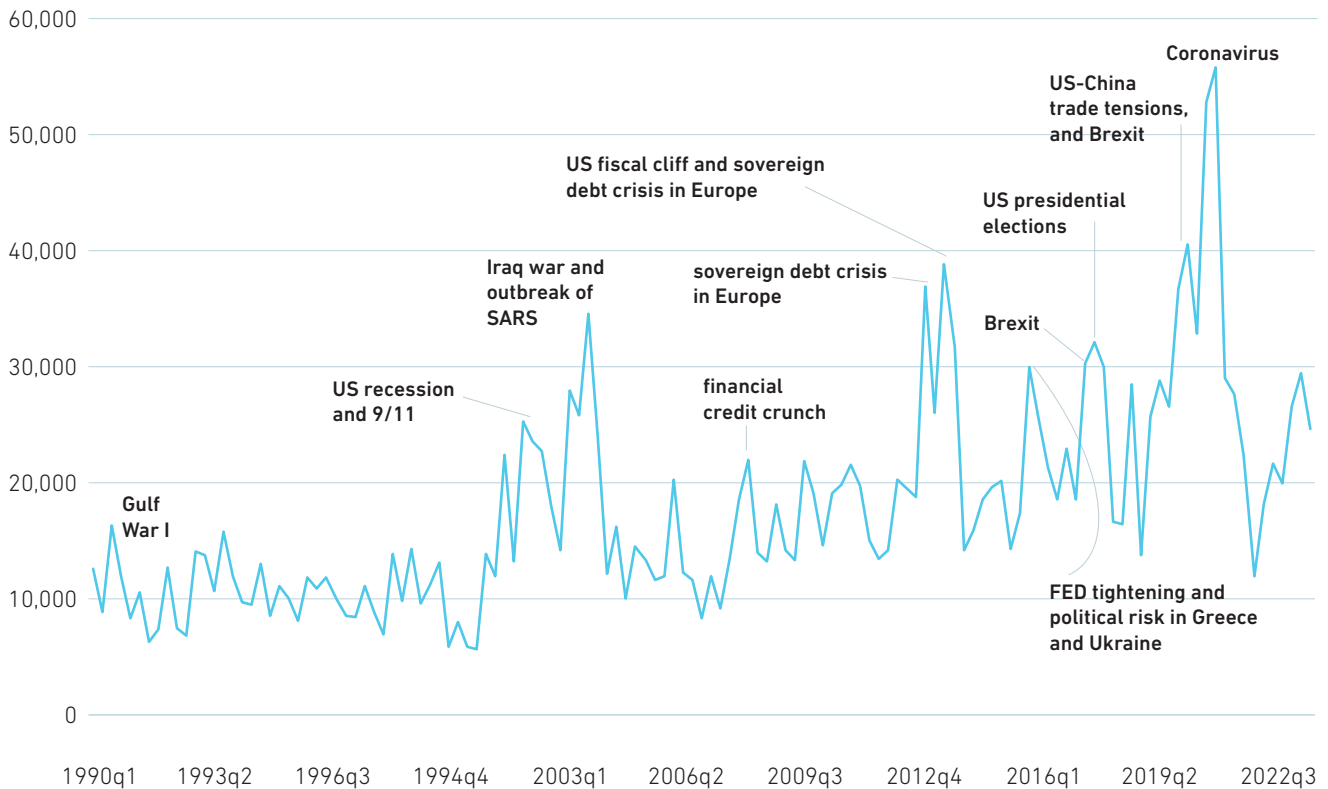
1 Multiplicity of Shocks and Calls for Strategic Autonomy

The world has suffered a sequence of adverse shocks since the GFC, which have changed the fundamental tenets of economic behavior. Prior to 2007, financial markets were governed by two key forces – (1) increasing globalization, which kept costs low and inflationary impulses contained; and (2) the rising hegemonic role of the dollar and interconnectedness of financial markets, which served as a transmission

mechanism for shocks (positive or negative) through the global financial system.

The GFC highlighted that financial shocks in the US can have major consequences on global economies, giving rise to the term “Our Dollar, Your Problem!”.¹¹ A sequence of adverse shocks since the GFC led to increasing uncertainty in policy markets, which can be seen in Exhibit 1.

Exhibit 1: World Uncertainty Index



Source: Ahir, H, N Bloom, and D Furceri (2022), “World Uncertainty Index”, NBER Working Paper

Protectionist Policies, Pandemic and Calls for Strategic Autonomy

In 2016, we saw the emergence of heightened calls for a move away from globalization under the Trump Administration.¹² The rhetoric was driven by a desire to stem the substitution of local labor for global labor. Immigration policies changed and thus began early action on the move to strategic autonomy from the perspective of the labor market. Other similar calls surfaced in parts of Europe where local labor was disenfranchised.

The rapidity of COVID-19's global proliferation, and the policy initiatives following such proliferation (such as India curbing supply of vaccines), highlighted the challenges from globalization. Supply of critical components such as semiconductors experienced severe shortage primarily due to the fact that manufacturing of chips were concentrated in a handful of countries.¹³ Calls grew for curbing the forces of globalization in critical areas.

Very few geopolitical events outlined the ills of globalization as did Russia's invasion of Ukraine. As we approach that event's one-year anniversary, the war in Ukraine has materially interrupted global supply chains (especially in food and energy), and resources such as access to energy lines became weapons of war. As the world came to realize that resources can be "weaponized," countries began striving for more autonomy and less dependence on strategic areas such as energy.¹⁴

Thus, the chain of events following the GFC (and particularly following the outbreak of COVID-19) resulted in a clarion call for strategic autonomy in many countries. The war, and

importantly the practice of weaponization of supply chains and financial eco-systems, made it abundantly clear that the extant cost-optimized global supply chain paradigm was fragile and created unhealthy dependencies. Acts such as wars (including cold wars), sanctions and even unexpected events (such as outbreak of fires)¹⁵, resulted in significant failure of the whole system, leading to wide and costly supply disruption and volatility in financial markets.

The fragility of the extant supply chain paradigm was the result of the focus on cost optimization, which resulted in concentration of strategically important assets such as semiconductors in a few companies/countries.¹⁶ More recently, countries such as the US have accelerated actions to redraw the map of global supply chain through friend-shoring/reshoring initiatives. Rational response of countries to achieve strategic autonomy will likely result in more fragmented and regionalized value chains for traded goods.

Strategic autonomy in global supply chains will necessarily mean that cost efficiency is not the only objective. Additional objectives include diversification of supply chains and reliability of supply during stress times. These additional objectives invariably translate to higher prices of goods.¹⁷ While complete, self-sufficient strategic autonomy in all areas is unlikely due to the web of existing dependencies, governments around the world will try to build more resilience and strive for greater competitiveness.¹⁸ We believe that the intensity of experiencing these shocks in short succession is likely to set forth a sequence of events toward strategic autonomy that will lead to structurally higher inflation and volatility.

2 China Maturing

Ever since joining the World Trade Organization (WTO) in 2001, China has been the backbone of global manufacturing, and over the last two decades has become a low-cost “factory of the world”.¹⁹ By providing low-cost manufacturing and labor, China served as a deflationary force on the world economy that contributed to the low, stable inflation we witnessed during the Great Moderation.²⁰

China today is going through both internal and external changes that will likely transform this important economic power in dramatic ways compared to the last two decades. These notable changes include changes in economic structure, changes in demographics and changes in political landscape.

Economic Structure

As China’s economy reaches a mature state, its structure is gradually shifting from an economy that is largely export-oriented to one that is import-oriented to support increasing domestic consumption.

According to the United Nations Conference on Trade and Development (UNCTAD), the share of exports in the Chinese economy has been rapidly declining recently as can be seen in Exhibit 2, implying increasing prominence of domestic demand. In addition, labor costs in China have been increasing, which erodes the nation’s competitiveness as a global manufacturing hub.²¹

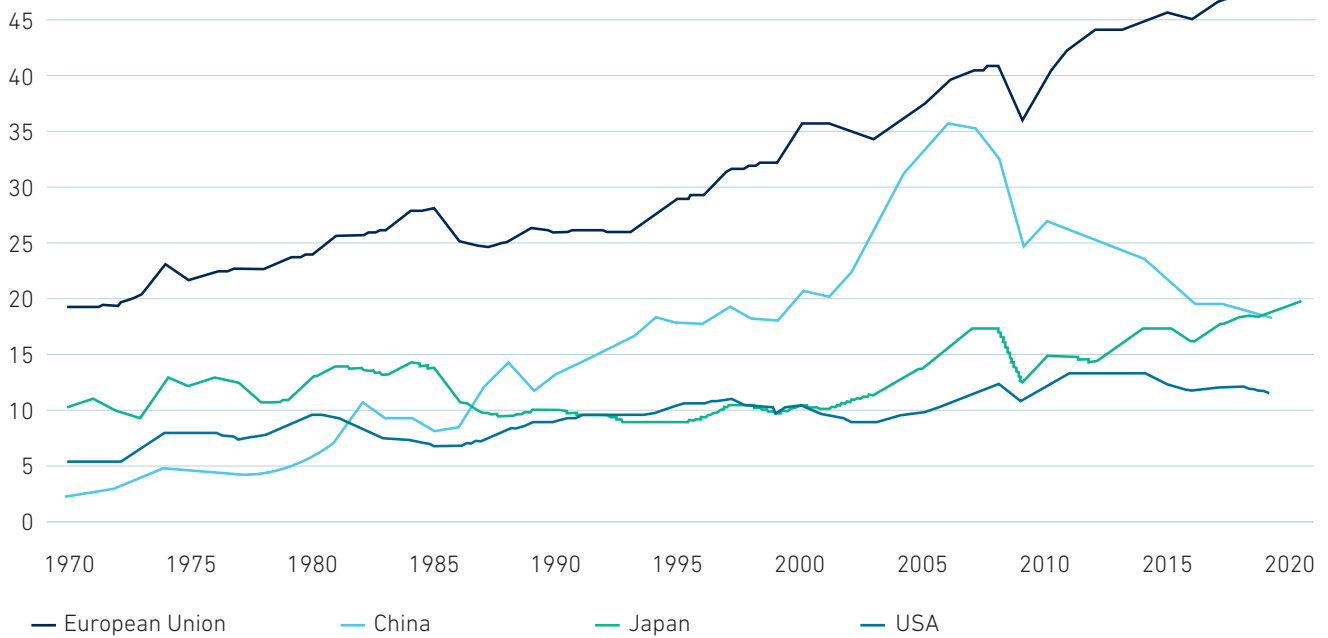
Recently, the government has made important changes to its economic policy in a shift away from being the low-cost factory of the world. For example, “Made in China 2025” policy is the government’s 10-year plan to transform China’s manufacturing base by rapidly developing 10 high-tech industries including electric vehicles, telecommunications, advanced robotics, artificial intelligence, etc.²² This shift away from low-value added, low-wage manufacturing to a high-tech, high-productivity economy necessarily implies that the world might no longer take as a given China’s role as a source of abundant low-cost consumer goods.



Exhibit 2: Exports of Goods and Services (% of GDP)

Chinese economy is increasingly about the internal sector

Exports of goods and services (% of GDP)



Source: UNCTAD

Demographics

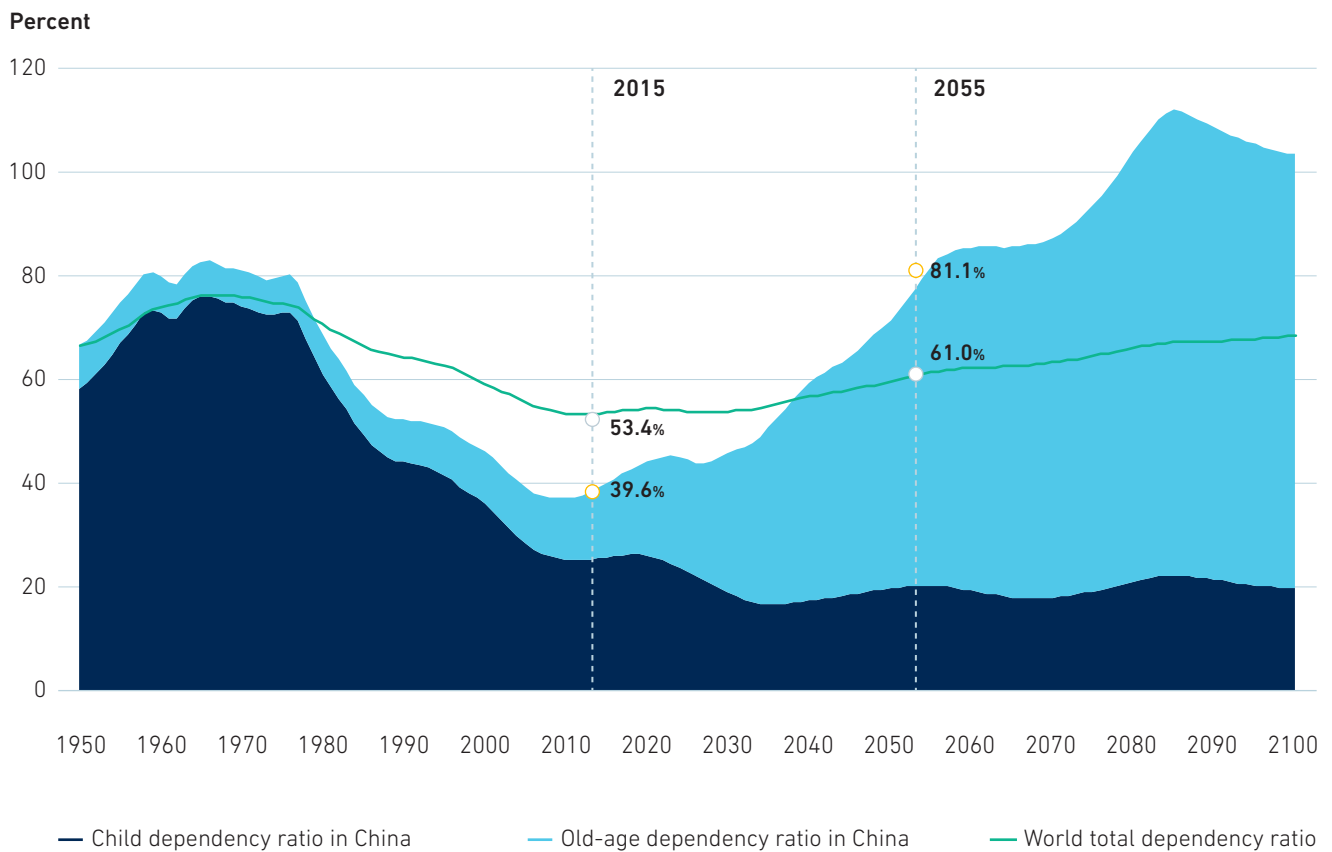
China’s demographics are also maturing, with the fertility rate having fallen below the replacement rate and continuing to decline. This trend promises to lead to a rise in the dependence ratio as can be seen in Exhibit 3. In fact, the United Nations expects that China’s dependency ratio will be above the world average by 2040.²³ What is the implication of the country’s changing age structure? We see two implications. The first implication is that the declining fertility rate should, over time, reduce the supply of labor, making it difficult to continue

to be the “low-cost factory” of the world. While the threat is not immediate, the effect of “one-child” policy instituted many decades ago is starting to impact dependency ratios, which will potentially erode the labor cost advantage of shifting manufacturing to China. The second implication is that of increasing dependency ratio on inflation. Research is somewhat divided on the inflation implications of aging populations. Papers such as *Goodhart and Pradhan (2020)* claim that an aging population adds to domestic inflation whereas others like *Yoon et al (2014)* claim it to be deflationary. That the effect on

inflation is nuanced and a function of distribution of age is made clear by *Juselius and Takats (2018)*, who show that the only cohort of the age structure that is deflationary is the working age group. Their robust results, analyzing data over nearly 15 decades and 22 countries show

in a statistically significant manner that as the proportion of the young (under 19) and the old (over 65) go up, it is more likely to ignite inflationary impulses in an economy. The direction of the journey from this demographic effect points to higher inflation.

Exhibit 3: China's Dependency Ratio



Source: United Nations, Department of Economic and Social Affairs, Population Division (2022), World Population Prospects 2022, Online Edition

Changes in Political Landscape

In October 2022 at the 20th National Congress of the Chinese Communist Party (CCP), Xi Jinping, current President of China, secured an unprecedented third term as party leader. President Xi has demonstrated a strong nationalistic stance in his last two terms through initiatives and policies that include

the Belt and Road Initiative, Made in China 2025 policy, One China policy, etc. From a macro perspective, this raises a concern over ongoing and deepening geopolitical tensions between China and the US. In fact, recent surveys have clearly noted this increase in likelihood of economic tension as seen in Exhibit 4.

Exhibit 4: Perceived Likelihood of Escalating Economic Tensions between the United States and China

Respondents in the United States and China were asked to predict the likelihood of bilateral economic tensions increasing over the next 12 months

Among U.S. adults



Among Chinese adults



— Very unlikely — Somewhat unlikely — Don't know/No opinion — Somewhat likely — Very likely

Source: Morning Consult. Accessed on November 17, 2022

In summary, after extraordinary growth over the last three decades, China is reaching another stage in terms of economic structure, demographics and politics. We believe that this

transformed and mature China will likely not continue to serve as a deflationary force but instead will contribute uncertainty to the global economy through its new stance in the world.

3 Structural Changes in the Labor Market

Two years after the onset of the pandemic, economists have observed important changes in the labor market evidenced by (a) uneven recovery of jobs across different job categories, (b) extraordinary tightness in some job market segments, and (c) fundamental changes in the formation of slack in labor markets based on the ability to work from home, which improves the mobility of those already employed.

While these trends are still in their early stages, it appears that the pandemic may have contributed to structural changes in the labor market that may take years to normalize while elevating the contribution of labor to overall inflation.

Changes to Labor Market Since the Pandemic

In addition to the tragic loss of more than a one million lives, the global pandemic resulted in more than 16 million cases of long COVID-19 and more than 1.7 million cases of disability. Given that the pandemic disproportionately impacted the elderly and those in contact-intensive sectors, the recovery of the labor market post-COVID-19 has been skewed and the reversal of labor slack to normal levels is uncertain, giving rise to concerns of structural shifts in the future labor market.

Labor economic theories have historically focused on the relationship between unemployment and inflation based on the *Phillips curve*. The rationale was simple – unemployment measures scarcity of labor, which should be inversely related to its price and, hence, inflation.

For years, the Phillips curve has been a good descriptor of the labor-inflation relationship.²⁴ As noted above, the pandemic changed the relationship, as certain segments of the market such as the elderly, those in high-contact industries, and families with young children simply did not conform to the hypothesized behavior of the Phillips curve. Thus, the reversal of labor dynamics post-COVID-19 started taking a different path, with high wage pressures in more competitive segments of the market (such as highly skilled laborers) and other segments facing fears of disappearance (such as elderly), and yet others facing structurally higher wages due to reduced supply (low-skilled labor and contact-intense sectors).²⁵

A New Wrinkle to Labor Market Dynamics in the Post-Pandemic World

A new dynamic in the post-pandemic world is the increased ability of presently employed people to look for other jobs partly due to the increasing acceptance/popularity of being able to work remotely, which heightened job-to-job mobility. According to the Department of Labor, the fraction of Americans switching jobs has been increasing at a very fast pace in the last 18 months.²⁶ This implied that the labor market was no longer defined solely by the unemployment rate, but by two additional factors – (1) the share of currently employed looking for other jobs and (2) the degree of misallocation of laborers (from high-paying jobs to low-paying jobs) that followed the dislocation from the pandemic.

Thus, the key determinant of the inflationary impulse of the labor market – namely, “slack” – needed to be redefined to accommodate new dynamics in the post-pandemic world.

Comprehensive research from the Chicago Fed (*Faccini et al., 2022*) studying these additional determinants has noted that the reduction in slack and tightening of labor markets from employed workers seeking other jobs was meaningful. In particular, the authors found that a nearly one-percent wage inflation was driven by this labor market segment seeking additional opportunities and driving up costs.

The reduction in slack was particularly notable among low wage, younger workers, according to *Autor et. al. (2022)*. The authors find that job-to-job transition rates were higher among younger and lower skilled workers than they were among older and higher skilled workers.

This has led to increased price elasticity in the lower skilled group resulting in sharper wage growth as transition accelerates in this group. Overall, the authors found that tight labor markets contribute about one percent to post-pandemic inflation. This change in the labor demand-supply dynamic in low wage cohort may be a lasting contributor to future inflation.

It is not clear how persistent these trends will be as the world returns to a semblance of normalcy and “Return to Office” programs are implemented. In the end, no firm would pay labor more than it makes sense economically and no firm has an unlimited pricing power to compensate for increased costs. As the difference between potential future earnings and current earnings normalizes, we may be able to see a return to more virtuous wage inflation cycle. We strongly believe, however, that in the absence of a deeper recession that could magnify slack, labor markets can continue rising out of a structural change in labor mobility due to heightened acceptance of remote working. This change in labor mobility may result in a structural shift in the way labor market slack responds to changes in aggregate demand, which will likely be inflationary in the medium term.

We strongly believe, however, that in the absence of a deeper recession that could magnify slack, labor markets can continue rising out of a structural change in labor mobility due to heightened acceptance of remote working.

4 Climate Transition

Due to exponential growth in the use of fossil fuel energy since the early 1900s, the world is now 1°C warmer than it was in the pre-industrial era, with frequent extreme weather events becoming a commonplace. As a result, per the 2015 Paris Climate Accord, governments around the world have committed to curtail their greenhouse gas (GHG) emissions and collectively make the world transition to a net-zero carbon emission state by 2050. Thus, the growing focus on climate change and the resulting likely transition of the main source of energy from fossil fuel to greener alternatives is another major force driving the Great Transition.

Transition from fossil fuels to renewable energy sources is inevitable to meet the net-zero target. This transition will have profound implications on the global economy in several ways, the most notable being what *Isabel Schnabel* termed as “fossilflation” and “greenflation”.²⁷

While the costs of renewables have come down dramatically in the last decade, fossil fuel still plays a key role in meeting global energy consumption, as we are witnessing in Europe today. Fossilflation refers to inflation coming from the increasing price of fossil fuels due to either their reduced supply or the increased price of carbon in the path to transition. Analysis by the International Energy Agency shows that the supply of low-emission energy sources will not be sufficient to fully substitute for fossil fuels,²⁸ as the supply of low-emissions energy will take time to ramp up. In the interim, efforts to curb the use of fossil fuels such as carbon-pricing or capping supply will increase the prices of fossil fuels. This is the main idea behind fossilflation.

Greenflation, on the other hand, refers to inflation arising from increasing price of metals that are necessary to build renewable energy infrastructures such as solar panels, wind turbines and electric vehicle batteries.²⁹ As seen in Exhibit 5, demand for the metals necessary to build renewable infrastructures such as copper, zinc, nickel, cobalt and lithium are likely to grow exponentially in the net-zero economy. According to the IMF, their supply is not sufficient to meet surging demand.³⁰ This will add further volatility in the market and can impact the prices of other capital goods that use these metals as raw materials. This is the primary idea behind greenflation.

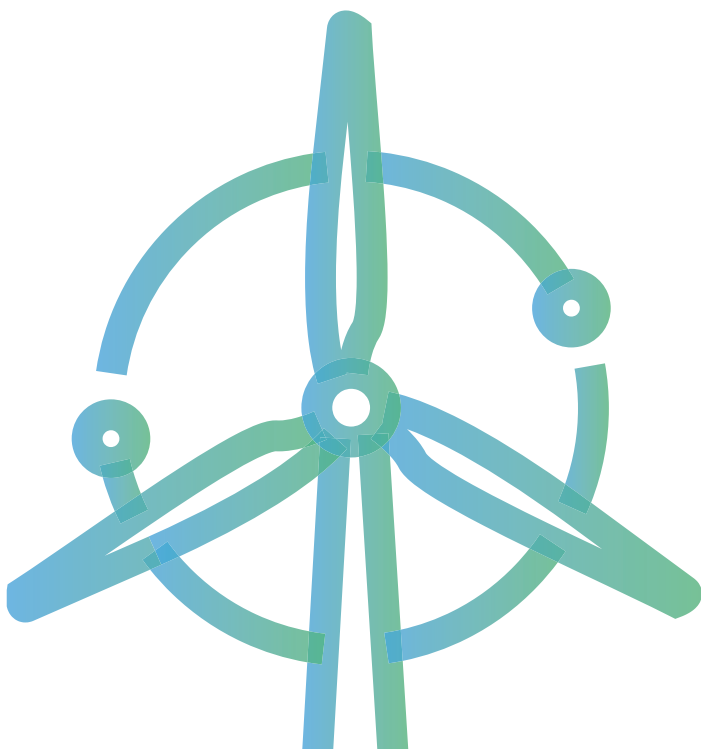
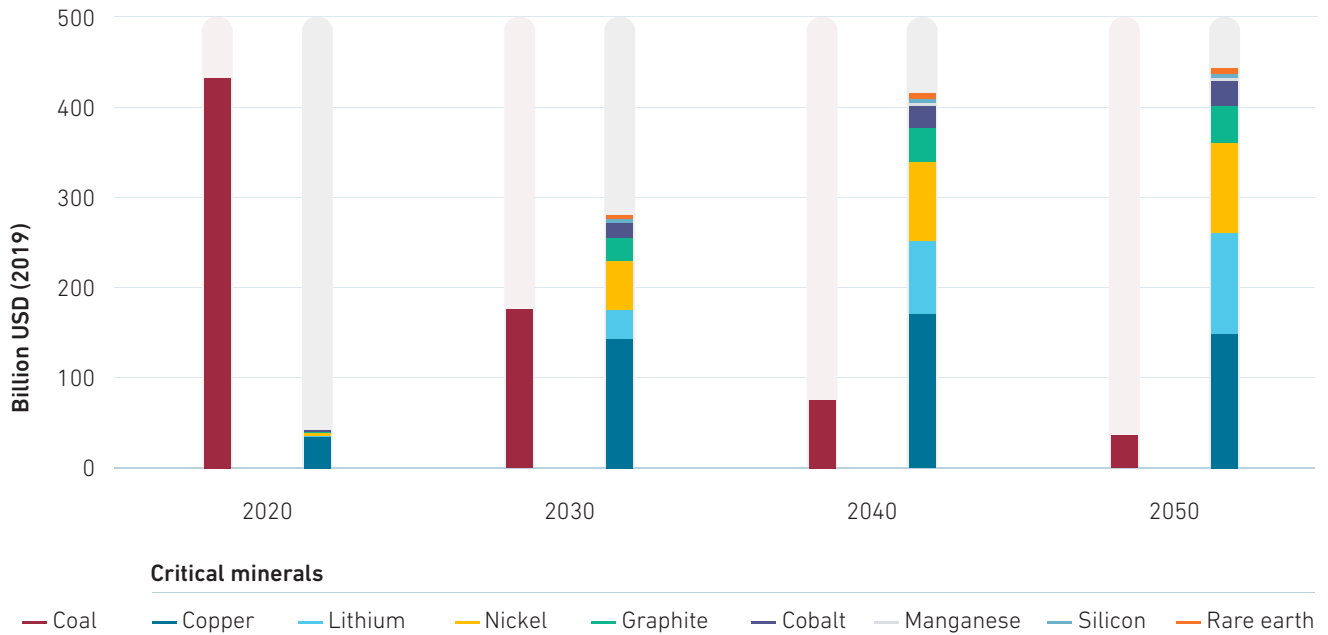


Exhibit 5: Global Value of Coal and Selected Critical Minerals in the Net Zero Economy



Source: International Energy Agency (2021), Net Zero by 2050, IEA, Paris

Consistent with the objectives of the Paris Accords, a net-zero economy must be achieved in a timely manner to avoid catastrophic consequences of climate change. The path to successful transition, however, is not without cost and uncertainty. We believe that transition will involve periods of higher inflationary forces and uncertainty due to demand/supply imbalance in both primary energy sources and raw materials required for transition.

Summary

In summary, all the structural changes highlighted above – strive for strategic autonomy, maturing China, changes in labor market, and climate transition – are likely to be inflationary at least in the near term and also result in elevated volatility. Are these inflationary forces likely to be permanent? We believe that technological changes will help ease some of the inflationary effects from these structural changes. This is because every crisis has brought forth technological changes that have benefitted the world from the point of view of cost and efficiency. We discuss this idea next.

Chapter 4

Role of Technology as Deflationary Counter Force



In his 2005 testimony before the U.S. Congress, then-Chair of the Federal Reserve Alan Greenspan stated that “the past decade of low inflation and solid economic growth in the United States ... is attributable to the remarkable confluence of innovations that spawned new computer, telecommunication and networking technologies, which have elevated the growth of productivity, suppressed unit labor costs and helped to contain inflationary pressures.”³¹

As noted by *Greenspan*, technology has been a key deflationary force over the last three decades, increasing labor and capital productivity.

Several studies empirically confirm the deflationary force of technology. Using foreign output gap and utilization of technological inputs in products and services as measures of globalization and technology, *Lv, Liu and Xu (2019)* assessed the contribution of both factors to inflation and found that the impact of technology on inflation has been increasing over the past 20 years.³² *Poloz (2021)* assessed the past three industrial revolutions and found that technological advances all resulted in creative destruction, financial excesses, lower inflation and rapid productivity growth through a rise in aggregate supply (thus, increased productivity) and more efficient labor inputs (thus, lower labor costs).³³

Technological innovations that encourage labor participation in new post-pandemic working environments have the potential to counter inflationary forces from structural changes in labor market. Remote working tools including Zoom and cloud-based storage tools are notable examples that have mitigated shocks to labor markets and aggregate economy during the global shock-like pandemic. *Fernald and Li (2022)* find that labor productivity in industries where it is easy to work from home has grown faster than those where it is difficult to work from home. Robots, speech recognition technology and other innovations have now become part of the services sector landscape.³⁴

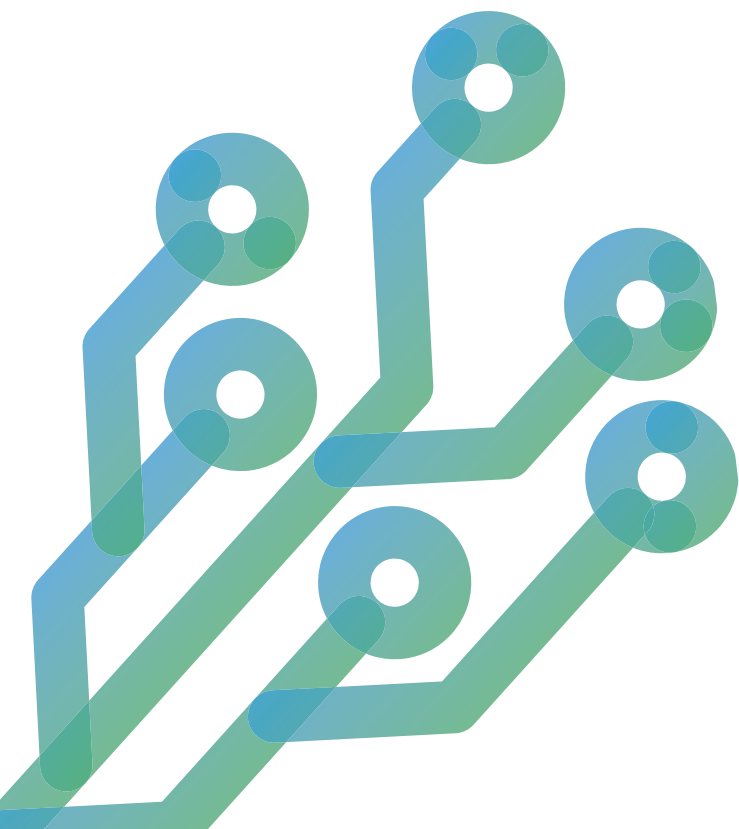
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A prominent example of an industry in which technology can meaningfully reduce costs is the mortgage origination industry. For example, a study by *Freddie Mac* estimates a cost saving of US\$200-US\$700 per loan and saving in closing time of 5-18 days, which translates to approximately US\$6.5 million in revenue per year.³⁵ Innovations such as Rocket Mortgage have also been able to cut closing time and costs as a result of applying algorithms to credit and payment data of mortgages.

Finally, as the transition to green technology accelerates, potential exists to reduce energy costs with new breakthroughs. One example is an effort to improve cobalt-free batteries among key companies like Tesla which, if realized, will make electric vehicles (EVs) markedly cheaper and likely spur EV adoption.³⁶

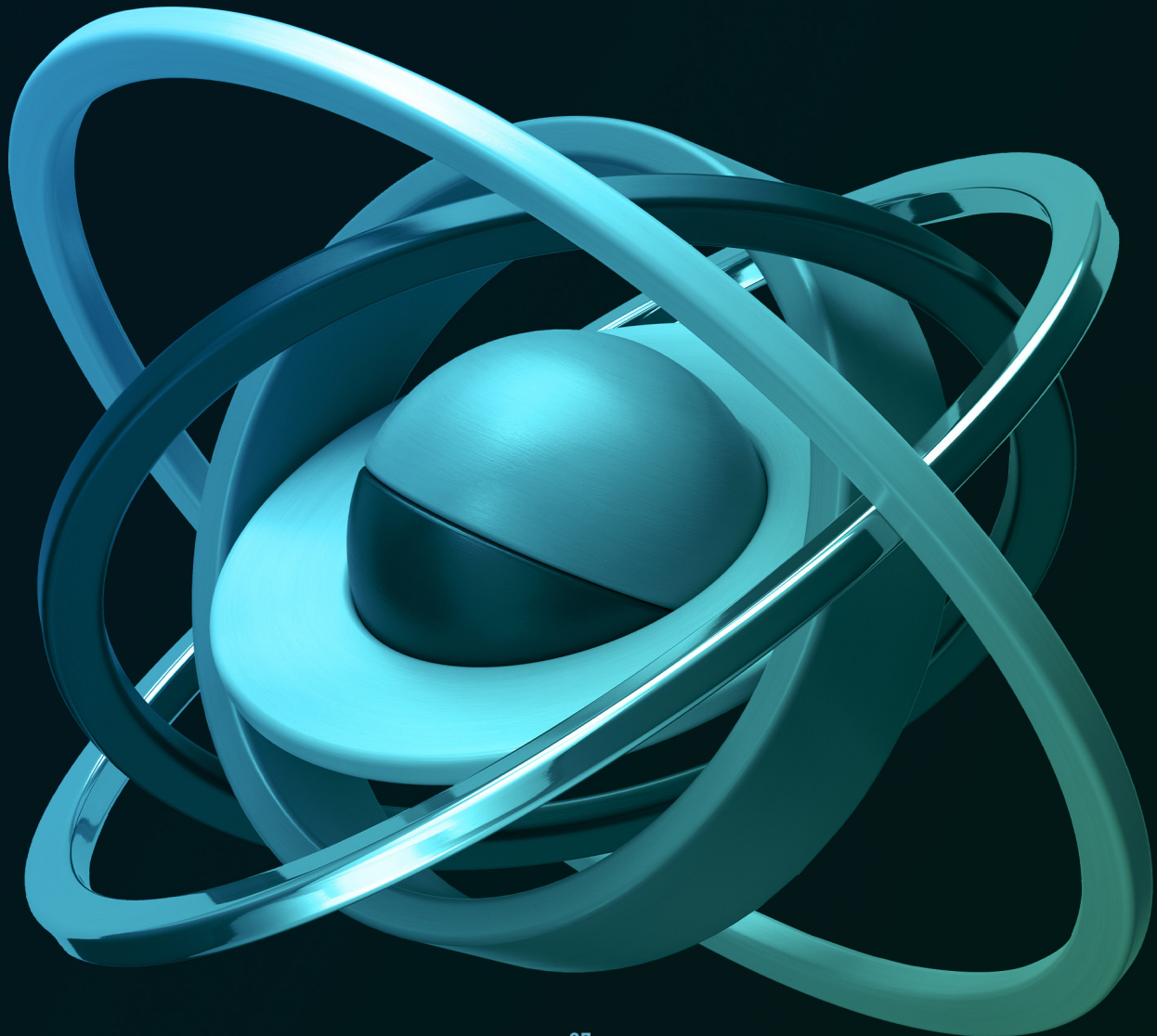
These technologies are also fungible across borders, meaning that technology developed in one location can be used in different locations with more competitive marginal cost of implementation. An example technology fungibility is the solar panel. Originally backed by Japanese and American policies, solar technology moved to Germany and eventually to China to bring down the cost further. *Helveston, He and Davidson (2022)* estimate that the globalized solar photovoltaic module market resulted in saving of US\$24 billion in the US, US\$7 billion in Germany and US\$36 billion in China from 2008 to 2020.

As history has shown, we believe technology has the potential to be a significant deflationary force by solving the labor shortage issues and optimizing the use of current resources. Furthermore, we believe that technology advances will play a key role in the transition to a net-zero emissions economy and continue to serve as a deflationary driver of the Great Transition. While we do not know which technology will emerge as a winner comparable to the steam engine, electrification, and computer chip seen during the past three industrial revolutions, we feel optimistic about the emergence of technological advances that can exert disinflationary forces through the replacement of labor costs as well as extension of productivity of capital expenditures.

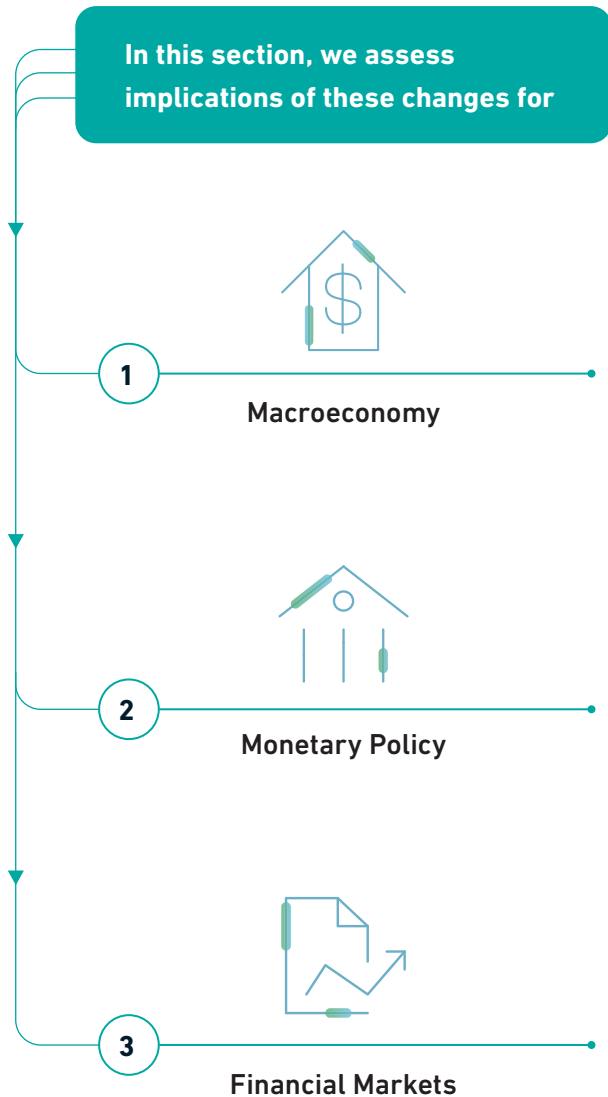


Chapter 5

Implications of the Dawn of a New Era of Higher Volatility



Changes to the global economy from forces outlined in the earlier sections – the drive for strategic autonomy, structural shifts in the focus of Chinese policies and demographic effects, and, finally, the costs of climate transition — can collectively contribute to tectonic changes in the global economy.



Implications for Macroeconomy

The structural changes discussed in the earlier part of this paper will likely accelerate inflationary impulses to multiple segments of the global economy. Structurally higher and longer inflation induces materially different price dynamics than one in a low, stable inflation regime. *Borio (2022)* presents key features of inflation dynamics during low and high inflation regime, which are:

1. During high-inflation regimes, it is the correlation among individual price changes and not the volatility that drives the change in inflation. Thus, the degree to which idiosyncratic price changes spill over to other sectors broadly becomes higher in high inflationary regimes.
2. The spillovers of shocks in prices across all sectors and countries tend to increase in high-inflation regimes implying that monetary authorities should not look through energy and food inflation during these environments. Research has shown that during low-inflation regimes, relative price

changes do not leave a lasting impact on aggregate inflation, and the inflation to some extent is self-equilibrating. On the other hand, during a high-inflation regime, inflation becomes increasingly sensitive to relative price shocks including large currency depreciations, and there is no self-equilibrating property.

High inflation is associated with higher inflation uncertainty, which increases inflation risk premium and potentially forces central banks to raise interest rates to help contain inflation uncertainty from the demand channel. Central bank tightening heightens interest rate volatility and can, in turn, cause output volatility. All of these result in escalation of volatility in metrics of financial markets such as equity and rate volatility.

Implications for Monetary Policy

Global debt reached a record US\$303 trillion in 2021³⁷, the equivalent of 350 percent of the global GDP. Excessive levels of debt limits central banks' capacity to implement countercyclical measures when those are most needed. According to *Bianchi and Melosi (2022)*, "trend inflation is fully controlled by the monetary authority only when public debt can be successfully stabilized by credible future fiscal plans." Excessive public debt (relative to GDP) will lead to instability in public finances resulting from the fiscal-led policy regime. In other words, when there is no increase in taxes or no spending cuts that reduce the debt burden, monetary policy will likely have a limited effect on controlling the inflation. ³⁸

Limitation of monetary policy implies that inflation induced by the end of Great Moderation can be structurally higher and stay longer.³⁹

Implications for Financial Markets

Higher volatility resulting from higher inflation can cause friction in the financial market through the increased risk of market fragility and increased risk-aversion of liquidity providers.

Market Fragility

When the market experiences higher volatility, liquidity providers become more risk averse and transaction costs spike. When liquidity dries up, minor shocks can be exacerbated into major shocks, increasing the risk of market fragility. Recently, the U.S. Treasury market has been experiencing some of its worst liquidity challenges since March 2020. As the Fed, which has been the largest buyer of U.S. Treasuries through Quantitative Easing (QE), steps back and begins balance sheet contraction through Quantitative Tightening (QT), the Treasury market has begun to see significant liquidity strains and heightened concerns of fragility.⁴⁰ Broker-dealers are not stepping up to fill the void due to increased risk-aversion, limiting the ability to absorb shocks to liquidity due to global macro events. *Acharya et. al. (2022)* examines the effect of QT from a liquidity perspective and notes the increased likelihood of financial fragility when the Fed stops providing liquidity to the market, as the banking sector may not decrease the liquidity claims as fast as the central bank withdraws its reserves.

Diversification

By definition, the end of the Great Moderation implies elevated volatility of inflation and GDP, and financial metrics that reflect these outcomes. The focus of monetary policy over the last two decades has been in stabilizing output volatility. As noted earlier, however, geopolitical developments have also resulted in concerns about supply shocks, as access to resources (such as gas lines, etc.) has become weaponized. Thus, recent output volatility also reflects supply shocks. As noted by Campbell et. al. (2014), when supply shocks dominate, bonds can be risky assets to own as supply shocks can trigger high-inflation recessions as seen in the 1970s.

It is our belief that a return to the period of the 1970s when supply shocks explained temporal movements in output is unlikely. We believe that monetary policy is likely to continue to be focused on output stabilization marked by gradualism and transparency with an eye towards stabilization of financial market metrics. Thus, the diversifying power of bonds should continue once market volatility and correlation structures (between stocks and bonds) normalize. Until such normalization occurs, risk aversion will be high as there is uncertainty about inflation pathways, persistence of supply shocks, geopolitical instability and other factors. This risk aversion will continue to be expressed

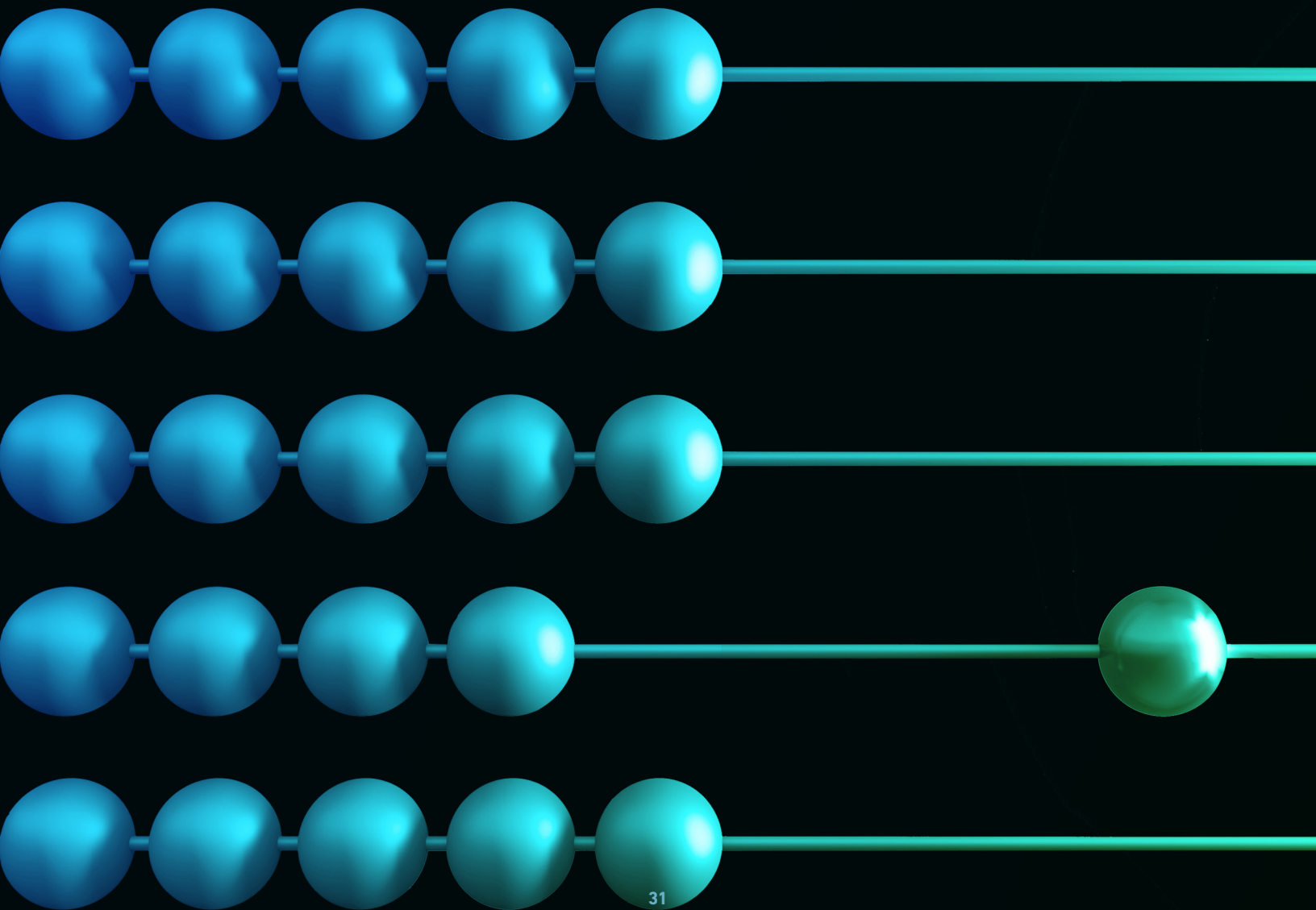
in reduced market liquidity and market depth by providers of liquidity and reduced risk taking by holders of capital. Risk aversion will warrant a higher risk premium, which, in turn, may impact asset allocation choices.

As noted earlier, there are multiple reasons to believe that inflation will be higher structurally, in which case monetary policy will need to continue to be restrictive to contain inflation. *Ilmanen (2003)* states that bonds and equities will show a positive correlation during periods when central bank policies are restrictive, irrespective of the inflation regime. This implies that investors will need to find other ways to diversify equity risk. Other options include currency strategies, exposure to real assets and sector allocation.

Empirical evidence suggests that the contribution of inflation to stock-bond correlation could be non-linear. All else being equal, the correlation is the lowest, and, conversely the diversifying power of bonds is the highest, when inflation is closest to two percent. The quicker it is for monetary policy authorities to bring inflation to these levels, the easier it is for instruments like bonds to help provide diversification benefits to portfolios. Until such time, the increased risk of market fragility, risk aversion and loss of diversification from traditional avenues may have to be endured by financial markets in this new era.

Chapter 6

Conclusion



While the immediate effects of these structural changes are likely to be inflationary and lead to higher uncertainty in the markets, we believe that some silver linings exist from the Great Transition.

First, over the longer term, climate transition will likely be deflationary after sufficient infrastructures to support renewable energy are built, given renewables' lower cost of energy than fossil fuels. A study by the *International Energy Agency (IEA)* shows that direct spending by households on energy decreases substantially as a share of disposable income in the net-zero economy compared to 2020.⁴¹

Second, a tight labor market is going to force technological solutions. As noted above, technology can help increase labor productivity and act as a deflationary counterforce during the Great Transition. Similarly, technological solutions can help ease pressures from a tight labor market caused by demographic and structural changes post-pandemic. Technological solutions that can complement or augment physical labor such as robotics, remote-collaboration tools, online learning platforms and cloud-sourcing platforms can enhance productivity and mitigate the negative impact of a tight labor market.⁴²

Third, a declining working population around the world, especially in advanced economies, will likely engender changes in immigration policy.

Last, a reconfigured global value chain will likely prove more resilient against geopolitical shocks and unforeseen events, which would be especially valuable during times of market stress. More diversified and internalized value chains will prevent adverse supply shocks from spilling over globally and turning into an inflation spiral.

When the history is written about the drivers of the Great Transition, we hope the global economy will emerge in a more stable state thanks to normalized central bank balance sheets, a more resilient global value chain, less volatile sources of energy and an economic structure adapted to aging demographics. What lies ahead in the near future, however, seems to be a volatile regime with lots of moving parts. Investors should be cognizant of the end of the era of low volatility and the upcoming era of the Great Transition, and build that thinking into their strategic decision-making.

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References

- Acharya, V., Chauhan, R., Rajan, R., and S. Seffen. 2022. "Liquidity Dependence: Why Shrinking Central Bank Balance Sheets Is an Uphill Task"
- "Asian Economic Integration Report 2019/2020: Demographic Change, Productivity, and the Role of Technology", Asian Development Bank. 2019 <https://www.adb.org/publications/asian-economic-integration-report-2019-2020>
- Autor, D., Dube, A., and A. McGrew. 2022. "The Unexpected Compression: Competition at Work in the Low Wage Economy". Markus' Academy, December 8, 2022.
- Bernanke, Ben S., "The Great Moderation," Remarks at the meetings of the Eastern Economic Association, Washington, DC, February 20, 2004
- Bernanke, Ben S., "A Century of US Central Banking: Goals, Frameworks, Accountability," Remarks at "The First 100 Years of the Federal Reserve: The Policy Record, Lessons Learned, and Prospects for the Future", a conference sponsored by the National Bureau of Economic Research, Cambridge, MA, July 10, 2013
- Bianchi, F. and L. Melosi. 2022. "Inflation as a Fiscal Limit". Federal Reserve Bank of Chicago Working Paper No. 2022-37
- Boer, L., Pescatori, A., and Stuermer, M. 2021. "Energy Transition Metals". IMF Working Paper WP/21/243
- Borio, Claudio., "Inflation: a look under the hood". Speech at the BIS Annual General Meeting, Basel, Switzerland, Jun 26, 2022
- Campbell, J. Y., Pflueger, C., L. M. Viceira. 2014. "Monetary Policy Drivers of Bond and Equity Risks". NBER Working Paper no. 20070
- Carney, Mark, "The Growing Challenges for Monetary Policy in the current International Monetary and Financial System," Speech at Jackson Hole Symposium, August 23, 2019
- Cochrane, John. 2022. "Inflation Past, Present and Future: Fiscal Shocks and Fiscal Limits". NBER Working Paper 30096
- Csonto, B., Huang, Y., and Camilo E Tovar Mora. 2019. "Is Digitalization Driving Domestic Inflation?". IMF Working Paper No. 2019/271
- Deitz, R. 2022. "Long COVID Appears to Have Led to a Surge of the Disabled in the Workplace," Federal Reserve Bank of New York Liberty Street Economics
- Faccini, R., Melosi, L., and R. Miles. "The effects of the "Great Resignation" on labor market slack and inflation." Chicago Fed Letter 465 (2022): 1-7
- Fernald, J. and Li, H. 2022. "The Impact of COVID on Productivity and Potential Output," Federal Reserve Bank of San Francisco Working Papers 2022-19
- Fueki, T. and K. Maehashi. 2019. "Inflation Dynamics in the Age of Robots: Evidence and Some Theory," Bank of Japan Working Paper Series 19-E-9, Bank of Japan
- Grant, A., Haider, Z., and Jean-Christophe Mieszala. 2022. "How to Build Geopolitical Resilience Amid a Fragmenting Global Order". McKinsey & Company

- Grazzini, J. and D. Massaro. 2021. "Great Volatility, Great Moderation and Great Moderation Again". *Review of Economic Dynamics* Volume 44 (2022): 269-283
- Greenspan, Alan. 2005. "Economic Outlook: Testimony before the Joint Economic Committee, US Congress," Statement before the Joint Economic Committee, November 3, 2005
- Goodhart, C. A. E. and M. Pradhan. 2020. "The Great Demographic Reversal. Aging Societies, Waning Inequalities, and an Inflation Revival", Palgrave Macmillan
- Helveston, J. P., He, G., and M. R. Davidson. 2022. "Quantifying the Cost Savings of Global Solar Photovoltaic Supply Chains," *Nature*. 2022 Dec; 612 (7938): 83-87
- Huang, Y., Liugang, S. and G. Wang. 2021. "How did rising labor costs erode China's global advantage?". *Journal of Economic Behavior & Organization* 183: 632-653
- Ilmanen, A. 2003. "Stock-Bond Correlations". *The Journal of Fixed Income* Fall 2003, 13 (2) 55-66
- International Energy Agency. 2021. "Net Zero by 2050", IEA, Paris <https://www.iea.org/reports/net-zero-by-2050>, License: CC BY 4.0
- International Monetary Fund. 2019. "Macroeconomics of Aging and Policy Implications", IMF Staff Note to the Group of Twenty
- International Monetary Fund. 2022. "Labor Market Tightness in Advanced Economies". Staff Discussion Notes No. 2022/001
- Juselius, M. and E. Takats. 2018. "The enduring link between demography and inflation". BIS Working Papers No. 722
- Lv, L., Liu, Z. and Y. Xu. 2019. "Technological progress, globalization and low-inflation: Evidence from the United States". doi: 10.1371/journal.pone.0215366. PMID: 30998700; PMCID: PMC6472747
- Mocuta, S. M. and A. Le. 2022. "How Accurate is the Missing Workers Narrative?". State Street Global Advisors
- Phillips, A. W. H. "The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957". *Economica*, n.s., 25, no. 2 (1958): 283-299
- Poloz, Stephen S. 2022. "Technological Progress and Monetary Policy: Managing the Fourth Industrial Revolution". *Journal of International Money and Finance* Volume 114 (2021), 102373
- Rudebusch, G. 2018. "A Review of the Fed's Unconventional Monetary Policy". FRBSF Economic Letter, 2018-27. Federal Reserve Bank of San Francisco
- Schnabel, Isabel, "A New Age of Energy Inflation – Climateflation, Fossilflation and Greenflation," Speech at the "ECB and Its Watchers XXII" Conference, Frankfurt am Main, March 17, 2022
- Schnabel, Isabel, "Monetary Policy and the Great Volatility," Speech at the Jackson Hole Economic Policy Symposium, Jackson Hole, Wyoming, August 27, 2022
- Valckx, N., Stuermer, M., Seneviratne, D. and P. Ananthakrishnan. 2021. "Metals Demand From Energy Transition May Top Current Global Supply," IMF Blog
- Yoon, J-W., Kim, J. and J. Lee. 2014. "Impact of demographic changes on inflation and the macroeconomy," IMF Working Papers, No 14/210 November

Endnotes

Chapter 1: Introduction

1. S&P 500 returned -19.4% for the year, 10-year Treasury yields rose from 1.5% to 3.9%, Federal Funds rate rose from 0.1% to 4.4%.
2. Future Fund, "Position Paper – The Death of Traditional Portfolio Construction?", December 2022.
3. For example, in the United States, annualized standard deviation of quarterly PCE inflation and quarterly real GDP growth during the period from 1970 to 1983 is double the magnitude (1.31% and 2.40%, respectively) of that during the period from 1984 to 2006 (0.63% and 1.03%, respectively).
4. See Rudebusch (2018) for more details.
5. Operation Twist refers to the Federal Open Market Committee's program of selling short-term Treasuries and purchasing long-term Treasuries.
6. In the United States, annualized standard deviation of quarterly PCE inflation and quarterly real GDP during the period from 2010 to 2019 are similar in magnitude (0.53% and 0.72%, respectively) to that during the period from 1984 to 2006 (0.63% and 1.03%, respectively).
7. Economic Policy Uncertainty index by Baker, Bloom and Davis shows 37% increase in global economic policy uncertainty between periods from start of 2021 to early 2022 before the Russian invasion of Ukraine and periods post that in 2022.

Chapter 2: Why We Witnessed the Great Moderation

8. See Bernanke (2004) for more details.
9. This relationship can be reflected through a well-known Phillips curve. The Phillips Curve is a convenient and parsimonious way to describe the relationship between inflation and economic activity. In this model, the relation between growth in economic activity (defined a number of ways) and inflation is analyzed.
10. See Bernanke (2004) for more details.

Chapter 3: Changing Dynamics: Dawn of the Great Transition

11. See Carney (2019) for more details.
12. Taylor, Adam, "The global wave of populism that turned 2016 upside down," Washington Post, December 19, 2016, <https://www.washingtonpost.com/news/worldviews/wp/2016/12/19/the-global-wave-of-populism-that-turned-2016-upside-down/>
13. Hille, Kathrine and Sevastopulo, Demetri, "TSMC: the Taiwanese chipmaker caught up in the tech cold war," Financial Times, October 24, 2022, <https://www.ft.com/content/bae9756a-3bce-4595-b6c9-8082fd735aa0>
14. For example, the European Commission presented REPowerEU Plan in light of Russia's invasion of Ukraine. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en
15. Macauley, Richard, "Another badly ventilated factory making Apple products caught on fire in China," Quartz, January 26, 2016, <https://qz.com/602794/another-badly-ventilated-factory-making-apple-products-caught-on-fire-in-china>
16. Yoon, June, "Lex in-depth: the cost of America's ban on Chinese chips," Financial Times, November 24, 2022, <https://www.ft.com/content/d3935b9a-a203-435d-b1a9-a22bcc9d79e7>
17. Taking the semiconductor industry as an example, the revised paradigm of strategic autonomy will need to include longer lead time to establish new infrastructure for chip production. To ensure strategic autonomy there needs to be a critical mass of skilled labor onshore – this can add to costs in the medium/long term.
18. See Grant et al. (2022) for more details.

19. According to UNCTAD, China had the largest share of global export of goods in the world as of 2020 with 14.7%. The United States and Germany are second and third with 8.1% and 7.8% shares respectively. <https://unctad.org/news/china-rise-trade-titan>
20. Schnabel, Isabel, "Monetary policy and the Great Volatility," Speech at the Jackson Hole Economic Policy Symposium, Jackson Hole, Wyoming, August 27, 2022. <https://www.ecb.europa.eu/press/key/date/2022/html/ecb.sp220827-93f7d07535.en.html>
21. See Huang et al. (2021) for more details.
22. Thus after nearly four decades of maturing, China is trying to step up from the days of "Hide your strength, bide your time, never take the lead," which has been the guiding principle for China's foreign policy set by Deng Xiaoping that advised Chinese leaders to adhere to a strategy of non-assertiveness. Kevin Rudd, "Emperor Xi's China is Done Biding Its Time," interview by Tobin Harshaw, Bloomberg Opinion, March 3, 2018. <https://www.belfercenter.org/publication/emperor-xis-china-done-biding-its-time>
23. United Nations World Population Prospects 2022 projects that India will surpass China as the world's most populous country in 2023.
24. A. W. H., Phillips, "The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861–1957." *Economica*, n.s., 25, no. 2 (1958): 283–299.
25. Deitz Richard, "Long COVID Appears to Have Led to a Surge of the Disabled in the Workplace," Federal Reserve Bank of New York Liberty Street Economics, October 20, 2022, <https://libertystreeteconomics.newyorkfed.org/2022/10/long-covid-appears-to-have-led-to-a-surge-of-the-disabled-in-the-workplace/>
26. See Faccini et al. (2022) for more details.
27. Speech by Isabel Schnabel, Member of the Executive Board of the European Central Bank, at a panel on "Monetary policy and climate change" at "The ECB and Its Watchers XXII" Conference, Frankfurt am Main, 17 March 2022.
28. See IEA (2021) for more details.
29. This definition does not include other costs needed for climate transition such as costs for innovative climate technologies.
30. See Valckx et al (2021) for more details. Boer et al. (2021) shows that prices of lithium, cobalt and nickel could rise several hundred percent compared to their average 2020 levels in a net-zero emissions scenario.

Chapter 4: Role of Technology as Deflationary Counter Force

31. See Greenspan (2005) for more details.
32. The contribution of globalization, on the other hand, has been weakening over the same period and has a lesser role on low-inflation in the United States.
33. Csonto, Huang and Mora (2019) found statistically significant negative effect of digitalization on inflation in advanced and emerging economies.
34. Fueki and Maehashi (2019) find that the use of robots instead of human labor has allowed the firms to increase efficiency, leading to more stable marginal costs.
35. https://sf.freddiemac.com/content/_assets/resources/pdf/report/cost-to-originate.pdf
36. Petrova, Magdalena, "Here's why battery manufacturers like Samsung and Panasonic and car makers like Tesla are embracing cobalt-free batteries," CNBC, November 17, 2021. <https://www.cnbc.com/2021/11/17/samsung-panasonic-and-tesla-embracing-cobalt-free-batteries-.html>

Chapter 5: Implications of the Dawn of a New Era of Higher Volatility

37. Wilkes, Tommy, "Emerging markets drive global debt to record \$303 trillion – IIF", Reuters, February 23, 2022, <https://www.reuters.com/markets/europe/emerging-markets-drive-global-debt-record-303-trillion-iif-2022-02-23/>
38. Bianchi and Melsoi (2022) note that the increase in trend inflation during the 1960s and 1970s can be attributed to the fast-growing government spending to support President Lyndon Johnson's Great Society initiatives as well as the Vietnam war. The course of trend inflation reversed when the fiscal authority was credibly committed to stabilize the debt and the Fed raised interest rates dramatically in early 1980s.
39. Cochrane (2022) emphasizes the coordination between fiscal and monetary policy to tame the inflation post pandemic.
40. Duguid, Kate and Stubbington, Tommy, "The cracks in the US Treasury bond market," *Financial Times*, November 15, 2022, <https://www.ft.com/content/632411eb-c3fa-4351-a3b6-b0e30bdc0ef7>

Chapter 6: Conclusion

41. See IEA (2021) for more details.
42. See ADB (2019) for more details.

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