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Reimagining Supply Chains: The Investing Challenge

From carmakers to smartphone manufacturers, companies around the world are reorganizing their supply chains amid a wave of disruptions. Equity investors will need to sharpen their analytical tools and engagement skills to determine which businesses are proactively adapting to a new reality.

It may be the biggest business revolution in a generation. After decades of globalization, when companies scoured the planet for the cheapest locations to source components and produce goods, the race is on to redesign supply chains. Company initiatives to rethink the logic of offshoring operations have been accelerated in recent years by the US-China trade war, pandemic-driven shutdowns and more recently by Russia's invasion of Ukraine.

Cost is no longer the main consideration. Executives must also weigh disruption risk potential in everything from workforces to shipping, and conduct a complex cost-benefit analysis of every stage of a production process. Mounting inflation of wages and input costs makes the exercise even harder.

The New Calculus

The new reshoring calculus throws up a whole new set of questions for investors. How do you identify the weak points of a chain that may include dozens, hundreds or even thousands of suppliers? Should investors demand a greater “offshore discount” to compensate for escalating supply chain risks? What can investors do to understand whether a company is moving in the right direction, given that reporting on supply chains is often short on detail? Questions like these are a starting point for understanding how current disruptions could affect near-term earnings forecasts and how companies are addressing the broader challenge of reimagining a supply chain for long-term resilience.

We believe three key aptitudes are required for an investing team to rise to the supply chain challenge. First, deep fundamental research is essential to understand whether a company can redesign its supply chain to withstand shifting macro- and microeconomic dynamics. Second, data science will play an increasing role in understanding the vulnerabilities of existing supply chains. And third, engagement with management is vital for gleaning insights that can't be found in standard reports.

For many years, the economic rationale for offshoring was clear. Offshoring generally made sense if a company could produce a good for at least 20% less than in its home country. Today, it's not just about cost. Companies must strategically calculate the risks of sourcing or manufacturing in a certain location and whether it's worth paying more to ensure greater security of supply. In addition to the costs of labor and logistics, US companies of all sizes are today considering multiple factors when weighing a decision to bring operations back home, according to a [recent survey by consulting firm Kearney](#). These include the quality of goods, delivery lead times, labor availability and their carbon footprint.

Know Your Company: Fundamental Depth Is Indispensable

As companies and investors reassess the trade-offs, there are no easy answers. Restructuring a supply chain is a process that could take several years, yet cannot be ignored today. We believe long-only investors, whose research processes look several years into the future and aren't derailed by market volatility, are better equipped to evaluate these changes than those with shorter time frames.

Investors must know a company's business model, financials and industry dynamics in depth to assess supply chain vulnerabilities and opportunities. How a company invests for the future can indicate whether it's shifting production toward new regions to avert future disruption. In some industries, we're seeing huge capital expenditures in manufacturing facilities to improve regional alignment with customers and revenue.

The semiconductor industry is among the leaders. Intel recently announced €29 billion of investments in new semiconductor manufacturing facilities in Germany and Ireland. It's also spending \$40 billion on new plants in Ohio and Arizona. Taiwan Semiconductor Manufacturing is investing \$19 billion in Japan and Arizona, with further investments expected in Germany. Some semiconductor buyers aren't willing to wait any longer and are taking matters into their own hands.

Some companies plan to use cash flow to increase working capital and/or to build more inventory on balance sheets. This could create short-term headwinds to cash flow for manufacturers, as some companies may need to take on more debt to fund the increase in working capital. On the other hand, we believe companies that facilitate the distribution of components and are integrated in supply chains will become more valuable. This trend is already visible. Some distributors across different industries have exceeded expectations in recent earnings reports, suggesting they are beginning to benefit from supply chain changes.

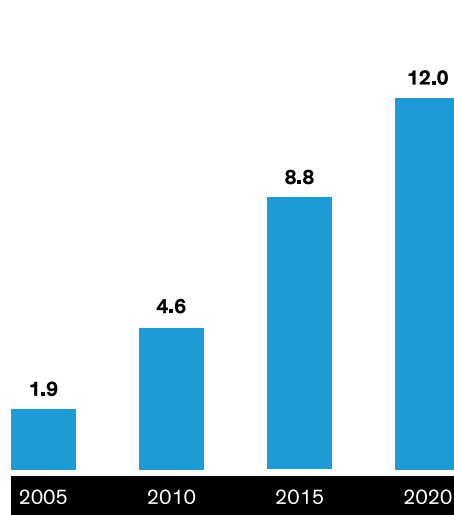
The war in Ukraine has created some acute supply problems. For example, a Russian company is a dominant global supplier of titanium, used for airplane structures and engines. Boeing and Airbus are scrambling for new sources of finished titanium, which could benefit Western suppliers. Investors in aerospace companies should closely monitor these efforts to diversify supply, which are indicative of broader changes in the industry's supply chain. Sourcing new supply quickly and at a reasonable cost could be a decisive factor in their ability to meet delivery deadlines and earnings expectations.

In the auto industry, many carmakers have faced production bottlenecks because of shortages. Ukraine is a major supplier of wiring harnesses for vehicles, and the conflict led to disruptions that forced some automakers to find alternative manufacturers in Eastern Europe and North Africa. Short-term solutions like these could point the way to longer-term shifts in supply chains.

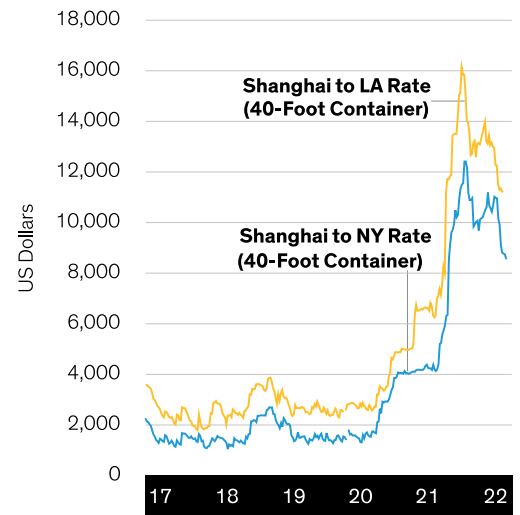
While recent shortages have pushed the supply chain issue to the top of company agendas, long-term macroeconomic realities are at the heart of the offshoring dilemma. For years, low manufacturing wages in China were a magnet for companies around the world. But now, wages in China are rising (Display), while increasing automation is reducing the higher cost of domestic labor needed to manufacture closer to home. Shipping costs have skyrocketed; one US furniture maker recently told us that freight issues from eastern Europe and China have been its biggest supply chain surprise this year. And for US companies, domestic energy costs are much cheaper than abroad, while tariffs stemming from US-China trade disputes have added another layer of costs.

DOES OFFSHORING STILL MAKE SENSE?

China Manufacturing Wages (USD Thousands)*



Shipping Rates (Weekly)



Past performance and current analysis do not guarantee future results.

Left chart as of December 31, 2020; right chart as of April 29, 2022

*Based on nominal CNY to USD exchange rate, averaged monthly.

Source: Bloomberg, National Bureau of Statistics of China, Trading Economics, UBS and AllianceBernstein (AB)

However, these trends don't automatically mean that US companies will be bringing manufacturing back home. While there has been a decline in the proportion of imported goods to the US originating in China, from 24.3% in 2018 to 20.1% in 2021, much of that manufacturing capacity appears to be shifting toward other Asian countries, according to the Kearney report. The same report shows an increase of nearly five percentage points in imports originating from elsewhere in Asia over the same period.

Big Data Can Generate Big Insights

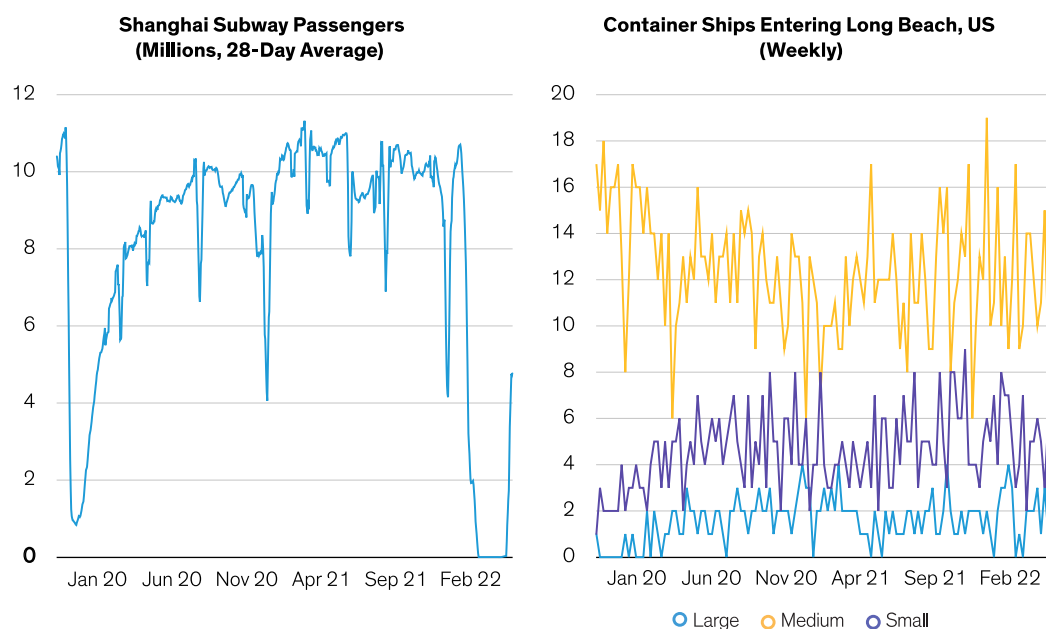
The gradual diversification of operations away from China doesn't necessarily eliminate risks. Yet it can be hard for investors to know when disruptions are developing within a diversified supply chain in real time.

Using big data tools, investors can generate independent quantitative insights that help complete the picture. Drilling down into alternative data sources allows us to fly around the world to examine the bottlenecks and linchpins in the system.

For example, we've developed a tool called a supply chain waterfall, which helps monitor bottlenecks from Asia in real time. This allows us to look at COVID-19 death rates as a proxy for policy shutdowns, workplace and transit activity in key markets, shipping activity and port congestion. This supply chain waterfall can indicate when each of these pieces is heating up or cooling down.

In China, we can also monitor activity like traffic congestion or subway passenger levels to understand if key production cities are at risk of shutdowns (*Display*). The recent increase in subway traffic in Shanghai indicates that the city may be coming out of full lockdown mode, which was imposed earlier in the year in response to a COVID-19 outbreak.

ALTERNATIVE DATA SOURCES PROVIDE INSIGHT ON SUPPLY CHAIN WEAK SPOTS



Past performance does not guarantee future results.

Left display through June 12, 2022; right display through June 4, 2022
Source: UBS Evidence Lab, Wind and AllianceBernstein (AB)

Alternative data can also help us understand the longer-term implications of reshoring. By web scraping company announcements of major reshoring projects, we can track in aggregate and by industry where reshoring is gaining momentum. Data tools can be used to track job postings at manufacturing firms, which provide another indicator of reshoring projects. This analysis helped support a hypothesis that reshoring was increasingly focused on less labor-intensive jobs.

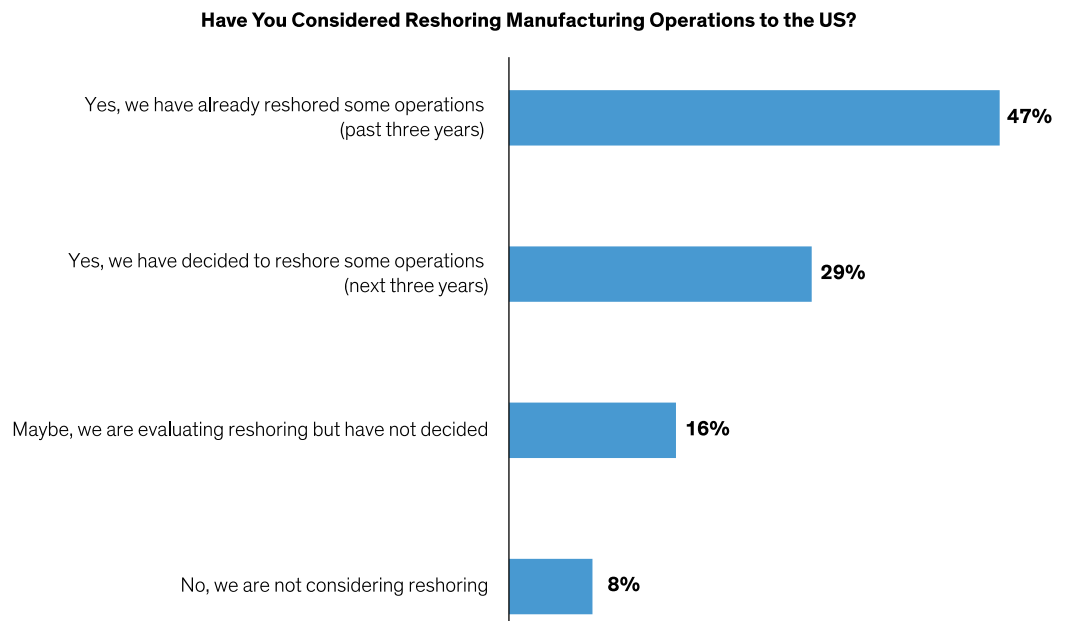
Big data can provide analysts with substantial advantages. Armed with this information, fundamental analysts can pinpoint supply chain vulnerabilities and project how disruptions may affect business performance. Data-driven information and insight can also help frame research questions and underpin an informed dialogue with management about the need to consider longer-term changes.

Mindset Matters: Engaging with Management

The mindset of a management team is equally important in evaluating supply chain strategies. Nearly half the manufacturing executives surveyed by Kearney said they had already brought some manufacturing activities back to the US, while 29% plan to do so in the next three years. For investors to fully understand corporate reshoring strategies, an open dialogue with management teams that are making decisions is essential.

US MANUFACTURING EXECUTIVES ARE ACCELERATING RESHORING EFFORTS

Kearney Survey of US Companies



Past performance does not guarantee future results.

Based on a survey of 115 US manufacturing executives from companies of various sizes conducted in March 2022 published in a report by Kearney, "The Tides Are Turning: The 2021 Reshoring Index".

Source: Kearney analysis

Reconfiguring supply chains is a strategic challenge that requires initiative, innovation and the ability to balance increased short- and medium-term costs with long-term benefits. The first thing investors must ascertain is whether management is taking the issues seriously or not. Are they having daily, weekly or monthly meetings to tackle the supply chain conundrum?

For most companies, rebuilding supply chains is a totally new endeavor. It requires the right people—and the right systems—to identify pain points and to launch transition plans. Discussions with management can help investors find out whether a company is prioritizing supply-chain issues and dedicating the appropriate resources to the problem.

It can also provide important insight on real-time industry dynamics. For example, semiconductors have been in short supply for automakers. This has wreaked havoc with production because vehicles rely on more electronic content than ever before. Yet by mid-2022, macroeconomic trends were beginning to resolve these problems, as demand for smartphones and other consumer goods waned. In discussions with semiconductor management teams, we've heard initial suggestions that chipmakers may be starting to repurpose some of their production capacity from more profitable consumer applications toward industrial applications, including autos. Engagements such as these provide important clues for investors to follow. In this case, if a shift in supply does pan out, it could be good news for car manufacturers and other industrial buyers of semiconductors, as chip prices might fall from very high levels. At the same time, it also signals an inventory correction that may reduce earnings for semiconductor manufacturers.

Meanwhile, one semiconductor buyer told us after experiencing ongoing problems sourcing products from a major manufacturer, it decided to diversify the suppliers for chips used in its end products.

Discussions with management can also help investors understand the rationale for diversification efforts. Reshoring back to developed-market sites isn't always the right move. Vietnam has become an especially popular destination for technology and textile companies seeking to shift production away from China. This trend began well before the COVID-19 pandemic led to shutdowns in China, and even before the US-China trade wars.

In addition to lower labor costs than China, Vietnam's government offered tax benefits which became a magnet for multinationals such as Nike and Adidas. Our research teams located in Asia have [visited facilities in Vietnam](#) to learn more about the business and cultural issues, as well as to gauge the environmental, social and governance issues that are needed to foster successful reshoring operations to the country.

Beyond location, strategic efforts to rethink supply chains in the 21st century require innovation. New automation technologies can be an effective antidote to spiraling wage costs. And innovation can offer solutions to manufacturing challenges in surprising ways.

For example, the science of [synthetic biology can offer cost-effective ways of creating raw materials](#) for products such as plastics, fertilizers, pharmaceutical ingredients, food and clothing, which were previously cheaper to source halfway around the world. Yet it's not always easy to know how companies are embracing solutions like these, which aren't necessarily featured in public earnings reports. Engaged investors can ask the right questions to discover whether a company is making smart investments in technology or securing patents that can help deliver creative solutions for supply chain fragilities.

It will take years for supply chains to be reconfigured for a less globalized world. As the process plays out, investors will need to compare and contrast companies within and across industries to determine how different types of structures should affect business performance, risk premiums and return potential for stocks. This will be a constant learning process. Creating a robust analytical framework now can help investors stay ahead of the curve and develop conviction in companies that are taking the right steps to ensure that their business advantages can prevail over time.

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Security Concerns Add Urgency to Global Energy Transition

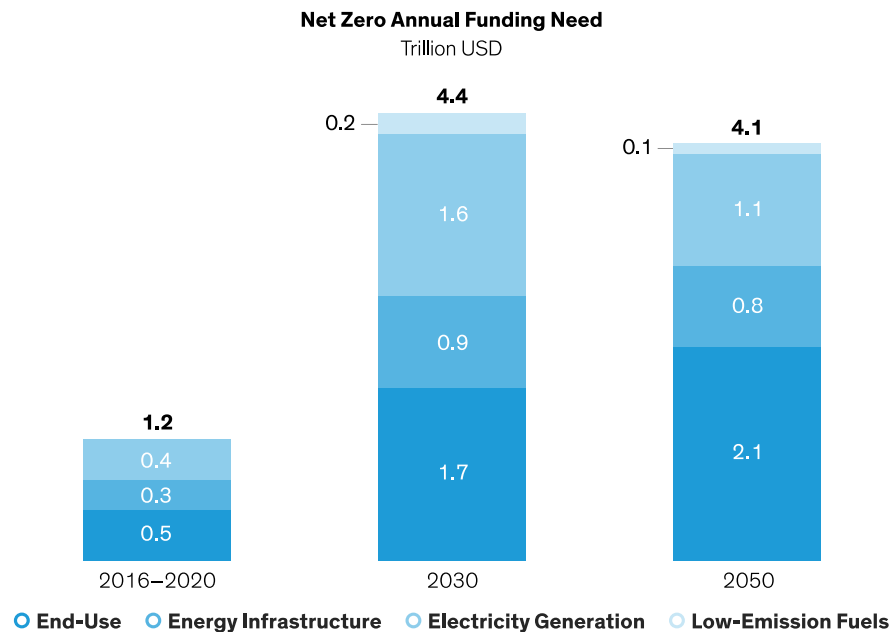
Russia's invasion of Ukraine has caused enormous human suffering and upended the previous political consensus in Europe. It's also prompted concerns that Western countries will be distracted from environmental priorities as they struggle to replace embargoed Russian oil and gas. But data suggest otherwise—that the global energy transition is accelerating and that the widespread effects from the conflict bolster the secular growth case for renewable energy.

Investment in Renewables Is Set to Soar

According to the International Energy Agency's (IEA's) [“Net Zero by 2050” roadmap](#), the world already had enough operational oil and gas fields and coal mines before the invasion to meet anticipated demand in their pathway to 2050. But increases in renewable energy generation and energy efficiency were behind target, despite impressive growth rates. As the IEA put it, *“The path to net-zero emission is narrow: staying on it requires immediate and massive deployment of all available clean and efficient energy technologies”* (Display).

WHAT IS NEEDED TO ACHIEVE NET ZERO?

Increased Spending Across a Spectrum of Decarbonization Solutions



Historical and current analyses do not guarantee future results.

As of September 30, 2021

Source: IEA

Now, as the world faces higher hydrocarbon prices and as Western Europe is [confronted by an absolute shortage of gas](#), the pressure is growing to economize on consumption, phase out Russian oil and gas, and substitute renewables. We expect investment in clean energy to surge in response to the existential threat of attack and the need for energy security.

Meanwhile, as renewable output ramps up, the Western world must still find ways to avoid an imminent energy deficit from reduced Russian oil and gas supplies. Addressing this problem will temporarily expand oil and gas exploration and production, but we don't believe it will reduce the long-term pace of the transition away from hydrocarbons.

Higher Prices for Oil, Gas, Power and Carbon Make Renewables More Attractive

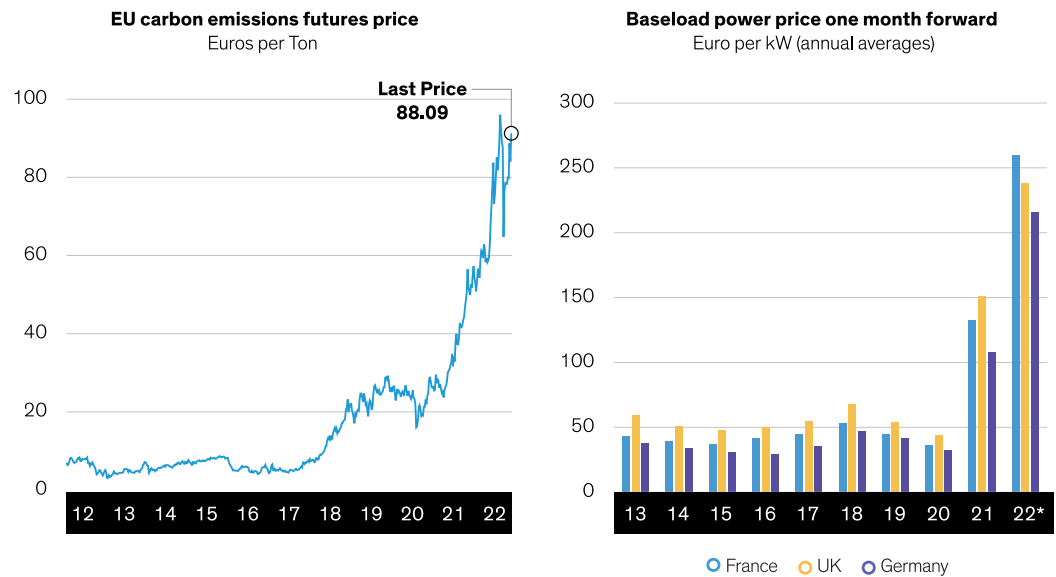
For Western countries, the invasion of Ukraine can only strengthen the case for much higher production of renewable energy as part of a more secure, sustainable energy infrastructure. Effectively, the Ukraine crisis adds urgency to the global energy transition by highlighting the increased need for energy security.

Until recently, hydrocarbons were cheap by historical standards and renewables were just becoming fully cost-competitive. Power prices in Europe (and the US), stable for several years, recently soared as natural gas prices rose and the supply/demand balance tightened (*Display, right*).

Russia's invasion of Ukraine has profoundly changed the outlook. On top of energy security considerations, the economics of renewables have improved versus fossil fuels—driven by higher oil, natural-gas and electricity prices. Higher and more volatile energy prices make renewables relatively more attractive and new technologies like electric vehicles (EVs) relatively more affordable. The price of carbon has also risen—another factor making clean energy more attractive (*Display, left*).

POWER AND EMISSIONS PRICES HAVE SURGED

Higher Prices Make Low-Carbon Solutions More Competitive



Historical and current analyses do not guarantee future results.

*Year to date

As of May 13, 2022

Source: Bloomberg and BloombergNEF

Renewables Are Now Price-Competitive...

The IEA and others now believe that wind and solar power are price competitive with, or cheaper than, fossil-fuel power in two-thirds of the world's countries. As a result, direct subsidies for renewables have now largely been phased out.

Prices for renewable-generating assets in the secondary market are rising sharply, demonstrating that renewable generation is now fully cost-effective and attractive to investors—who are currently paying between 1.5 and two times as much for existing clean-energy assets as they were two years ago.

Another way to quantify the robust appetite for renewable energy is through movements in the prices of power purchase agreements (PPAs), long-term agreements for the purchase of energy between renewable developers and consumers. These prices have risen materially since the first half of 2020 across Europe.

Because PPAs feature an agreed-on price over a long period, they can be particularly attractive when hydrocarbon prices are volatile. Buying renewable energy is also a reputational positive for energy-intensive consumer businesses such as airlines, enabling them to demonstrate cleaner supply chains.

...with Attractive Investment Characteristics

As a result of these developments, we believe investments in clean energy projects offer visible long-term growth potential with defensive return characteristics.

Over a medium-term five- to 10-year horizon, clean energy represents a strong secular growth story. The energy transition program will be the primary growth driver, and is now accompanied by the greater need for energy security. Two other developments may also spur growth in renewables. First, energy demand typically expands with economic growth, and it would take major advances in energy efficiency for that relationship to be broken. Second, stubbornly high hydrocarbon prices would also speed the adoption of clean energy sources.

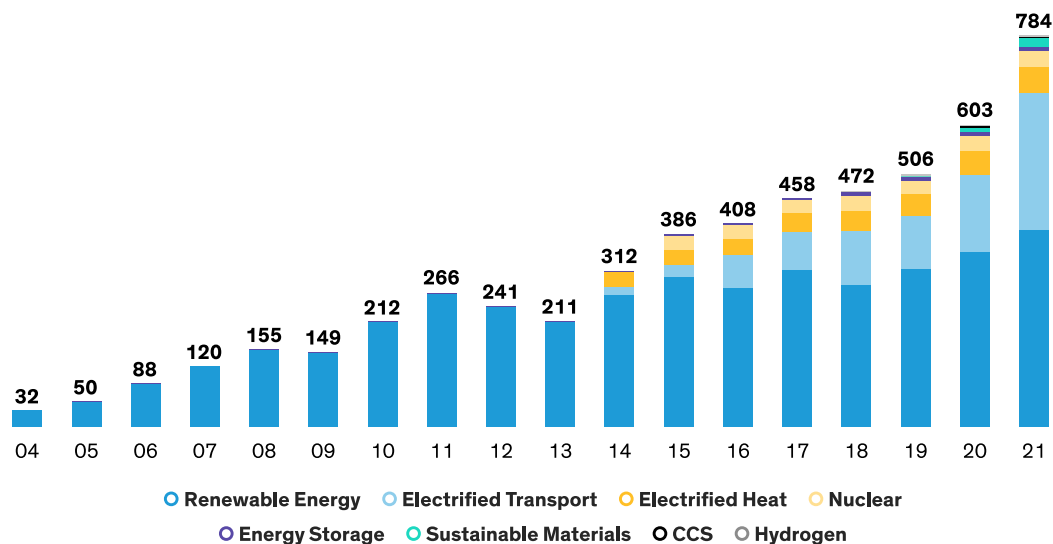
Together these factors should make clean energy one of the foremost defensive growth sectors in the foreseeable future. Clean energy, as is the case with oil and gas, has the added attraction of offering a potential hedge against inflation. We also believe that companies whose products and services help conserve energy and [reduce net carbon emissions](#) may be similarly attractive.

Investment in the Energy Transition Has Already Accelerated

Last year, global spending on the energy transition was up 30%. That's after posting 19% growth in 2020, and 10% compound average growth from 2014 to 2019, according to BloombergNEF statistics (*Display*).

ENERGY TRANSITION INVESTMENT HAS ACCELERATED

Global Investment Has Grown Across Multiple Sectors (USD billions)



Historical and current analyses do not guarantee future results.

CCS = Carbon Capture and Storage

As of May 31, 2022 Source: BloombergNEF

Consumers are adapting fast, too. For example, in a weak market for vehicle sales generally, global EV sales have kept rising strongly in 2022, with two million vehicles sold in the first quarter—that's up 75% from the same period in 2021 (according to the [Global EV Outlook](#)).

Further Growth in Renewable Capacity Faces Bottlenecks

European and other governments have acted promptly to bring forward their decarbonization targets and to announce new renewable projects and energy conservation measures, with the European Union's (EU's) [REPowerEU](#) plan a notable example. However, these ambitious programs face practical obstacles.

In theory, it should be possible to expand capacity in solar and onshore wind power, and to create a bigger role for hydrogen, relatively quickly. In practice, though, labor, supply-chain and planning issues all create bottlenecks. And to be truly clean, hydrogen must be generated from renewable sources. It may not be until the 2030s that the world has enough excess clean energy to make hydrogen a substantial contributor to the share of renewables. And while European and other governments may favor relaxing planning controls, they will likely face stiff opposition.

Costs are a further constraint, given the rising prices of metals and components. So [the energy transition will be a complex journey](#).

Oil and Gas Still Have a Place in the Energy Mix

Replacing Russian energy will be an enormous project. Considering the practical obstacles, renewables alone can't fill the gap over a five-year time frame.

The world currently has less than 2% spare oil capacity (according to Saudi Aramco), which could swiftly be absorbed by normalizing demand in the airline industry and/or the end of COVID-19 lockdowns in China. The crisis in Ukraine further aggravates an already tight supply position. Re-allocating existing oil and gas supplies worldwide is problematic—for instance, creating the infrastructure to transfer more US and Asian liquid natural gas throughout Europe is a multiyear project.

This leaves a continuing role for new oil and gas exploration as well as production in the interest of energy security. Meeting that need presents a dilemma for the energy industry, as companies need assurances from national governments that they will back capital expenditures in low-carbon secure projects through the term of the project life (typically 10 years). Without government endorsement, oil and gas firms are unlikely to develop the necessary assets. Politicians also face tricky decisions in terms of allocating the cost of transition among consumers.

Investors Have an Important Role, Too

Investors' aversion to oil and gas companies has curbed these firms' willingness to invest in upstream oil and gas and led them to divert cashflows to stock buybacks and investment in the energy transition. As a result, new oil and gas supply will likely be constrained and prices will stay higher for longer. Low-income groups, particularly in emerging economies, will be hit the hardest by this expense. Faced with a lack of energy security, affordability and availability, emerging countries, in particular, will simply burn more coal, further increasing environmental damage.

Investors willing to engage with oil and gas management teams to advocate action—rather than shunning them and divesting—can help ensure that these companies have robust energy transition plans in place. Renewables remain a fast-growing but relatively small part of the energy mix, so oil and gas companies continue to be vital for today's economy. Investors that disregard that fact risk abdicating their responsibility to encourage progress. By actively engaging, they can play a key part in reducing the impact of the current energy crisis and ensuring an orderly evolution to clean energy worldwide.

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Conflict Brings a New Challenge to Global Food Security

February 24 marked the beginning of one of the largest military conflicts to break out in Europe since World War II, as Russian military forces invaded Ukraine. The unprovoked and devastating attack ratcheted up geopolitical tensions and triggered a massive humanitarian crisis.

The conflict has created huge transportation and logistical challenges for food trade, both domestic and international. Physical damage to Ukraine's infrastructure has hindered the movement of food commodities, a majority of which are transported by rail and truck to ports on the Black Sea and Sea of Azov. Some of Ukraine's infrastructure, such as roadways, was in disrepair even before the war; since the conflict erupted, eastern Ukrainian ports have been destroyed or heavily damaged—and the Russian navy controls the Black Sea, bringing shipping to a near standstill.

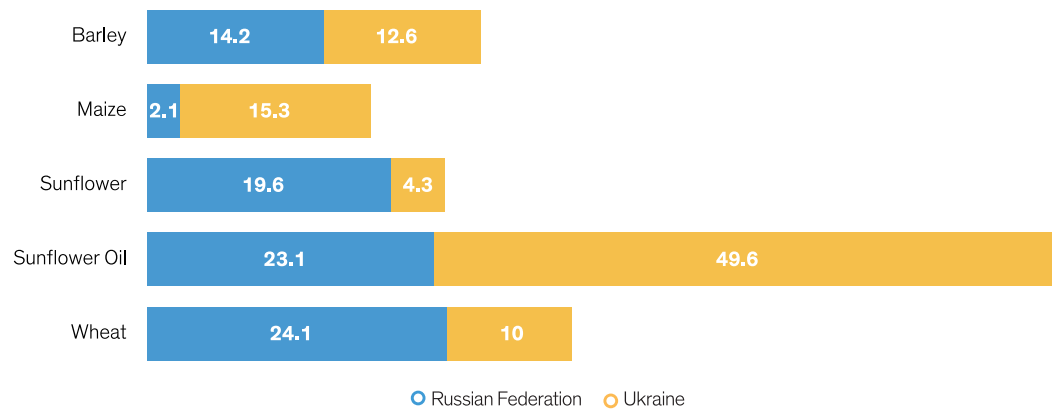
Conflict in One of the World's Breadbaskets

The widespread destruction and disruption in Ukraine and retaliatory measures by world governments pose new challenges to the global problem of food insecurity. It follows on the heels of the COVID-19 pandemic, which had already exacerbated food security issues.

Russia and Ukraine are two economies that play critical roles in the world's food supply. Between 2018 and 2020, the two countries accounted for nearly 35% of the global wheat market (*Display*). And it may be somewhat surprising that they also account, collectively, for more than 70% of global trade in sunflower oil, which is used for cooking. Ukraine's share alone accounts for about half of the world market.

RUSSIA AND UKRAINE PLAY CRITICAL ROLES IN GLOBAL FOOD SUPPLY

Percentage Share of Global Markets by Volume, 2018–2020



Past performance does not guarantee future results.

Excludes intra-European Union trade

Data through December 31, 2020

Source: International Food Policy Research Institute

The stakes of the conflict are very high. According to the World Food Program, 811 million people went to bed hungry globally even before the war's outbreak. In fact, we've witnessed a dramatic increase in the number of people experiencing acute food insecurity since 2019—from 135 million up to 276 million people. Even before the war, extreme food insecurity existed, especially in sub-Saharan Africa but also in nations such as Afghanistan and Iraq. Many of those challenged areas face painful shortages of vital food imports.

Export Restrictions Disrupt the Food Supply Chain

Growing cases of interventions in the global food system through export restrictions is a major concern for food security. Indonesia was one of the more recent nations to react—in early May, the Southeast Asian country imposed export restrictions on its sizable palm oil market production. India also announced restrictions on wheat exports in May, although the actual extent remains unclear.

Fertilizer market disruptions are an added wrinkle to the current food crisis. Russia and its ally Belarus are responsible for a tremendous volume of world fertilizer exports—not only to Europe but also to some of the countries facing the greatest food insecurity. The fertilizers affected include potassium and nitrogen—which require a substantial amount of energy to produce.

The nitrogen crisis highlights the link between food security and energy prices. The sizable spikes in energy prices that have taken place both before and after the outbreak of hostilities limit the ability of the global food system to respond to the disruptions.

How Does the Current Crisis Differ from 2007–2008?

Combine this fragile food system with severe hunger, amplified by a wartime disruption to commodities ranging from grains to food oils—and factor in impacts to energy prices and fertilizer—and you have a unique crisis. It's also a very different one from the 2007–2008 crisis.

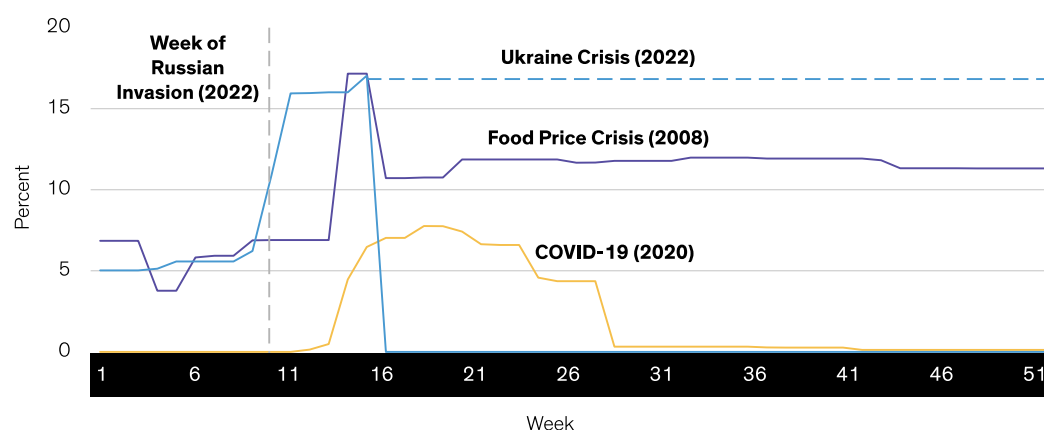
In that earlier episode, the world had already experienced a steady rise in wheat prices, leading to spillover effects that impacted rice markets. At the time, Vietnam and Thailand, the major rice exporters, were considering imposing export restrictions until Japan stepped in to release significant rice reserves, helping to settle food markets.

The current crisis includes huge uncertainties related to how long the war will last and how intense and sustained the disruptions will be. This bout will likely be more intense and is already having knock-on effects on fertilizer market prices, which we didn't see in 2007–2008. An example of an unanticipated knock-on effect that we didn't see in that earlier episode is Russian farmers facing shortages of machinery replacement parts.

The 2007–2008 food crisis was less about declining global production than about panic buying and other food-system interventions. Right now, from the perspective of total calories impacted by export restrictions, we're already at the maximum level from 2008 (*Display*). More than 15% of global trade has been impacted, so the world is really into uncharted territory.

EXPORT RESTRICTIONS POSE A MAJOR CHALLENGE

Share of Global Trade, in Calories, Impacted by Export Restrictions



Past performance does not guarantee future results.

Week represents week of year

Data through April 12, 2022

Source: International Food Policy Research Institute

Evaluating a Range of Food Supply Outcomes

Given the many moving parts to this crisis—not only geopolitical but physical—it can help to put dimensions around potential outcomes, whether they're more favorable or less favorable. Researchers at Columbia University and their colleagues are currently conducting research to explore a range of scenarios, including a quick peace agreement, protracted stalemate, intensifying conflict, and intensifying conflict combined with global trade repercussions.

The goal is to get a sense of the potential impacts on food supplies at the country level and also on global commodity prices, using a model that incorporates global commodity inventories and production levels. For the worst-case scenario for wheat markets, as just one example, we could see wheat prices spike higher than during crises in 2007–08 and in 2010–11, when prices surged again after a brief relief period related to the global economic downturn.

Under a worst-case scenario, many countries could see wheat supply impaired by as much as 25%, presenting a major gap to be filled. Many of these nations happen to rely heavily on wheat imported from Russia and Ukraine. They also may lack the means—in terms of financial capacity—to find new trade partners that reduce this regional dependence, especially when prices are high.

Responding to an Enormous Global Challenge

What can be done to address the crisis? Reducing food waste has long been a top agenda item among key global stakeholders, particularly United Nations agencies, given that as much as 30% to 40% of food is wasted somewhere along the supply chain.

More effective policies on food waste could help, though their impact is likely to be more long-term in nature. Rising food prices, of course, will naturally provide an incentive to reduce food waste, but the heart of the matter is more persistent: supply chains are quite complex and highly interdependent, given the high level of trade globalization.

While it's important that countries be able to produce some share of staple foods domestically, trade will always be vital. Each country has to balance the risks of domestic production with its risk of local concentration and the risks of trade, which have become painfully clear in the current crisis.

North Korea is an interesting case study. China is by far its largest trade partner, but most of North Korea's food is produced domestically. While this model reduces the country's external food dependence and the direct impacts of global systemic trade disruption, it also magnifies the risk of a severe weather event, such as flooding, that could hurt local food production.

There are no easy answers or choices in national food supply management: it's a question of balancing the risks of each path of food supply and identifying ways to reduce systemic risk from import disruptions. One way to tackle this issue would be to build up a more diversified roster of trade partners, over time, for the food commodities that a country imports.

Exploring the Climate Dimensions of Global Food Supply

Food production and climate are inextricably linked, which begs the question of whether global climate change will make it riskier to concentrate food production in specific regions or countries.

Among the takeaways from *Climate Change and Land*, a wide-ranging report from the Intergovernmental Panel on Climate Change, is the growing risk of extreme weather events. Droughts, high temperatures, heavy rains and other hazards will likely impair the structure of the world food supply in coming decades. The report notes regional threats such as warming compounded by drying in the Mediterranean and food-security risks in the drylands in parts of Africa, Asia and South America.

Corn production is highly concentrated in the US, with just a few states responsible for the majority of US production. A significant amount of maize is exported to global trade partners. Given that climate extremes affect sizable—and multiple—areas, highly concentrated food commodities like corn are more at risk from regional climate extremes than those such as wheat, for which production is more distributed.

The impact of the war also highlights a key risk to be managed as the world transforms its global climate policy. Part of the drive to slow climate change has involved transforming global agricultural systems to reduce, and even capture, greenhouse gas emissions. The war is a stark reminder that even as we move toward more sustainable food systems, we can't downplay the risk of these types of disruptions.

We believe that it helps to take a broader view of our food system and how it's interconnected with the world's energy production systems. The world's food supply depends on many variables: food production, transportation, energy sources, energy prices and even fertilizer prices. It's vital to consider all these dimensions as we continue on our transition to more climate-resilient—and less climate-impactful—food sources.

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