



FINANCE AND DEVELOPMENT

DECEMBER 2022

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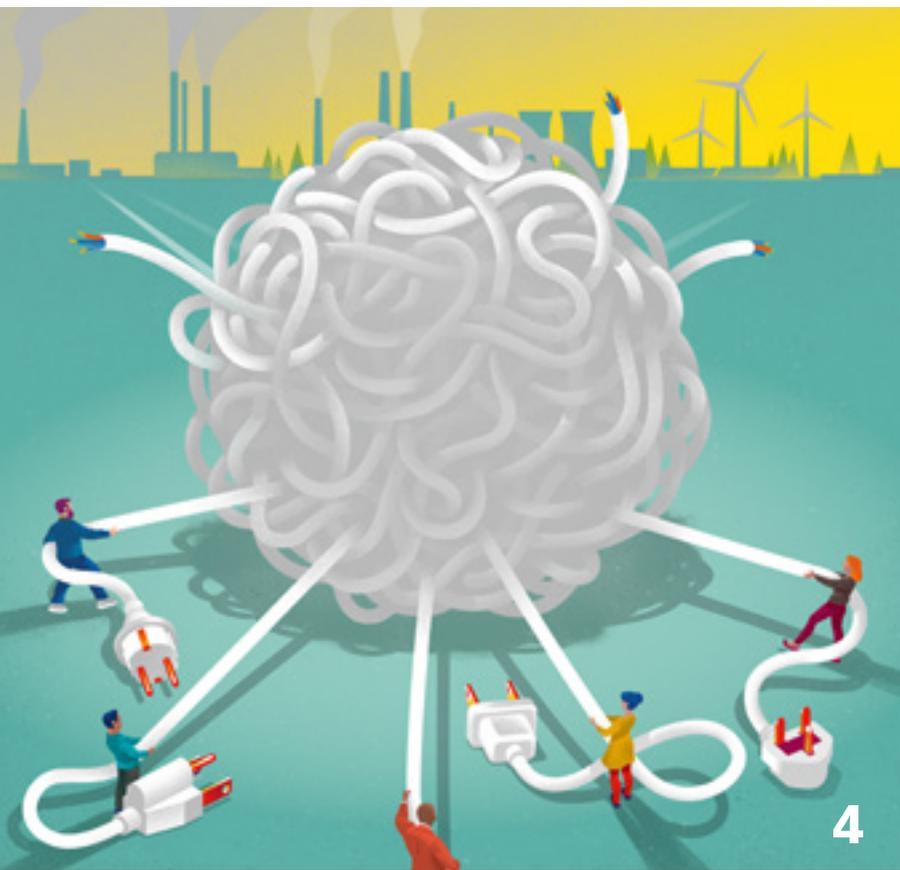
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A central illustration depicts a large, tangled mass of white cables. Several people are shown pulling on these cables, which are connected to various electrical outlets and plugs. The background features a stylized landscape with industrial smokestacks on the left and wind turbines on the right, set against a yellow sky and a teal ground.

The Scramble for Energy

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Securing the Path to Green

A FEW YEARS ago, when energy was cheaper and more plentiful, the world's focus was on curbing fossil-fuel use to achieve net-zero carbon emissions. Today, priorities have

shifted amid supply threats and price increases since Russia's invasion of Ukraine. The scramble for quick solutions to secure affordable and reliable energy could imperil climate action. How do nations manage the gap between near-term energy needs and long-term green goals?

In this issue, leading energy policy experts look at where the clean energy transition stands amid geopolitical tensions.

It's a fallacy that the world must choose between energy security and climate action, writes International Energy Agency chief Fatih Birol. He warns against using the current energy crisis as an excuse to deepen dependence on fossil fuels. In fact, he says, the situation strengthens the case for more investment in clean energy to reduce dependence on imported oil and gas.

Author Daniel Yergin warns that the energy transition needs careful planning and will lose public support if it comes at the price of economic disruption, especially in developing economies. "Advocacy has too often taken precedence over analysis," he writes.

But Europe's energy supply challenge is now. The IMF's Andrea Pescatori and Martin Stuermer explain the structural differences between oil and gas markets. European think tank Bruegel's Jeromin Zettelmeyer urges EU countries to strike a "grand bargain" and work together to reduce energy demand and boost supply while keeping internal energy markets open and compensating vulnerable consumers.

For emerging market and developing economies, the clean energy transition offers an opportunity to supercharge growth, says Harvard's Ricardo Hausmann. Investing in green technologies creates value and jobs, enabling these nations to do more to help the world decarbonize, he argues.

Long-term security still depends on a mix of clean energy technologies, from solar and wind power to nuclear, "green" hydrogen, electric vehicles, and carbon capture. As Birol argues, massive investment in clean energy is the best guarantee of energy security. Indeed, the two must go hand in hand. **FD**

GITA BHATT, editor-in-chief



ON THE COVER

Illustrator Björn Öberg's December 2022 cover depicts the scramble to secure reliable energy in the face of supply threats and price rises since Russia's invasion of Ukraine. The crisis only strengthens the case for investment in clean energy, Öberg suggests.

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FSC FPO

CRISIS UPON CRISIS

IMF ANNUAL REPORT 2022



FACING THE CHALLENGE



SCAN ME

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In a shock-prone world, long-term, inclusive growth requires resilient policy frameworks

The IMF promotes global financial stability and monetary cooperation.

A CALL TO CLEAN



ENERGY

The global energy crisis highlights the need for a massive surge in clean energy investment

Fatih Birol

The global energy crisis is fueling fierce debate around the world over which new energy projects should or shouldn't go ahead.

Conversations about energy and investment often fail to take into account the considerable lag between investment decisions and when projects actually go live. At the International Energy Agency (IEA), we warned years ago that global investment in clean energy and energy efficiency was not sufficient to put us on a path to reach our climate goals. Without a surge in clean energy spending, the amounts invested in conventional energy projects also risked falling short of what would be needed to meet potential increases in demand.

Even though the current energy crisis was triggered by Russia's invasion of Ukraine, we must still pay close attention to these underlying investment imbalances as we emerge from the crisis, or we risk more volatility ahead. Are today's sky-high fossil fuel prices a signal to invest in additional supply or further reason to invest in alternatives?

Energy investment decisions are being clouded by the fog of war. Russia's invasion has thrown investment plans across all energy sectors into turmoil and exacerbated strains in global commodity markets that were already visible. Energy-importing countries are now scrambling to replace disrupted supplies of fuels, and soaring costs have wreaked havoc in many economies and forced millions of people back into poverty and energy insecurity.

Of course, countries need to find immediate substitutes for the fuel imports that were suddenly cut off. If not, factories will close, jobs will be lost, and people will struggle to heat or cool their homes. But today's energy crisis—the first truly global energy crisis—has given rise to a false narrative that now is not the moment to invest in clean energy.

This could not be further from the truth. We do not have to choose between responding to today's energy crisis and tackling the climate crisis. Not only can we do both, we must do both because they are intimately linked. Massive investment in clean energy—including energy efficiency, renewables, electrification, and a range



of clean fuels—is the best guarantee of energy security in the future and will also drive down harmful greenhouse gas emissions.

A worrying divide

Global-energy-related CO₂ emissions rose by a record amount in 2021, and investment in clean energy technologies is still well below what it will take to bring emissions down to net zero by mid-century or soon thereafter. The \$1.4 trillion we expect the world to spend on energy transitions in 2022 would have to rise to well over \$4 trillion by 2030 to get us on track to limit global warming to 1.5 degrees Celsius while also ensuring sufficient energy supply.

At the same time, lower investment in recent years has left some oil and gas producers unable to quickly ramp up production to meet today's demand, even with the incentive of record high prices. We risk seeing the worst of both worlds: the inability to provide for current energy needs and falling woefully short of what is needed to meet international climate goals.

We do not have to choose between responding to today's energy crisis and tackling the climate crisis. Not only can we do both, we must do both.

Published earlier this year, the *World Energy Investment 2022* report shows some encouraging trends—but also plenty of cause for concern.

The good news is that investment in clean energy transitions is finally picking up. In the five years following the 2015 Paris Agreement, clean energy investment grew only 2 percent a year. However, since 2020, this rate has risen to 12 percent a year, led by increased spending on solar and wind power, including a record year for offshore wind power in 2021.

There is strong momentum in other new areas, like low-emission hydrogen; new battery technologies; and carbon capture, utilization, and storage

(CCUS), even if this impressive growth is coming from a small base. For example, in 2021 plans for about 130 commercial-scale carbon capture projects in 20 countries were announced, and six CCUS projects were approved for final investment. Meanwhile, Russia's war against Ukraine has bolstered policy support for low-emission hydrogen, especially in Europe. And investment in battery energy storage is hitting new highs and is expected to double in 2022.

But this investment is concentrated in advanced economies and China, leaving many emerging market and developing economies, particularly in Africa, unable to attract the clean energy investments and financing they need, widening an already troubling divide. Except in China, clean energy spending in emerging market and developing economies is stuck at 2015 levels, which means it hasn't increased since the Paris Agreement was reached. Falling clean technology costs mean that this money goes further, but the overall amount—about \$150 billion a year—is far short of what is needed to meet rising energy demand in developing economies in a sustainable way.

In these economies, public funds for sustainable energy projects were already scarce and have become scarcer still since the COVID-19 pandemic. Policy frameworks are often weak, the economic outlook is uncertain, and borrowing costs are rising. After the pandemic hit, the number of Africans without access to electricity rose, wiping out years of progress on that crucial front.

No shortage of capital

This is where international financial organizations and development institutions have a major role to play. They can work with local governments to develop policies to improve the investment environment, and their financing can help de-risk private sector involvement.

There is no shortage of capital globally. The amount of sustainable financing available worldwide has surged in recent years and is a strong tailwind for solar and wind projects in particular. But far more needs to go to emerging market and developing economies. For example, sustainable debt issuance in 2021 hit a record \$1.6 trillion, but more than 80 percent was in advanced economies.

Sustainable finance, and the wider world of environmental, social, and governance (ESG) investing, would greatly benefit from clearer standards,



definitions, and reporting obligations, and there has been progress. For example, the European Union has introduced risk management and reporting requirements for financial market participants regarding climate risks and sustainability practices. Clearer guidelines and opportunities to finance credible transition plans in carbon-intensive sectors would ensure that ESG requirements do not prevent financing for essential-but-emitting energy sectors. Finally, the entire ESG ecosystem must engage more with emerging market and developing economies and take account of their needs and circumstances. Institutions such as the IMF have a major role to play.

In the IEA's landmark road map to net zero emissions by 2050, we said a massive surge in investment in clean energy technologies and energy efficiency could cut global demand for fossil fuels so much that there would be no need for investment in new oil and gas fields. At the same time, continued spending on existing assets—including investments to reduce upstream emissions—remains essential in this pathway. Moreover, Russia's war against Ukraine has brought major disruptions to the global energy system. Immediate shortfalls in fossil fuel production from Russia obviously must be replaced by production elsewhere—even in a world working toward net-zero emissions by 2050.

Balancing these demands requires judicious investment, and the IEA is helping decision-makers around the world with data, analysis, and policy advice. The key is to avoid spending on infrastructure that would either lock in heavy emissions for years to come or quickly turn into stranded assets. Suitable options include extending production from existing fields and making better use of natural gas that is currently flared or vented. Some new infrastructure may be needed, especially liquefied natural gas import terminals in Europe, to diversify supply away from Russia. But with careful investment and planning, these terminals could facilitate future imports of low-emission hydrogen or ammonia. In countries open to it, nuclear power has a role to play, especially the promising new small modular reactors that are in development.

A historic turning point

The current situation offers a crucial opportunity for the oil and gas sector to show it is serious about

the transition to clean energy. The run-up in prices is set to generate an unprecedented \$2 trillion windfall for oil and gas producers this year, bringing their total income to a record \$4 trillion in 2022. Yet the oil and gas industry is still spending only modestly on energy transitions: on average, clean energy spending accounts for about 5 percent of total oil and gas company capital expenditure. That is up from 1 percent in 2019, but still far too little. Today's windfall gains are a once-in-a-generation opportunity for oil- and gas-producing countries to diversify their economies and prepare for a world of lower fossil fuel demand—and for major oil and gas companies to seize leadership roles in some of the clean energy sources that the world will rely on for decades to come.

Let's not forget that energy security is not just about increasing the supply of power and fuels. It is also about efficient use of energy—especially given today's array of technologies that can help. The IEA's 10-point plan to reduce the European Union's reliance on Russian natural gas, published in March—one week after Russia's invasion—includes steps to replace Russian gas but also calls for a major push on renovating building stock to reduce demand. Better materials and insulation, newer technologies, and more efficient appliances greatly reduce the energy needed to heat, cool, and light our homes and workplaces. Smart electrical grids will better manage and reduce power demand. Consumers can take immediate and simple steps such as adjusting the thermostat to avoid overheating or overcooling, which can collectively add up to massive savings.

The current global energy crisis presents huge challenges, especially for the coming winters. But after the winter comes spring—and the right investment decisions can transform this crisis into a historic turning point toward a cleaner and more secure energy future. We are already seeing encouraging steps in this direction—such as the Inflation Reduction Act in the United States; the REPowerEU package in the European Union; Japan's Green Transformation plan; and the growth of renewables in China, India, and beyond. A new global energy economy is emerging, and the governments and businesses that invest early and wisely stand to reap the benefits. [FD](#)

FATIH BIROL is executive director of the International Energy Agency.



BUMPS IN THE ENERGY TRANSITION

Despite a growing global consensus, obstacles to reducing net carbon emissions to zero are stark

Daniel Yergin

The global disruptions in energy markets and the war in Ukraine have added impetus to the push for renewable energy and the drive toward net-zero carbon emissions. Yet, even as the global consensus around the energy transition becomes stronger, the challenges to that transition are also becoming clearer.

In addition to the uncertain pace of technological development and deployment, four issues in particular stand out:

- The return of energy security as a prime requirement for countries
- Lack of consensus on how fast the transition should and can take place, in part because of its potential economic disruptions
- A sharpening divide between advanced and developing countries on priorities in the transition
- Obstacles to expanding mining and building supply chains for the minerals needed for the net-zero objective

The *need for energy security* was a concern that had largely faded over the past several years. The energy shock, the economic hardship that ensued, skyrocketing energy prices that could not have been imagined 18 months ago, and geopolitical conflicts—all these have combined to force many

governments to reassess strategies. This reassessment recognizes that the energy transition needs to be grounded in energy security—that is, adequate and reasonably priced supplies—to ensure public support and avoid severe economic dislocations, with the dangerous political consequences that can follow.

The current global energy crisis did not start with the February 2022 invasion of Ukraine. Rather, it began in late summer of 2021. The economic rebound that came with the ending of the global COVID-19 lockdowns fired up global energy consumption. Oil, natural gas, and coal markets all tightened in the latter part of 2021, sending prices up as demand pushed against what became apparent—insufficient supply. It was in November 2021, three months before the invasion, that the US government announced the first release from its strategic petroleum reserve. What has become clear is that “preemptive underinvestment” has constrained the development of adequate new oil and gas resources. There are a number of reasons for this underinvestment—government policies and regulations; environmental, social, and governance (ESG) considerations by investors; poor returns caused by two price collapses in seven years; and uncertainty about future demand. The shortfall in investment was “preemptive” because

Energy transitions throughout history

The first energy transition was from wood to coal in the 18th century. Although coal was used as early as the 13th century in Britain because the cost of wood had gone up, it emerged as a distinctive industrial fuel only in January 1709—when English metalworker Abraham Darby proved that coal was, as he said, “a more effective means for iron production” than wood. He noted, though, that “there are many who doubt me foolhardy.”

Yet energy transitions have hardly been swift. Although the 19th century is known as the “century of coal,” that century actually still ran, in the words of energy scholar Vaclav Smil, on “wood, charcoal, and coal residues.” It was not until 1900 that coal supplied half the world’s energy demand.

Oil was discovered in the United States in 1859. More than half a century later, on the eve of World War I, then First Lord of the Admiralty Winston Churchill directed the conversion of the Royal Navy from coal to oil for technological

reasons—speed, flexibility, ease of refueling, and the elimination of crews shoveling coal. But it took until the 1960s, a century after it was discovered, for oil to overtake coal as the world’s number one energy source.

Until now, energy transitions have unfolded over long periods of time (see “Picture This” in this issue of F&D). They also have really been energy additions rather than transitions. In the six decades since oil overtook coal as the world’s number one energy source, the global consumption of coal has almost tripled.

The current climate-driven energy transition is meant to be achieved quickly—in little more than a quarter century. And it is meant to be transformative. Coal is to disappear, and the European Union anticipates that hydrogen will provide 20 to 25 percent of its total energy by 2050. While it is the focus of increasingly intense activity and ambition, hydrogen provides less than 2 percent today.



The objective of this transition is not just to bring on new energy sources, but to entirely change the energy foundations of what today is a \$100 trillion global economy.

of what was mistakenly assumed—that sufficient alternatives to oil and gas would already be in place at scale by now. Some have described what is currently unfolding as the “first energy crisis of the energy transition”—a mismatch between supply and demand. If it does prove to be only the first, future such crises will create uncertainty, cause major economic problems, and undermine public support for the energy transition.

Speed of the transition

If energy security is the first challenge of the transition, *timing* is the second. How fast should it—and can it—proceed? There is much pressure to accelerate a significant part of the 2050 carbon emission targets toward 2030. But it sometimes seems that the scale of what is being attempted is underestimated.

In my book *The New Map* (2021), I looked at the previous energy transitions, and it is clear that this one is like no other. All previous transitions were driven largely by economic and technological advantages—not by policy, which is the primary driver this time. Each of the preceding transitions unfolded over a century or more, and none were the type of transition currently envisioned. The objective of this transition is not just to bring on new energy sources, but to entirely change the energy foundations of what today is a \$100 trillion global economy—and do so in little more than a quarter century. It is a very big ambition, and nothing on this scale has ever been attempted up to now.

Some have warned that because the scale of the transition is so large and far-reaching, the macroeconomic impact needs deeper analysis. The economist Jean Pisani-Ferry, cofounder of Bruegel, Europe’s leading economic think tank, has observed that accelerating the targets for net carbon

emission reductions too aggressively could create much larger economic disruptions than generally anticipated—what he called “an adverse supply shock—very much like the shocks of the 1970s.” Such a transition, Pisani-Ferry presciently wrote in 2021, just before the current energy crisis began, is “unlikely to be benign and policymakers should get ready for tough choices.” He subsequently added, in 2022: “Climate action has become a major macroeconomic issue, but the macroeconomics of climate action are far from the level of rigor and precision that is now necessary to provide a sound basis for public discussions and to guide policymakers adequately. For understandable reasons, advocacy has too often taken precedence over analysis. But at this stage of the discussion, complacent scenarios have become counterproductive. The policy conversation now needs methodical, peer-examined assessments of the potential costs and benefits of alternative plans for action.”

North-South divide

The third challenge is the *emergence of a new North-South divide*—a sharpening difference between developed and developing countries on how the transition should proceed. The original North-South divide of the 1970s was a collision between developed and developing nations over the distribution of wealth and, in particular, the pricing of commodities and raw materials. That division faded with globalization and advances in technology, as reflected in the shift in nomenclature to “emerging market” nations.

The new North-South divide reflects disagreement over climate and transition policies, their impact on development, and who is responsible for cumulative and new emissions and who pays. The global commodity shocks triggered by the



For developing countries, what seems a singular emphasis on reducing emissions needs to be balanced against other urgent priorities—health, poverty, and economic growth.

war in Ukraine and the interest rate increases and currency devaluations that have ensued have only deepened the pressures on developing countries.

For developing countries, what seems a singular emphasis on reducing emissions needs to be balanced against other urgent priorities—health, poverty, and economic growth. Billions of people still cook with wood and waste, resulting in indoor pollution and poor health. Many of these countries are looking to increased use of hydrocarbons as integral to raising standards of living. As former Indian Petroleum Minister Dharmendra Pradhan put it, there are multiple paths for energy transitions. India, while making a big commitment to renewables, is also building a \$60 billion natural gas distribution system. Developing countries are seeking to initiate and expand the use of natural gas to reduce indoor pollution, promote economic development and job creation, and, in many cases, eliminate the emissions and pollution that come from burning coal and biomass.

There may be a tendency in countries with advanced economies to wave away this divide, but the reality was sharply captured in September 2022, when the European Parliament voted, in an unusual expression of extraterritoriality, to condemn a proposed oil pipeline from Uganda through Tanzania to the Indian Ocean. The parliament denounced the project for what it said would be the pipeline’s detrimental impact on climate, environment, and “human rights.” The parliament is headquartered in France and Belgium, where the per capita income is about 20 times greater than in Uganda. Not unexpectedly, the condemnation set off a furious reaction in Uganda, where the pipeline is viewed as crucial to economic development. The deputy speaker of the parliament

denounced the European resolution as “the highest level of neocolonialism and imperialism against the sovereignty of Uganda and Tanzania.” The energy minister added, “Africa has been green, but people are cutting down trees because they are poor.” The national student union in Uganda took to the streets to demonstrate against the European Parliament, with one of the student leaders saying, “The Europeans have no moral superiority.” Whatever the specific issues, it’s hard to deny the sharp difference in perspectives.

The split is particularly evident when it comes to finance. Western banks and multilateral financial institutions have shut off finance for pipelines as well as for ports and other infrastructure related to hydrocarbon development. One African energy minister summed up the impact of the denial of access to finance as akin to “removing the ladder and asking us to jump or fly.” Finding a balance between the perspectives of the developing world, where 80 percent of the globe’s population live, and Western Europe and North America will take on increasing urgency.

Finance shut off

The fourth challenge will be *ensuring new supply chains for net zero*. The passage in the United States of the Inflation Reduction Act, with its massive incentives and subsidies for renewable sources of energy; the REPowerEU plan in Europe; and similar initiatives elsewhere will accelerate the demand for the minerals that are the building blocks for renewable energy, which requires wind turbines, electric vehicles, and solar panels, among other things. A host of organizations—the IMF, the World Bank, the International Energy Agency (IEA), the US government, the European Union,

Japan—have all issued studies on the urgency of those supply chains. The IEA projects that the world economy will be moving from “a fuel intensive to a mineral intensive energy system” that will “supercharge demand for critical minerals.” In *The New Map*, I summarize this as the move from “Big Oil” to “Big Shovels.”

S&P Global, the financial and analytical firm of which I am vice chairman, has sought to build upon those studies and quantify what that “supercharged demand” for minerals might be. S&P Global’s study “The Future of Copper: Will the Looming Supply Gap Short-Circuit the Energy Transition?” (2022) focused on that metal because the thrust of the energy transition is toward electrification, and copper is “the metal of electrification.” The study took the types of year 2050 targets advanced by the US administration and the EU and assessed what realizing those targets would require for specific applications—for instance, the different components of an offshore wind system or electric vehicles. An electric car, for example will require at least two-and-a-half times more copper than a vehicle with a conventional internal combustion engine. The conclusion of this analysis is that copper demand would have to double by the mid-2030s to achieve the 2050 goals

The choke point is supply. At the current rate of supply growth—which encompasses new mines, mine expansion and greater efficiency, and recycling, as well as substitution—the amount of copper available will be significantly smaller than the copper supply requirements. For instance, the IEA estimates that it takes 16 years from discovery to first production for a new mine. Some mining companies say more than 20 years. Permitting and environmental issues are major constraints around the world. Also, copper production is more concentrated than, say, oil. Three countries produced 40 percent of world oil in 2021—the United States, Saudi Arabia, and Russia. Just two countries produced 38 percent of copper—Chile and Peru.

Copper is crucial

Copper prices have fallen about 20 percent from their high point this year. That reflects the metal’s oft-noted role as “Dr. Copper”—its price as a predictor of economic slowdowns and recessions. And indeed, the IMF sees a sharp slowdown in global

growth in 2022 and projects further slowing in 2023 and potential recession—as do many other forecasters. But, post-recession, the coming flood of demand from the energy transition will cause copper prices to rise again. As has been the historical pattern, the surge in demand and prices will likely create new tensions between resource-holding countries and mining companies, which in turn will affect the rate of investment. Moreover, as the race to net zero intensifies, there is a risk that the competition for minerals will become caught up in what has become known as the “great power competition” between China and the United States.

S&P Global’s copper study is meant to contribute to a deeper analysis of the physical challenges to the energy transition. The wind industry has what a 12th century English champion of windmills called “the free benefit of wind.” And solar has the free benefit of the sun. But the physical inputs that go into harnessing wind and solar power are not costless. The effort to push a significant part of the 2050 goals toward 2030 will likely have to contend with significant physical constraints.

These four challenges—energy security, macroeconomic impacts, the North-South divide, and minerals—will each have significant effects on how the energy transition unfolds. None are easy to grapple with—and they will interact with each other, which will compound their impacts. But recognizing them will promote deeper understanding of the issues and requirements in seeking to achieve the energy transition. **FD**

DANIEL YERGIN is vice chairman of S&P Global. His newest book is *The New Map: Energy, Climate, and the Clash of Nations*. He received a Pulitzer Prize for his book *The Prize: The Epic Quest for Oil, Money & Power*.

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GREEN GROWTH OPPORTUNITIES

How developing economies can capitalize on the green transition

Ricardo Hausmann

Picture yourself as finance minister of a developing economy. An eager environmentalist tries to convince you of the moral imperative of cutting your country's greenhouse gas emissions. You soon become bored because you've heard it all before, and your mind moves to more pressing matters. Your country is full of problems, from economic instability and inflation to challenges funding public services. Reducing emissions is not a priority.

Even if you were to succeed, your impact on the climate would be minuscule. Countries as populous as Pakistan, Nigeria, and Egypt each represent less than 1 percent of the world's emissions. Your country's emissions—even cumulative since the Industrial Revolution—are infinitesimally small. Eliminating them all would have no material impact on the climate: you would have incurred costs and forgone opportunities to deliver economic prosperity with little to show for it.

Yet it would be a grave mistake not to consider climate change as an important aspect of your job. Change is sweeping across the global economy as countries recognize that the world must slash emissions to prevent a climate catastrophe. Decarbonization will reduce demand for dirty goods and services and increase demand for those that are cleaner and greener. The question is not what you can do to reduce your country's emissions but how you can supercharge your country's development by breaking into fast-growing industries that will help the world reduce its emissions and reach net zero.

Your country's history has been fundamentally shaped by the development of the few products it is able to make at home and sell abroad. Successful economies in east Asia and eastern Europe have sustained decades of high growth by upgrading their areas of comparative advantage, from garments to electronics to machinery and chemicals. They did not remain stuck in industries bequeathed by the past. If your country is to create jobs that pay higher wages, it will have to find new industries that can grow and export competitively even with higher wages.

Pessimists say that opportunities may have been there in the past for countries like Japan, Korea, or China, but those paths to development are now closed. Decarbonization will, however, create new opportunities—especially for those that move

fast. The paths that are opening up have not been trod by many predecessors. Some are still virgin. Decarbonization will require significant greenfield investments, and plants will have to find new places to locate. This could be a great opportunity for your country, but to assess it, you must understand the changing landscape.

We do not know what technologies will power the low-carbon global economy or what materials and manufacturing capabilities they will need—nor what regulatory regimes the world will adopt, let alone what kind of cooperation or conflict will characterize relations between the largest emitters. These uncertainties will be resolved by those countries that play an active role and master the capabilities that will underpin their future comparative advantage. Keep in mind these six themes as you explore and exploit the opportunities and threats.



Embrace global electrification.

More than 70 percent of global emissions come from energy use. To decarbonize, the world needs to electrify the things we currently do with fossil fuels and generate that electricity from green sources such as wind and solar. This will require massive amounts of solar panels, wind turbines, electrical cables, and capacitors as well as mechanisms to store energy, such as lithium-ion batteries. Electrolyzers and fuel cells will be needed as well to convert electricity into hydrogen and back. All these products are highly intensive in metals and rare earth elements. Production of these minerals will have to expand by several multiples if the world is to achieve net zero. So net zero requires a mining boom.

Mining itself is a highly energy-intensive industry. The future is likely to demand that the energy used in mining be green, too. Mining also has local environmental impacts and is water-intensive. Most countries fail to implement a regime that is open to investment but adequately manages these risks and conflicts of interest.

In addition, these minerals must be processed into the capital goods needed by electrification. This involves long manufacturing global value chains. Today many megafactories are being built to produce lithium-ion batteries, mostly in China, Europe, and the US. Why are none in your country? Do you have what it takes to host them? If not, can you acquire the missing capabilities?



While some industries will grow as the world decarbonizes, others will shrink. Some may be in your country. You must identify export industries that will face headwinds because they are high emitters or supply high-emitting value chains. Vested interests at home will dismiss global warming as a hoax and mobilize against greening policies. But they will be impacted nonetheless by these global trends. Sooner than you think, your companies in these industries will struggle to access financing because capital markets will fear that the assets they fund will be stranded. Find ways to redeploy capabilities to more promising prospects.

2 Capitalize on proximity to renewable energy. The sun shines and the wind blows in many countries, but some (including Namibia, Chile, and Australia) are working hard to use these resources to produce green energy products. This may be a first step to an even more promising future. Here's why.

Oil and coal are incredibly energy-dense, meaning they contain a lot of energy per unit of weight and volume. This makes them cheap to transport. If a barrel of oil is worth about \$100 at the well, shipping it halfway around the world costs less than \$4. As a consequence, oil and coal made the world flat from an energy perspective. Energy-poor countries could become competitive in energy-intensive products. China, Japan, and Germany, for example, are major steel exporters but energy importers.

This is unlikely to be the case with the alternatives to oil. With natural gas, for instance, there are huge price differences between markets because of the difficulty and cost of liquefying and transporting liquefied natural gas. Countries with a lot of sunshine produce solar energy for less than \$20 a megawatt hour. To move the energy a long distance, it must be stored in a molecule such as ammonia. But the conversion will increase the cost of energy sixfold (not counting the cost of transport). This creates enormous incentives to use renewable energy in situ. Energy-intensive industries will move toward places rich in green energy. Will your country be one of them?

3 Keep the cost of capital low. The sun shines, the wind blows, and the rain falls for free. Most of the cost of renewable-energy production is the

fixed cost of the equipment, including the cost of the capital to buy it. How much are you paying? If you are in Germany, maybe you can get funding at 2 percent. In the Dominican Republic, it may be 7 percent. So, although the Dominican Republic is sunnier than Germany, this does not translate into cheaper solar energy. This is a major issue because the sun is strong in the tropics, but capital markets shun these regions, reversing their comparative advantage. Good institutions and macroeconomic management that keep country risk low are critical determinants of the cost of capital and hence your country's ability to be competitive in green energy.

The world is full of countries that have squandered their natural endowments because of failures in macroeconomic and mining-sector governance. Venezuela arguably has the world's largest oil reserves, but oil production has fallen by 80 percent from a peak in 1998 because of oil expropriation and macro mismanagement that scared off capital markets. A similar fate could await countries with metals needed for the green transition, such as lithium, cobalt, copper, aluminum, and nickel, if they mismanage their resources.

4 Manage technological risks. Technological uncertainty has always been with us. Who would have thought the smartphone would displace the alarm clock, the camera, the CD player, and even the personal computer? Today one megawatt hour of solar energy when the sun is shining or the wind is blowing is cheaper than the fossil fuel needed to generate the same megawatt using a thermal plant. This was unthinkable a decade ago.

On the road to net zero, we do not know which technologies will win the race. But we are aware of many of the technologies in the running. They first appear as ideas in scientific papers and patents. They then move on to pilot and eventually commercial plants. You should be aware of the bets being placed across the world.

Technological surveillance is done regularly by industry, but few governments do enough of it. Israel and Singapore have chief scientists in their economy ministries to anticipate changes that may be coming and decide the most promising R&D bets. Given the large lithium resources in Chile, the government is investing in a lithium research center with a consortium of global universities so

Decarbonization will require significant greenfield investments, and plants will have to find new places to locate. This could be a great opportunity for your country.

that it can be on top of the technologies that might reduce costs and enhance the use of lithium while tracking those that may displace it.

5

Explore carbon sinks. Net zero is not gross zero. The difference is carbon capture, and the future is likely to create markets for it. You may be

able to obtain carbon credits by reforesting deforested areas or by protecting existing forests. In the Amazon, for example, people are felling trees because it is more profitable to use the land for cattle ranching. Yet at reasonable carbon prices, the forest can capture carbon that is more valuable per hectare than beef. But carbon prices today are not reasonable. In many countries they do not even exist or, if they do, they are a small fraction of those in Europe—too low to make forests more profitable than cattle ranching.

In a well-functioning market, carbon prices should be equalized globally because the atmosphere is global. But markets cannot trust that carbon captured by trees this year is not going to return to the atmosphere next year when somebody clears the land for cattle. For this reason, your carbon credits trade at a huge discount, if at all. You need to develop the institutions for credible carbon credits.

There are other sinks, too. You may have geological formations that are ideal to store carbon that has been captured. You should figure out where these are and certify that they are safe and sealed. You must define property rights on these geological formations so that investment can take place and you can collect a rent from storage space. This will require work because legislation was built assuming people would take valuable materials out of the ground, not put unwanted residues into it.

6

Plan to learn. No country today excels at the technologies and industries that will shape the future. But some will learn and others will not.

What will you do to make sure your country is in the first group? Too often countries are told to shun things they don't do well and focus on things they are good at. But growth has never been just about focusing on current areas of comparative advantage. It is also about evolving that advantage. France has a long history of being good at wine and cheese, but it also became good at commercial aircraft and high-speed rail. Who will develop the capacity to manufacture electrolyzers competitively? Who will transform their sunshine and wind into a source of advantage? It will be those that focus on attracting strategic investments and global talent, on facilitating technological adoption by supporting research programs at universities and beyond. It can seldom be done by closing off the domestic market.

Asking countries to contribute to global decarbonization by prioritizing the reduction of their own carbon footprints is an unhelpful framework. Creating value and livelihoods at home by helping the world decarbonize is a more promising proposition. Because these are new challenges, they are bound to be open to new players. You can be one of them. The payoffs could be huge. [FD](#)

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NUCLEAR RESURGENCE

The energy security case for nuclear power is building

Ted Nordhaus and Juzel Lloyd

Recent months have marked a dramatic turn-about for the fate of nuclear energy across the developed world. As the Russian invasion of Ukraine turned post-pandemic energy shortages into a full-blown energy crisis, nuclear power plants slated for closure across Europe have been given an 11th hour reprieve. Japan has announced, after a decade of paralysis, that it plans to restart many of its reactors, which have sat idle since the nuclear accident at Fukushima Daiichi. France, which had launched plans to reduce its dependence on nuclear energy during President Macron's first term, reversed course and now plans to build six new reactors and a dozen more small modular reactors. The UK has launched an ambitious plan to build eight new reactors and 16 small modular reactors. Even anti-nuclear Germany has conceded to basic geopolitical energy realities and extended the life of the nation's last three operating nuclear power plants.

The turn back to nuclear energy has been a ray of hope in an otherwise dark geopolitical landscape. Despite significant progress on the cost and feasibility of renewable energy, the energy crisis reminds us just how dependent the world remains on fossil fuels. Europe, arguably the wealthiest and greenest precinct of the global economy, and a region that has invested trillions over the past two decades to transition its energy economy to wind and solar energy, has been forced to engage in a wild scramble to replace Russian oil and gas with alternative sources of fossil fuel, importing liquefied natural gas from the United States and other regions, fast-tracking new pipeline projects from North Africa, and firing up mothballed coal plants to keep the lights on and its factories humming.

The picture is darker still across emerging market and developing economies. Europe is buying its way out of energy poverty. Many other regions of the world do not have the resources to do so.

THE TURN BACK TO NUCLEAR ENERGY HAS BEEN A RAY OF HOPE IN AN OTHERWISE DARK GEOPOLITICAL LANDSCAPE.

Soaring energy prices have resulted in shortages, blackouts, and protests across the developing world and have pushed hundreds of millions back into extreme poverty. Meanwhile, the resulting spike in fertilizer prices has threatened harvests and raised the specter that famine, largely banished from even the poorest regions of the world in recent decades, might be back for an encore.

The limits of renewable energy

Taken together, these developments suggest two interlinked conclusions. First, the world remains far too dependent on fossil fuels. Progress to reduce dependence on them and cut carbon emissions is real. But that progress has been limited to rising shares of renewable energy in the power sector, which accounts for only about 20 percent of energy use and emissions globally, along with incremental improvements to energy efficiency across the rest of the global energy economy, which remains powered almost entirely by fossil fuels.

Second, wind and solar energy alone will not be sufficient to break that dependence. Even in the power sectors of the wealthiest countries in the world, no economy has succeeded in getting much more than about a third of its electricity from wind and solar combined. Even the exception proves the rule. Green icon Denmark generates about 50 percent of its electricity from wind. But it is fully integrated into the much larger Scandinavian grid, which includes Sweden, Norway, and Finland and is dominated by hydroelectric power and nuclear energy. Denmark's vaunted wind energy accounts for only about 4 percent of total electricity generation annually across the Scandinavian grid.

Nuclear energy represents a potential solution to both problems, providing a firm source of electricity that can complement the variable sources of renewable energy on electrical grids, as it does in Scandinavia. It also features the ability to produce carbon-free heat as well as power for a range of industrial and other energy-intensive activities—from refining and fertilizer manufacturing to steel and hydrogen production—that are difficult to fully electrify.

To be relevant beyond generating electricity in the power sectors of technologically advanced

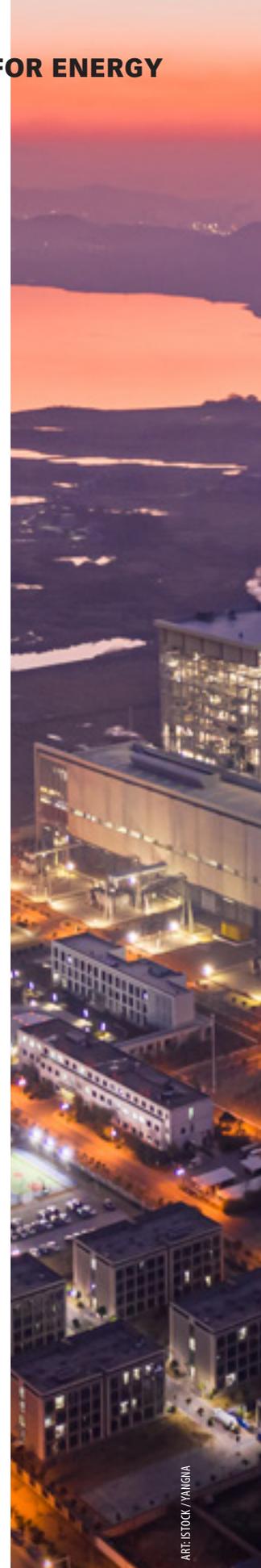
economies, however, nuclear technology will need to change. Under the right economic and institutional circumstances, the large light-water reactor technology that has dominated the sector historically can be remarkably effective at replacing fossil fuels on electricity grids. France gets 75 percent of its electricity from nuclear energy, while Sweden and several other advanced economies get about 50 percent.

But large light-water reactors are complex technologies, requiring highly trained personnel to maintain and operate them. They have a large amount of fissile material in their core and so depend on a multiplicity of active safety systems to ensure safe operations. These, in turn, require sophisticated regulatory capabilities to ensure that the plants are operated safely. Large light-water reactors also need to be refueled regularly, every 18 months or so. This makes it more difficult practically to decouple reactor operations in any given locale from the nuclear fuel cycle, which raises a range of nuclear proliferation concerns.

Light-water reactors operating at lower temperatures cannot meet heat requirements for many important industrial uses and so are limited to use primarily in the electricity sector. And even in that sector, they have limited ability to ramp up and down and so are not optimized for grids that have significant amounts of variable wind and solar generation as well.

Refining nuclear

For these reasons, the nuclear sector will need to evolve in important ways if it is going to play a major role in addressing energy security and climate challenges in many parts of the world and beyond the power sector. Several new advanced reactor technologies are under development that are better suited to industrial uses and are being targeted to replace existing coal-fired energy production. China has connected its first high-temperature gas reactor to the grid, and it envisions that it will ultimately be a drop-in replacement for existing coal-fired power plants and will be used for other industrial purposes, such as hydrogen and chemical production. The United States has committed to



ART: ISTOCK/YANGVIA



building two advanced demonstration reactors this decade. One by X-energy will be designed to provide industrial heat and power; one by TerraPower is planned as a coal plant replacement and will feature an integrated molten salt energy storage system that will optimize it to back up variable wind and solar electricity generation.

Similarly, smaller and less complicated advanced reactors—more suitable to the energy development needs of countries without the technical know-how and institutional capabilities to maintain, operate, and regulate large conventional reactors—are currently in the development pipeline. New advanced technologies such as Oklo’s Aurora reactor are applying for licenses in the United States and Canada. These very small reactors are sealed and don’t require regular refueling, making them well suited for applications in which the entire reactor can be plugged into a grid or dropped into a remote off-grid location. These reactors can operate for years without refueling and can eventually be replaced by a new unit and sent back to a factory for refueling and refurbishment.

Innovation of this sort will be necessary if nuclear is going to play a significant role in many developing economies, and beyond the power sector, and extends well beyond the technologies themselves. New business models; new and more flexible regulatory, licensing, and export rules; and a revised global nonproliferation framework will be needed to fully realize the potential of these new technologies to provide low-carbon heat and power consistent with displacing fossil energy at global scale.

So too will be significant reconsideration of the long-running festival of hypocrisy that is climate development financing. While rich countries scramble to monopolize global fossil fuel resources in response to the energy crisis, the European Union, the Biden administration in the US, and the global climate movement have put pressure on the poorest nations in the world. With a fraction of the wealth, infrastructure, and technological capabilities, they are expected to achieve what the richest countries in the world cannot—power their economies without significant additional fossil fuel development—because of blanket bans on fossil fuel development financing in the name of mitigating climate change.

Because most development banks exclude nuclear and hydropower, largely because of environmental objections from donor nations, climate

development financing today in effect limits the poorest countries’ development aspirations to the use of renewable energy. And while wind and solar energy have begun to gain a foothold in many poor countries, it is still very small and will do little to help these countries build passable roads, manufacture steel or fertilizer, or build modern housing and infrastructure in rapidly growing cities.

Powering Africa

If there is any place in the world that should be able to pursue an all-of-the-above energy agenda, it is sub-Saharan Africa, which uses about the same amount of electricity as Spain despite having 18 times its population. More than 600 million lack access to electricity, clean cooking fuels, and modern transportation. The entire continent has only two factories capable of producing ammonia, the critical precursor of synthetic fertilizers, and lack of access to affordable fertilizers punishes small farmers, whose yields are five times lower than US or European farmers’.

Nuclear energy, like wind and solar, is not a panacea and can’t solve all these problems. And new nuclear technologies designed and scaled to Africa’s needs are at least a decade away.

But numerous African nations, including Ghana, Kenya, Namibia, Nigeria, South Africa, Sudan, Tanzania, Uganda, and Zambia, have in recent years expressed significant interest in developing new nuclear plants. And any long-term pathway toward a prosperous and modern African future is likely to need them. Africa’s population is expected to double by 2050, making it one of the most populous regions in the world.

No less than in the richest countries, fossil fuels across Africa and much of the rest of the developing world are likely to remain a fact of life for many decades to come. Accelerating a transition away from them globally will require putting new low-carbon options on the table, not taking them away. Nuclear energy is without question one of those options. As the rich world reconsiders the value of the atom, a reconsideration of its potential to address the global development challenge, as well as the global climate challenge, is long overdue. **FD**

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HYDROGEN'S DECADE

The global race for clean hydrogen means new geopolitical realities and interdependence

Thijs Van de Graaf

If the 1990s were the decade of wind, the 2000s the decade of solar, and the 2010s the decade of batteries, the 2020s could launch us toward a next frontier of the energy transition: hydrogen. Hardly a week goes by without a major new hydrogen project or breakthrough. In just the past five years, more than 30 countries have developed or started to prepare national hydrogen strategies (IEA 2022). The Paris climate goals have been a key driver, but Russia's war in Ukraine and soaring gas prices have also driven a shift to greener fuels. Economic development and industrial policy loom large as well.

Clean hydrogen has the potential to upend the geopolitics of energy as we know it. New geographies of trade may emerge around clean hydrogen and its derivatives, such as ammonia. Countries blessed with abundant sun and wind could emerge as major exporters of green fuels or sites of green industrialization. Industrial competition could intensify as countries aspire to technology leadership around key segments of the hydrogen value

chain. In general, scaling up clean hydrogen could foster intense geo-economic competition, spur new alliances and collaboration, and beget new nodes of power along future centers of hydrogen production and use.

The hydrogen promise

It is the smallest molecule in the universe, but hydrogen has immense potential as a clean fuel for the global energy transition. It is a gas that can be burned in an engine or used in a fuel cell to power vehicles, produce electricity, or provide heat. It can serve as a feedstock and as a building block for other chemical products, such as ammonia (a key fertilizer input) and methanol (used in plastics production). Hydrogen and its derivatives can be stored indefinitely in tanks and salt caverns, which means they might be one of the key solutions for long-term energy storage.

Crucially, hydrogen can replace fossil fuels for all those purposes without emitting carbon dioxide. It is a zero-carbon energy carrier, just like electricity,



but it has an edge when it comes to decarbonizing sectors that are hard to electrify—think of heavy industry, long-haul transportation, or seasonal storage. Most decarbonization scenarios anticipate a key role for hydrogen in achieving net-zero emissions by mid-century. The International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), for example, expect hydrogen to meet 12–13 percent of final energy demand by 2050, up from virtually zero today.

Hydrogen is already a major industry, but the current hydrogen market has three traits that are about to be radically transformed: hydrogen today is still made largely from unabated fossil fuels, used almost exclusively as a feedstock, and is produced and consumed mostly on-site. Each of these steps in the value chain must undergo a massive overhaul if hydrogen is to live up to its potential as the missing piece of the clean energy puzzle. Its production must shift to cleaner sources and its consumption expand to new sectors—and hydrogen and its derivatives could become internationally traded energy commodities.

Hydrogen battles

The pathway for clean hydrogen growth remains contentious, however. Two primary fault lines have emerged: how to produce it and in which sectors to deploy it.

In terms of production, the two main routes to clean hydrogen are “green” hydrogen from renewable electricity and “blue” hydrogen from natural gas equipped with carbon capture technologies. Green hydrogen was once two to three times more expensive than blue hydrogen, but that was before the current gas price crunch. Moreover, green hydrogen offers the greatest potential for cost reductions. A growing number of projections now foresee green hydrogen that is cheaper than both blue and “gray” hydrogen (from unabated fossil fuels) before the end of the decade.

Both pathways spur their own debates. The production of green hydrogen could divert renewable electricity from other end uses, which prompts debate about whether “additionality” criteria should apply—that is, whether hydrogen can be called green only if it is produced from renewable capacity that would not otherwise be commissioned or used. It could also exacerbate water stress in some regions.

After all, the sunniest places also tend to be the driest. Blue hydrogen, for its part, raises concern over potential methane leakage, insufficient carbon dioxide capture, and lock-in of fossil gas infrastructure. Other production pathways, such as from nuclear or biomass sources, are equally controversial.

In terms of consumption, similar debates rage. Hydrogen is sometimes called the Swiss army knife of the energy transition because you can do pretty much everything with it, although it might not always be the best tool for the job. Using hydrogen is often a less energy-efficient route than direct electrification. For instance, to drive the same distance with a hydrogen car, you need two to three times more wind farms than you do for an electric vehicle (Transport & Environment 2020). Certain hard-to-abate sectors such as steel, shipping, and aviation will need hydrogen or a derivative—that’s not up for debate. These are the no-regrets sectors. Yet indiscriminate use of hydrogen could slow the energy transition.

Technology leadership

Policy support for clean hydrogen has grown in recent years, bolstered by post-COVID-19 recovery spending and Russia’s invasion of Ukraine. Clean-hydrogen-focused companies are raising more money than ever, and annual investment in clean hydrogen now stands at half a billion dollars a year, according to the IEA. Countries are jockeying for mastery over what is set to become a multibillion-dollar international industry in a decade or two.

This geo-economic calculus is already influencing hydrogen policies. In Europe, for example, there are fears that China might come to dominate the hydrogen industry, just as it dominates solar photovoltaic (PV) manufacturing, battery production, and rare earth mining. Many national hydrogen strategies are therefore as much an instrument for industrial policy as a tool for decarbonization. Countries have a strategic interest in being technology makers, not technology takers, in such critical areas of the energy transition.

The biggest prize in the hydrogen value chain may be the electrolyzers needed to produce green hydrogen. Like solar PV, electrolyzers are a very modular technology subject to a steep learning curve. Electrolyzers may today be where solar PV

technology was 10–15 years ago, on the cusp of moving from niche to mainstream. While this emerging industry is still very much in flux, electrolyzers made in China are 75 percent cheaper than those manufactured in the West, according to Bloomberg New Energy Finance.

Many countries and regions have support measures for clean hydrogen, but the United States recently upped the ante with the passage of the Inflation Reduction Act. Its generous tax credits (\$3/kg) will make US renewable hydrogen the cheapest form of hydrogen in the world. The US law probably influenced the European Parliament's decision in September to relax the rules on additionality for green hydrogen, amid warnings from the sector of a mass exodus of the industry to the United States.

Export dreams

Hydrogen and its derivatives could usher in a reconfiguration of energy trade relations. Some regions, notably in Europe and northeast Asia, are gearing up to become major importers of hydrogen; others dream of being major exporters or even, as in the case of Australia, renewable energy superpowers.

Fossil fuel exporters like Australia and countries in the Middle East and North Africa have several advantages: they can build on their existing energy trade relations, skilled workforce, and established infrastructure to become exporters of clean hydrogen. It is an attractive way for them to diversify their economies while retaining their roles as energy exporters.

Yet it would be foolish to think that hydrogen rents will replace fossil fuel rents or give these countries the same geopolitical leverage. Unlike oil and gas, hydrogen is a manufactured product. It can be produced wherever you have electricity and water. Even when it is produced from natural gas, it is a conversion business rather than an extraction business. Hydrogen is therefore *not* a zero-carbon version of oil.

Hydrogen could be more of a geopolitical game changer for countries that currently depend on fossil fuel imports but have ample renewables potential—for example, Chile, Morocco, and Namibia. A German consortium is developing a green hydrogen project in Namibia worth \$9.4 billion, roughly equivalent to the country's GDP.

Egypt, the host of the COP27 climate change summit, has attracted investment pledges of more than \$40 billion this year alone for green hydrogen and green ammonia projects. No continent has better technical potential for producing cheap green hydrogen than Africa.

Governing hydrogen

Many obstacles need to be overcome to bring clean hydrogen to scale, and these require international governance. I will highlight just three.

First, costs must come down further and production must ramp up. Governments can help de-risk investment in clean hydrogen supply by creating durable demand in no-regret sectors through policy instruments such as public procurement and carbon “contracts for difference.”

Second, there is a need to establish harmonized standards, certification, and monitoring processes for safety, interoperability, and sustainability along the entire clean hydrogen value chain. These should not focus only on preventing hydrogen leakage or reducing emissions but also on other areas, such as the impact on water security.

Third, developing economies should get financial and technological assistance so they can benefit from the green hydrogen boom. A pitfall is that developing economies blessed with abundant wind and solar energy are regarded solely as suppliers of green energy molecules to serve the industrial demand centers of the Global North, rather than as potential sites of green industrialization in their own right.

Hydrogen has long been touted as the fuel of the future. This decade, it could finally turn into a fuel of the present. There are still major challenges to overcome, but done right, the clean hydrogen revolution could unlock a triple prize: more climate stability, energy security, and global equity. **FD**

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A black faucet is mounted on a sand dune. The faucet is turned off, and no water is flowing. The background is a cloudy sky. The title 'From ABUNDANCE to Thirst' is overlaid on the image.

From ABUNDANCE to Thirst

The world has gone from plentiful cheap energy to scarcity, amid low investment and war

Andrea Pescatori and Martin Stuermer

The last decade seemed to herald an era of energy abundance, with fast growing hydrocarbon and renewable energy production. Now this seems a distant memory, especially in Europe.

European gas prices have reached unprecedented levels in the third quarter of 2022, increasing roughly 14-fold from the third quarter of 2019 (see Chart 1). At the same time, US gas prices have tripled and global oil prices have increased by about 40 percent.

Even though prices have moderated a bit since the third quarter of 2022, high energy prices are one of the major drivers of high inflation and a major drag on economic growth around the world.

How did the world go so swiftly from a period of cheap energy to today's unfolding energy crisis? How vulnerable were energy markets before the war in Ukraine shook them up? And why was natural gas hit so much harder than oil?

Beginning around the turn of the century, the world saw a surge in oil and gas investment, peaking in 2014 (see Chart 2). The investment

boom was driven by high prices (following buoyant demand from emerging markets) and the U.S. shale oil and gas revolution following technological innovation in fracking unconventional deposits. It was transformative. The United States became a net exporter of hydrocarbons, roughly doubling its oil and gas production within a decade. But booms sow the seeds of their busts. In this case, the boom in US oil production and OPEC's decision to defend its market share by increasing production led to a collapse in energy prices in 2014. As a result, global oil and gas investment was cut drastically.

What could have been a typical boom-bust cycle interacted with the clean energy transition, with two implications. First, producers slashed investment and started to divest from fossil fuels at a fast pace. At the same time, however, investment in renewable energy lagged the United Nations' target of net zero emissions by 2050 by about \$1 trillion a year, according to the International Energy Agency (IEA). Together, these trends led to a shortfall in total global energy investment.

Second, as electrification rates rose, many economies increased their dependence on natural gas as a buffer against interruptions in renewable (wind, hydro, solar) energy production and to replace coal-fired power plants. The global share of gas in total primary energy production rose, from 16 percent in 2010 to 22 percent in 2021. In OECD countries, the share of gas in power generation increased from 23 percent to 30 percent during the same period, according to the IEA.

War in Ukraine

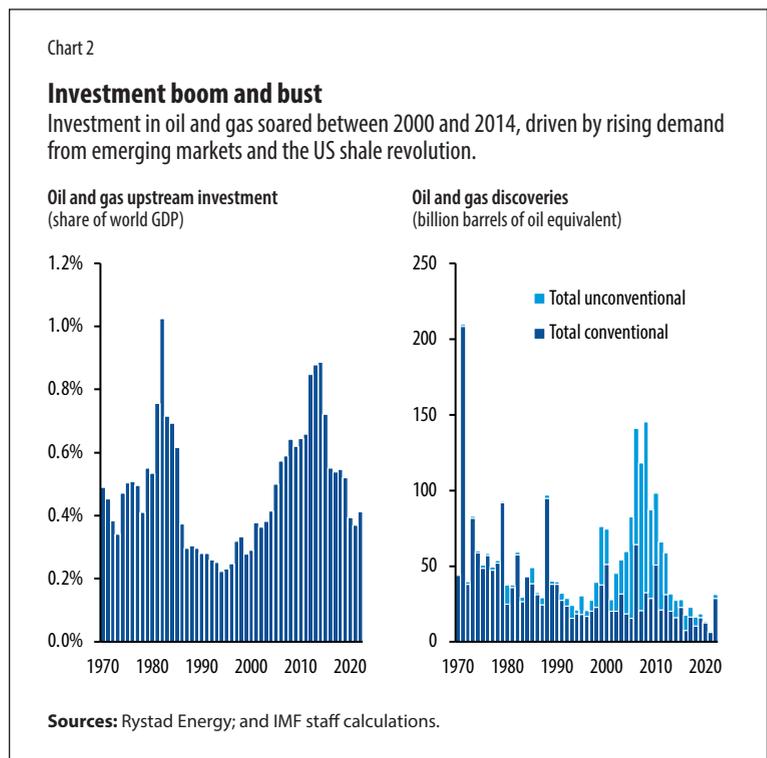
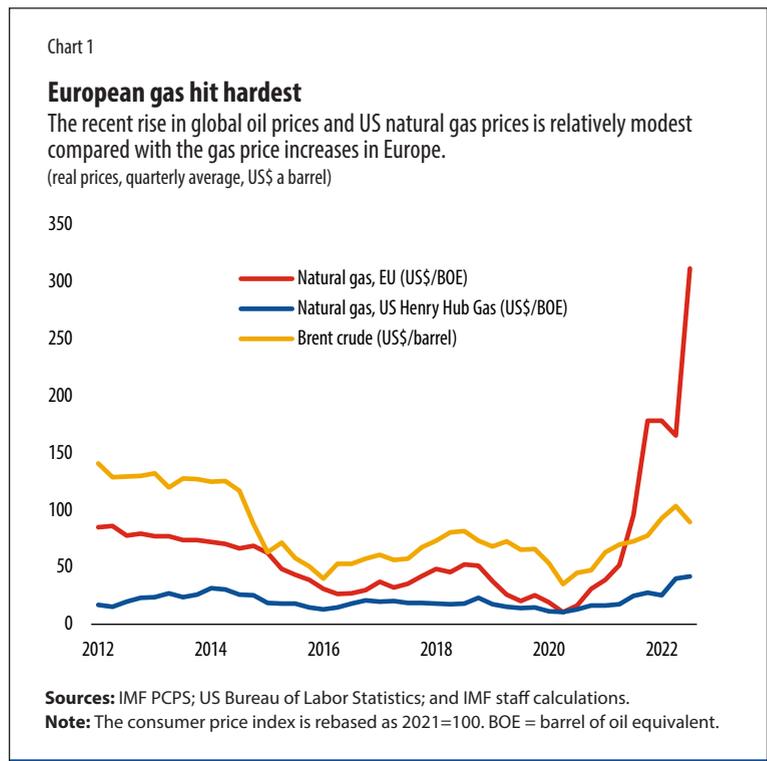
In 2021, before Russia’s invasion of Ukraine, these trends coincided with a cold winter and weather-driven low power generation from renewables in Europe and Brazil. Gas markets were already imbalanced since global gas consumption had rebounded faster than expected after the pandemic. What’s more, Russia, which usually supplied one-third of European gas consumption, reduced its gas flows to Europe starting in mid-2021 before the start of the war (Chart 3, next page). Gazprom, the Russian energy corporation, decided not to fill up its central European storage facilities. European gas prices and Asian gas prices, which generally move together because of the global liquefied natural gas (LNG) market, increased almost sevenfold to \$33 per million British thermal units in the fourth quarter of 2021 from \$4.90 in the fourth quarter of 2019. In contrast, oil prices stood at \$78 per barrel in the fourth quarter of 2021, only \$18 higher than eight quarters earlier. Coal more than doubled to \$182 a ton from \$73 over the same period.

When the reverberations of the war in Ukraine hit, natural gas markets were already under severe stress, whereas oil markets were relatively balanced. Since the start of the war, the divergence between gas and oil prices has grown further. After six months of war, European gas prices in the third quarter of 2022 had climbed another 75 percent; oil prices were up only 15 percent since the invasion.

Why have gas and oil prices reacted so differently to the shocks from Russia? The answer lies in the differing structures of the two markets and the underlying shocks.

Fragmented gas markets

Natural gas markets are globally fragmented because they rely mostly on pipeline infrastructure that prevents arbitrage across regions. Currently,

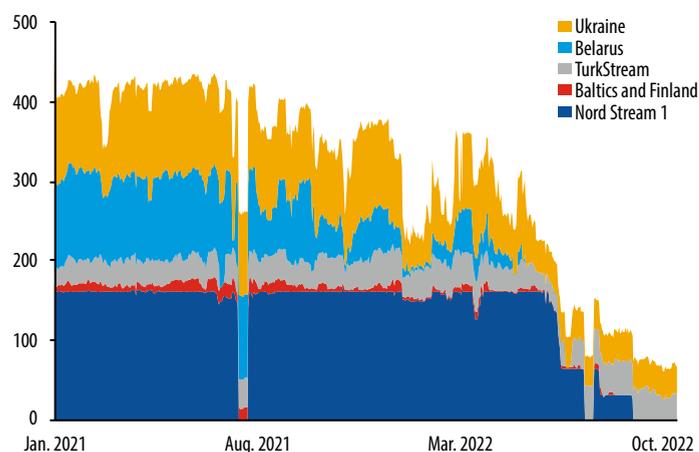


ART: ISTOCK / IVAN BAJIC

Chart 3

Turning off the taps

Russian gas flows to Europe were already declining before the invasion of Ukraine. (EU pipeline gas supplies from Russia by route, million cubic meters a day)



Sources: European Network of Transmission System Operators for Gas; Gas Transmission System Operator of Ukraine; and IMF staff calculations.

Note: Latest data point is October 16, 2022. Recent data are provisional. Gas flow volumes are measured at EU border cross-points; excludes flows to Kaliningrad (Russia).

Chart 4

A widening spread

Russian oil prices now trade at a steep discount following the invasion of Ukraine. (Brent-Urals oil price spread)



Source: Argus Media (latest observation: October 17, 2022).

Note: CIF = cost, insurance, and freight; FOB = free on board; NWE = northwest Europe.

only a quarter of global gas markets are integrated. European pipeline gas markets are connected to the market for LNG through gas liquefaction and re-gasification terminals. These terminals allow the transportation of gas across continents using tankers, connecting European gas consumers to consumers in other LNG-importing countries around the world, mostly in east Asia.

Russia does not have sufficient pipelines or gas liquefaction terminals to reroute a large fraction of its European gas pipeline exports to elsewhere. That's why the decline in Russian gas flows is a true supply shock. It is equivalent to about 17 percent of European gas consumption and non-European LNG imports combined evaporating off the market.

Rerouting LNG from Asia and Europe has helped to buffer the supply shock, gas consumption in the EU has declined, and supply from Algeria, Azerbaijan, and Norway has increased somewhat as well. To incentivize such market adjustments, gas prices need to increase by several times as demand and supply elasticities are low. Government policies that shield consumers by distorting price signals, e.g., price subsidies, are therefore not helpful. If market forces are not allowed to induce adjustment, rationing becomes the only option, which is far more damaging to the economy. Governments can still protect vulnerable households through lump sum payments and other mechanisms but should keep price signals working.

Integrated oil markets

In contrast to gas markets, global integration provides a buffer against shocks to the oil market. Transportation and processing infrastructure allow for arbitrage across borders. As a result, even though shocks to the oil market still have a strong impact on prices, the impact is more temporary than for natural gas prices. Supply and demand price elasticities are higher since they can adjust at a larger scale.

Moreover, unlike gas markets the oil market has not experienced a physical shock to supply due to the war. Russian oil exports have been steady in 2022. Sanctions and Western companies reducing business with Russia caused dislocations in oil markets. These were in part absorbed by a widening spread between Brent and Russian oil prices. Brent prices rose while Russian oil sold at a discount (Chart 4). This creates an incentive to reroute Russian oil to India, China, and elsewhere. Unlike for gas,

there are strategic oil reserves that were released to tame higher prices. In addition, the slowdown of economic activity in China and around the world exerts downward pressure on oil prices.

Fallout for electricity markets

As the war in Ukraine hits natural gas markets harder than oil markets, the fallout for European electricity markets is substantial. Wholesale electricity prices move in tandem with gas prices in Europe because electricity prices are determined by the highest marginal cost of production (as in any competitive market) and gas-powered plants are currently the highest-cost producers. As a result, electricity prices have been extremely volatile and recently peaked at seven times what they were in early 2021, even in countries such as Spain and Portugal, where the share of natural gas in power generation is relatively small compared with renewables.

The shock to electricity prices is being felt across Europe, but not in the same way in every country. Though Europe has integrated gas and electricity markets with considerable cross-border trade, there

are infrastructure bottlenecks, differences in the mix of sources of power generation and diverging policies regarding subsidies or price caps. These factors have caused a large divergence in wholesale energy prices.

It is hard to know what events will hit the energy markets in the coming months amid the war and a weakening global economy. At the same time, a comparison between natural gas and electricity markets on one side and oil markets on the other shows the risks of fragmentation and the benefits that more integrated markets offer to buffer supply and demand shocks. Governments should foster the integration of global natural gas as well as regional electricity markets. In addition to support for renewables, they should assist in the building of gas liquefaction and trade infrastructure as well as denser electricity transmission networks. Doing so in an expedited way will help replace Russian energy supplies and deal with the intermittence of renewable energy. ^{FD}

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The energy crisis is yet another reminder that we must urgently end our dependence on fossil fuels, which damage our health and damage the planet. It's vital that we incentivize the shift to renewable energy and green technology for a cleaner and more resilient tomorrow.

KRISTALINA GEORGIEVA
IMF managing director



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BEATING THE EUROPEAN ENERGY CRISIS

The EU needs a grand bargain that reduces demand,
increases supply, and keeps energy markets open

Jeromin Zettermeyer, Simone Tagliapietra, Georg Zachmann, and Conall Heussaff

Europe's energy system faces an unprecedented crisis. Supplies of Russian gas—critical for heating, industrial processes, and power—have been cut by more than 80 percent this year. Wholesale prices of electricity and gas have surged as much as 15-fold since early 2021, with severe effects for households and businesses. The problem could well worsen. Europe may be about to experience its first winter without Russian gas, risking even higher prices, gas shortages, and a major recession.

European governments have started to implement a range of policy responses. One class of policies aims to mitigate the impact of higher costs on consumers and businesses. These include retail price caps, regulated tariffs, support programs for energy-intensive companies, and liquidity or capital backing for energy companies, including even nationalization. Another class of measures seeks to stabilize and reduce wholesale prices and ensure energy security. This includes policies to encourage energy savings and increase supply but also to cap energy costs, particularly wholesale gas prices.

Such measures don't offer clean solutions, for two reasons. First, conflicting objectives: subsidies or capping prices can make the underlying problem

worse by increasing demand. Second, cross-border spillovers: subsidizing energy consumption may benefit consumers in one country but would also raise consumption, leading to higher wholesale prices across the European Union and hurting consumers in other countries.

An assessment of the available policy options leads to a clear conclusion. The approach that best addresses both problems is a coordinated effort by governments to reduce energy demand and increase supply while keeping internal energy markets open and protecting vulnerable consumers.

High, volatile prices

The primary cause of the massive increase in European gas prices is the reduction of Russian supply. Liquefied natural gas (LNG) is the primary replacement option. The cost of LNG has more than doubled since Russia's February invasion of Ukraine.

The increase in wholesale electricity prices reflects the surge in natural gas prices and shortfalls in nuclear and hydroelectric generation, which have had to be supplemented with power from more expensive coal and gas plants. As a result, the most expensive energy source to meet demand in most

The energy crisis poses an immense challenge that no European state can navigate alone.

European power markets is now gas. This implies that most lower-cost power producers are making extremely high profits (unless they have locked in lower prices by selling forward).

In some cases, even increases in coal- and gas-fired power generation have not been enough to meet demand. As a result, prices have climbed so high that some customers have stopped consuming entirely, a phenomenon known as “demand destruction.” European energy markets have tightened to the point that small changes in supply have large effects on prices. This is why wholesale energy prices have been so volatile in addition to going through the roof.

The situation will eventually encourage expanded renewable power and more efficient use of electricity. One approach might be to do nothing except offer financial support to companies and households until prices ease. However, this could be extremely expensive. If governments were to fully cover the projected increases in energy costs, that would easily add up to €1 trillion, or about 6 percent of EU annual GDP. Massive government support could delay adjustment to a new price equilibrium and create the need for even more support. The impact of the crisis on macroeconomic and financial stability could be devastating because of accelerated inflation and could force the European Central Bank to tighten policy even more. In addition, the energy sector would face liquidity squeezes and insolvencies.

Something needs to be done to address the problem at its core, by reducing the level and volatility of energy prices in European wholesale markets. But what exactly?

Wholesale price caps

Price cap proposals come in two stripes: limiting the price of gas imports and putting a lid on wholesale prices within the European Union.

Regulating all gas import prices would be counterproductive, making it impossible to attract sufficient gas to the European Union and leading to

even higher prices. A cap only on Russian gas, aimed at cutting the country’s gas profits while lowering costs for Europe, might make more sense, although that approach is not without risk: Russia cannot easily redirect its gas supplies elsewhere, so its commercial interest would be to continue supplying Europe, even at lower prices. However, Russia has already acted against its own commercial interest by slashing supplies to Europe by 80 percent. If it retaliated by stopping the remaining 20 percent, that would make matters worse.

In June 2022, Spain and Portugal adopted what came to be known as the “Iberian exception,” capping the price of gas used for generating electricity. It effectively limits the cost of electricity because gas-fired plants typically determine the marginal price. The policy has been effective in containing wholesale electricity costs in Spain and Portugal, but it has also provided an incentive for Iberian generators to burn more gas to produce electricity. Broad application of the Iberian approach to the European Union would likely increase gas prices to the detriment of consumers that use gas directly. Electricity-intensive and gas-intensive industries are distributed unevenly across the bloc, so the mechanism would also have distributional consequences between member states.

A third option is a cap on all transactions at Europe’s gas hubs and on over-the-counter trading and exchanges. Such limits would apply to many longer-term contracts—including those with Russian state-owned gas giant Gazprom—that are indexed to gas hub prices. To ensure that such a cap wouldn’t compromise Europe’s ability to attract LNG, a contract-for-difference mechanism could pay importers the difference between the international price and the European price. The funds could come from the EU budget. This would result in lower wholesale gas and electricity prices. Taxpayers would have to pick up the tab, but they would be more than paid back in the form of lower prices and subsidies.

The problem is that it would be difficult to enforce a cap on all transactions. Trading at capped hubs could dry up as sellers offer their gas over the counter at higher prices. More important, demand for gas and electricity will increase if prices are substantially limited. Foreign sellers, especially Russia, might push back against the cap, reducing or stopping supply. Foreign buyers might also subsidize LNG imports to protect their



consumers, leading to increased competition from outside the European Union. Demand would then outpace supply, and rationing would be required to rebalance the market.

A grand bargain

An alternative to price caps could be measures to increase supply and encourage energy savings. One question is how to do that while also protecting consumers and minimizing economically inefficient disruptions. A second is how to do so in a way that considers the effects of each country's policies on other EU member states.

The answer to the first question about consumer protection and economic efficiency could be to combine support payments that do not depend on energy consumption with subsidies for reducing usage while retaining price signals for demand reduction. Subsidies could be proportional to recent energy consumption. Another approach is to employ the design principle behind Germany's "electricity price brake." It starts by calculating the energy needs of a frugal household that makes a reasonable effort to save energy. The program then subsidizes the retail price of electricity up to that level but not beyond. As a result, the cost of electricity for additional usage would be sharply higher than the average cost, encouraging households to use as few extra units as possible.

The answer to the second question about coordinating policies would be a grand bargain in which EU countries all agree to undertake broadly comparable efforts to reduce demand and increase supply. The ensuing free-rider problem—that every country would prefer not to undertake such efforts or would prefer to ignore spillovers to neighbors—must be resolved politically and legally through regulation. Financial incentives such as access to an EU fund are a possibility.

The European Union has taken the first steps in this direction. In July, member governments committed to reducing gas demand by 15 percent during the winter. In September, they endorsed a regulation committing them to four sets of policy actions: electricity demand reduction, a revenue cap for low-cost power producers benefiting from high electricity prices (except those burning coal), a "solidarity contribution" from fossil-fuel companies (including coal producers), and support for small and medium enterprises. Low-cost power producers are to return profits above the revenue cap to their

national governments, which in turn will use the funds to finance support for consumers.

Such actions are an important first step, particularly because of their emphasis on coordinated gas and electricity demand reduction. But they ignore the supply side. There are two sets of initiatives that could address that.

First, the European Union should leverage its purchasing power as the world's second-biggest combined economy behind the United States. The bloc could negotiate with gas suppliers as a single buyer. This could be a win-win: while the European Union needs to secure gas at a reasonable price, suppliers need long-term contracts to better manage investment plans. Living without Russian gas means replacing the 150 billion cubic meters Russia used to export annually to Europe. The European Union has a chance to pool this enormous demand and negotiate long-term deals that offer suppliers a predictable revenue stream while ensuring gas security and affordability to Europe.

Second, the European Union needs to maximize domestic energy supply in the short term. This requires additional efforts from countries such as The Netherlands in raising gas output and Germany in continuing to operate nuclear power plants that were scheduled to close. These measures are politically difficult but could become feasible based on reciprocity. In addition, a joint EU fund might be considered, for example, to compensate citizens of The Netherlands for the increased earthquake risk associated with greater gas production.

Clearly, the energy crisis poses an immense challenge that no European state can navigate alone. Emergency interventions like gas price caps risk worsening the situation, especially if rolled out in a patchwork of uncoordinated national policies. The European Union needs to strike a grand bargain that relies on its strength as an economic bloc and sets the course for energy policy at the EU level. Today's choices over how to manage limited supply will shape the future of Europe's energy system. Deeper integration and accelerated investment can allow Europe to both overcome this crisis and advance the transition to cleaner, renewable, and more affordable energy. **FD**

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HELPING EUROPE'S HOUSEHOLDS

Governments risk worsening the energy crisis by seeking to suppress price rises—there are better options

Oya Celasun and Dora Iakova

As Europe approaches the cold winter months, governments face difficult policy choices as they seek to protect consumers from soaring energy bills in an environment of generally high inflation. Wholesale prices for natural gas were on average seven-and-a-half times higher in the summer of 2022 than they were in early 2021. Even though they have since fallen from their highs at the end of the summer, they remain well above their early 2021 levels and could rise again ahead of the 2023–24 winter. There have been steep rises in the cost of coal and crude oil, too.

In recent work, we estimate that high energy prices have raised the cost of living for the average European household by about 7 percent this year relative to early 2021—adding to inflationary pressures from disruptions to food shipments

and supply chains (see Chart 1). The energy price shock—and the implied loss of national income for energy importers—is persistent: futures contracts suggest prices will stay above pre-invasion levels for the foreseeable future. Governments should focus on softening the impact of the price surge on the more vulnerable households—some of which face a choice between heating or eating this winter—while allowing the rest of the economy to learn to live with higher prices, including by becoming more energy efficient.

Efforts to suppress energy price increases and to provide broad-based support could actually make matters worse. Imagine that all countries in Europe have sufficient fiscal space to allow only a small portion of the current increase in wholesale gas prices to pass through to retail prices. What would happen then? European consumers would reduce

their consumption only marginally, and since the supply of gas is limited, global gas prices would rise further, increasing fiscal costs and reducing the effectiveness of government efforts to protect consumers at home. Moreover, non-European countries would then have to contend with even higher prices. In short, Europe’s price suppression would result in even higher gas prices and hardship internationally, while domestic consumers would not be significantly better-off.

Europe’s response so far

European governments have up to now used a wide range of policies to lessen the effects of high energy prices, including various forms of price suppression. In some countries the fiscal cost of the energy crisis response is set to exceed 1.5 percent of GDP in the first year alone—with more than half of that in costly non-targeted measures (see Chart 2).

Measures that mute price signals, such as capping retail energy prices or reducing fees, charges, and taxes have been adopted in nearly all countries (including Austria, Italy, France, Germany, Portugal, Spain, and the United Kingdom). Most measures were meant to be temporary, but they have already been extended, expanded, or both in many places.

Some countries have also adopted blanket measures that benefit both low- and high-income households, including fuel subsidies and energy vouchers for all. Countries with a history of highly regulated retail tariffs, such as Hungary and Malta, have continued to allow very little or no pass-through to consumers. This keeps demand for energy higher than it should be at a time of scarcity and when energy is also becoming increasingly costly.

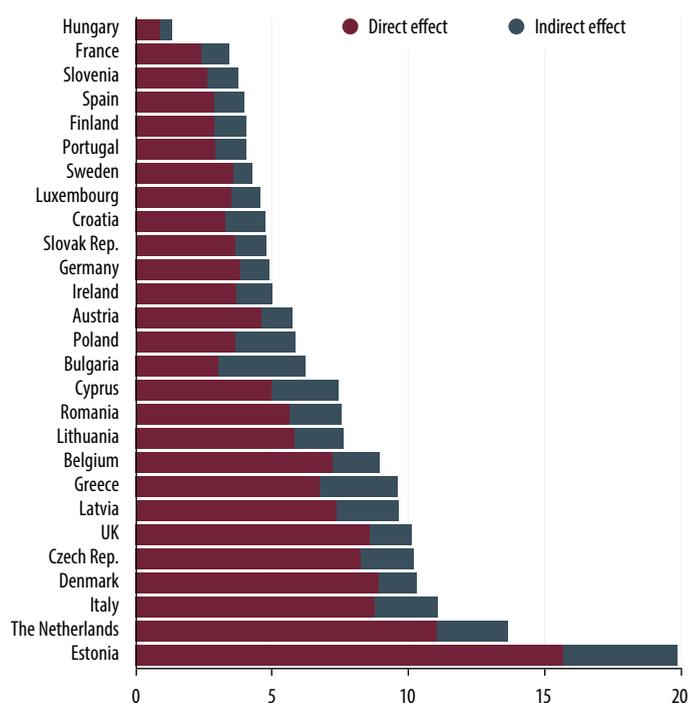
Last but not least, relief to households to cover surging energy costs adds to overall demand for goods and services, complicating the fight against inflation. Broad-based price-suppressing schemes and other forms of untargeted support provided to all households tend to add more to aggregate demand than measures that are more targeted.

Rather than seeking to suppress the pass-through from wholesale to retail prices through price caps, rebates, tax reductions, and the like, governments should ideally let price signals operate and provide lump-sum transfers to vulnerable households. The IMF staff estimates that it would cost 0.9 percent

Chart 1

Soaring energy bills

Households’ burden of higher energy prices varies across Europe.
(increase in cost of living due to energy in 2022, percent of average household consumption)



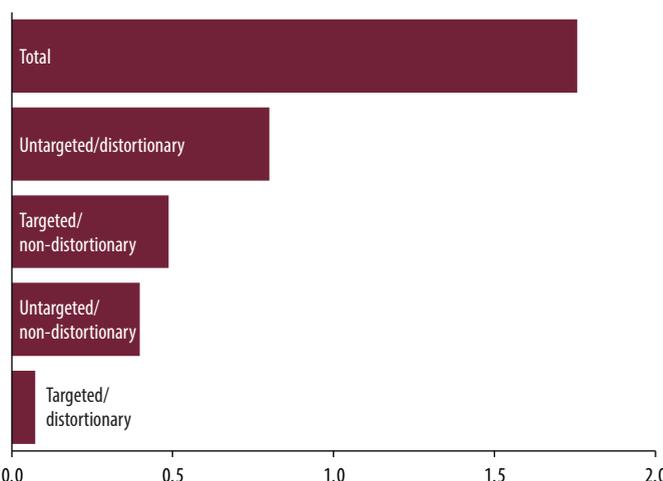
Sources: Bloomberg Finance L.P.; European Network of Transmission System Operators; Eurostat; and IMF staff calculations.

Note: Increase in households’ cost of living due to observed increases in energy prices, both directly (direct impact of higher energy prices) and indirectly (indirect impact of higher energy prices through increased prices of other non-energy goods).

Chart 2

Expensive intervention

The fiscal costs of protecting Europe’s households from higher energy bills are large, especially expensive untargeted measures.
(2022/23 fiscal costs of household support measures, percent of GDP, median across European countries)



Source: IMF calculations based on official announcements.

of GDP in 2022 and 1.2 percent in 2023 to fully compensate the bottom 40 percent of Europe's households for the surge in the price of energy since early 2021—that's about half the average cost of Europe's current policies. Support to households should ideally be designed so that benefits taper off gradually at higher income levels.

Second-best options

This first-best policy response may be hard to implement rapidly in practice. In many countries, income transfers can be extended quickly only to households already receiving social benefits. But given the extent of the recent price surge, some low- and lower-middle-income households that are outside safety nets may also need support.

To help them, governments could send bank transfers or checks based on income tax information or encourage households to sign up for support and provide the required income information. Data privacy laws and capacity constraints mean that these approaches aren't feasible in many countries. An alternative, requiring minimal paperwork, is to give all households a lump-sum rebate on their energy bill (or a lump-sum check unrelated to the energy bill since the former may be perceived as a consumption subsidy). Additional transfers would go to the poorest through the welfare system, while support to higher-income households would be reclaimed through the tax system.

Another option that still preserves some price signals is “block pricing”: charging consumers a discounted price for energy up to a subsistence level and the market price for energy they consume above that level. Subsistence consumption could be set at the same level for all households, or it could differ across households and be set at a fraction of each household's recent consumption (as a proxy for household size). These approaches don't differentiate support by household income level. They should therefore be complemented with actions to raise additional tax revenues in a progressive manner so as to claw back support to higher-income households.

Some countries have implemented specific measures (among a mix of relief programs) that do not interfere with price signals. Examples include progressive or uniform lump-sum transfers (Cyprus and Germany, respectively); lump-sum transfers to lower-income households that are neither covered by a “minimum vital income” benefit nor receiving

a pension (Spain); lump-sum rebates on energy bills with a clawback through the tax system for those with higher incomes (Belgium, Germany); and expansion of existing lump-sum social assistance programs to more households (Belgium, Germany, Luxembourg). Block pricing has been implemented or announced in several countries.

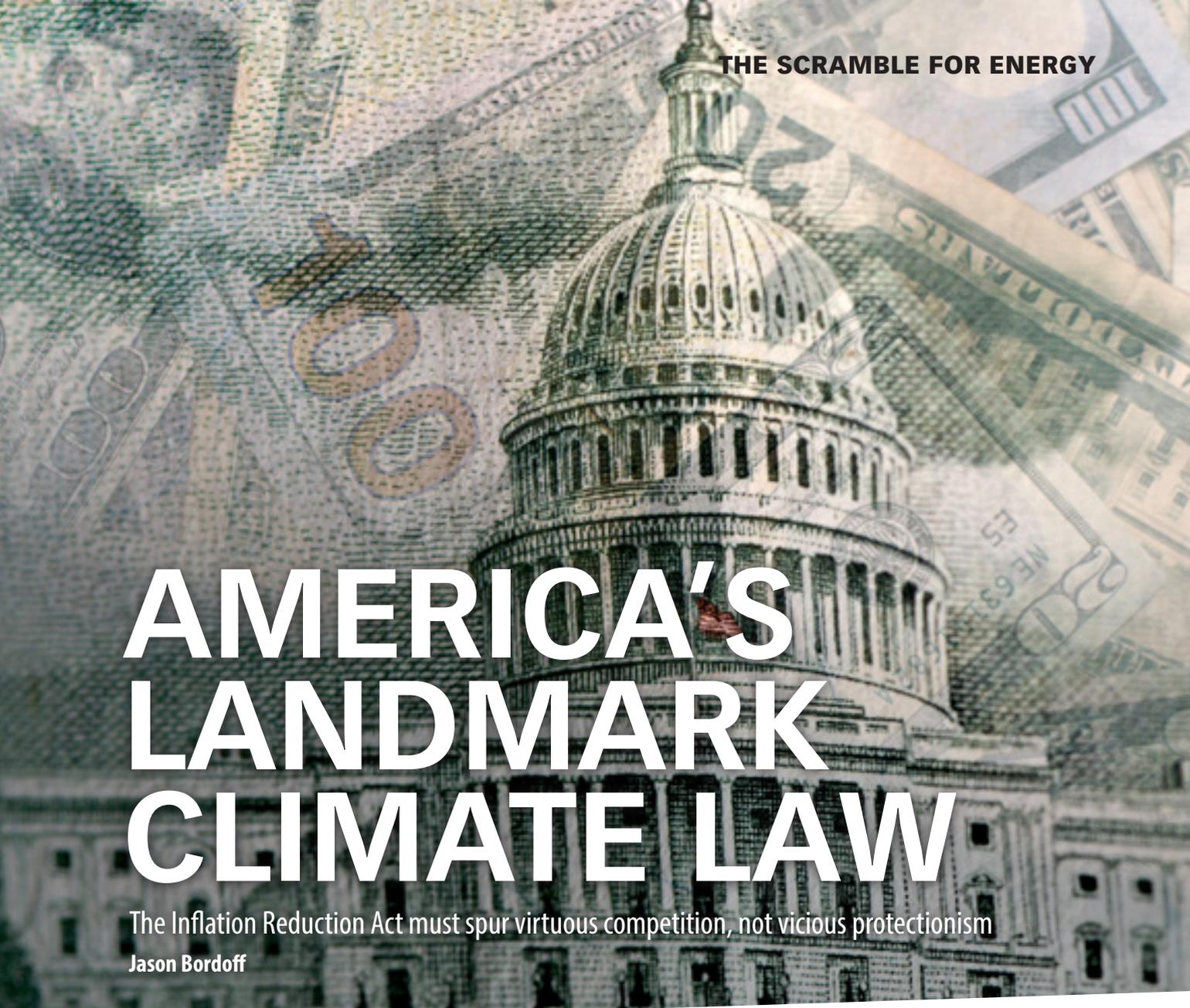
Governments could also pay users to reduce energy consumption or shift it to times of the day when there is a greater supply of renewable energy and less reliance on gas. This could be done through auctions to reduce total consumption or consumption during peak hours. If auctions are held on a large scale at the European level (where electricity markets tend to be interconnected, albeit imperfectly), they could result in substantial benefits by reducing overall demand and thus lowering global energy prices. Germany is considering auctions for energy savings by firms, for example.

In sum, with energy prices projected to remain higher than prewar levels for some time, Europe's policy emphasis must shift rapidly from price-suppressing measures to income relief targeted to the vulnerable. Measures must provide strong incentives to save energy and switch out of fossil fuels while also containing the fiscal costs. Given the scale of the shock, some households that do not currently receive welfare benefits may also need support.

While some countries may struggle to implement the first-best policy of letting price signals operate and providing targeted transfers to vulnerable households, there are reasonable practical second-best options, including uniform lump-sum transfers or subsidies for subsistence-level consumption through block pricing, which can be clawed back from the better-off through taxes. Given the high-inflation environment, relief should be provided within a non-expansionary fiscal stance so as not to add to aggregate demand. In the longer run, increasing the supply of non-fossil-fuel energy sources is the most reliable way to bring energy prices down and ensure energy security. Maintaining clear price signals will help with that transition. **FD**

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This article draws on an update of IMF Working Paper 2022/152 (“Surging Energy Prices in Europe in the Aftermath of the War: How to Support the Vulnerable and Speed up the Transition away from Fossil Fuels”).



AMERICA'S LANDMARK CLIMATE LAW

The Inflation Reduction Act must spur virtuous competition, not vicious protectionism

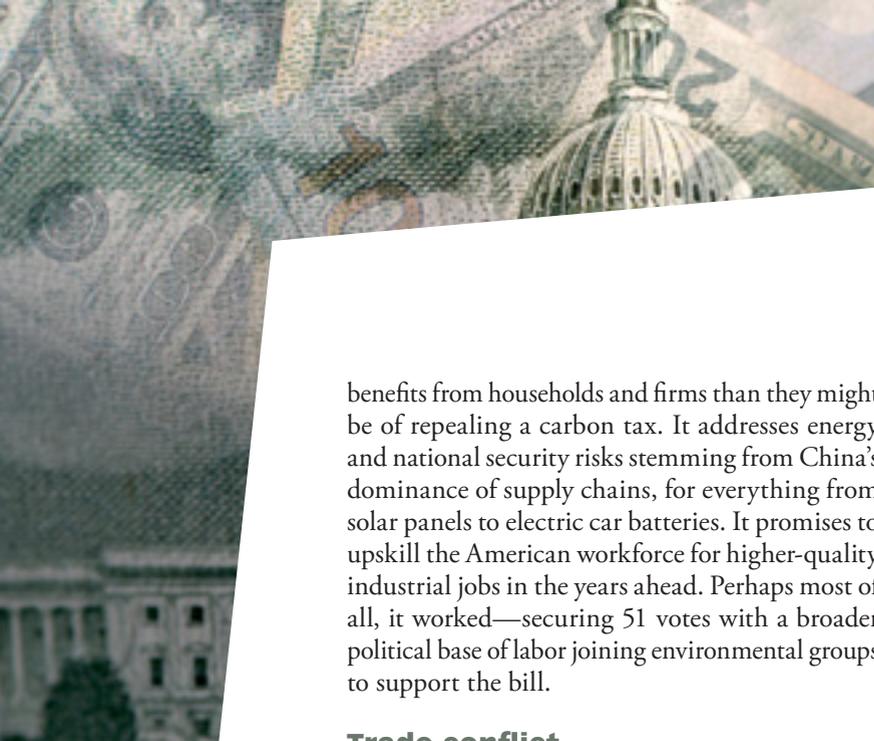
Jason Bordoff

The Inflation Reduction Act is the most significant piece of climate legislation in the history of the United States. It will deploy nearly \$400 billion over the coming decade to slash carbon emissions. By lowering the cost of clean energy technologies, the law can accelerate their deployment not only at home but abroad. But to achieve its full climate potential, US diplomats and trade officials must now ensure that the large subsidies and domestic manufacturing requirements in the law spur the right mix of competition and cooperation from other countries, rather than feed the growing forces of protectionism that could stymie a clean energy transition.

The law's successful passage after decades of congressional stalemate reflects not only growing

alarm over climate change but also two notable shifts in strategy. First, carrots work better than sticks to build political support, and thus the law subsidizes clean energy rather than taxing or restricting carbon pollution—despite a large academic literature demonstrating the economic efficiency of a carbon price. Second, the law explicitly favors clean energy manufactured in the United States, part of a broader shift evident elsewhere, such as a recent law to boost the domestic semiconductor industry, toward “industrial policy”—a catchall phrase referring to government intervention to promote and protect firms in targeted and strategic sectors.

This policy approach offers several benefits. It is likely more durable against political shifts, as opponents will be more wary of removing tax



benefits from households and firms than they might be of repealing a carbon tax. It addresses energy and national security risks stemming from China's dominance of supply chains, for everything from solar panels to electric car batteries. It promises to upskill the American workforce for higher-quality industrial jobs in the years ahead. Perhaps most of all, it worked—securing 51 votes with a broader political base of labor joining environmental groups to support the bill.

Trade conflict

Yet the approach also runs the risk of protectionism triggering wider trade conflict. Unless properly managed, these trade risks could undermine the rapid transition to clean energy, not to mention the economy.

Consider, for example, that the new climate law requires that electric vehicles be assembled in North America to qualify for the subsidies and that the batteries in them be made from components mined or processed in the US or its free-trade partners. Or that larger renewable energy subsidies are available if the projects use materials, such as steel and iron, sourced from domestic manufacturers. Or that its massive subsidies for hydrogen and ammonia made using renewable electricity (so-called green hydrogen) lower the delivered cost of such exported green fuels below that of competitors in the Middle East and Asia.

While they help build domestic industries and increase American influence over supply chains, such measures also risk alienating allies and sparking backlash. The European Union and South Korea have already indicated they may challenge the electric-vehicle restrictions, for example. EU Executive Vice President Frans Timmermans, who is responsible for Europe's Green Deal, warned in September in remarks at Columbia University about the protectionist measures contained in the landmark US climate law.

Moreover, countries worried that their own hydrogen or electric-vehicle firms will be undercut by large US subsidies may be tempted to respond by putting in place their own protectionist policies to counter the law's support for US firms and exports. Many companies have expressed new interest in investing in green-hydrogen projects in the US to take advantage of the generous subsidy, and several

have hinted that existing projects in other countries might be scrapped and relocated to the US.

Trade risks are also prevalent in how the US might respond to a surge in taxpayer-funded export projects, as many of the proposed green-hydrogen and ammonia projects are intended for export given limited domestic demand at present. There are surely limits to the willingness of the American taxpayer to subsidize the cost of energy for consumers and businesses in Japan, Germany, or elsewhere.

The law risks exacerbating already growing protectionist impulses in other parts of the world. Indonesia's president, for example, has articulated a goal of banning exports of nickel, a vital input for electric vehicles, so that his country can build its own domestic manufacturing industry further up the value chain.

Broadly speaking, the Inflation Reduction Act is the latest action in a growing trend toward industrial policy measures to capture the full economic value of supply chains. After the global disruptions to supply chains caused by COVID-19 economic lockdowns, firms and governments alike are also reevaluating the security of supply, whether it's energy or other goods. Domestic job creation and supply security combine to form a powerful accelerant of already growing trends toward reduced global trade and integration.

Fragmentation

Following Russia's invasion of Ukraine, these economic headwinds for globalization will now combine with geopolitical drivers of fragmentation as political and economic alliances are reshaped into new regional blocs. This complex geo-economic and geopolitical backdrop means that the Inflation Reduction Act's requirements for production in the US or ally nations must be implemented with particular sensitivity to avoid further fueling the flame of fragmentation. These risks come on top of already growing trade tensions between the US and China that have darkened the outlook for US solar projects in recent years.

As it relates to combating climate change, tit-for-tat retaliation by America's trading partners would not only be economically and geopolitically problematic, it would risk undermining the energy transition itself if it limits access

to the lowest-cost clean energy materials and products. To achieve net-zero emissions by 2050, the world must dramatically increase trade in clean energy across borders. Total energy-related trade declines as we decarbonize because more of the system is electrified, and electricity tends to be produced locally. But trade in the components for renewable energy, critical minerals for batteries, and fuels such as hydrogen must expand so fast that it is far costlier and harder to decarbonize without cross-border trade that leverages countries' own comparative advantages. According to the International Energy Agency, for example, achieving net-zero emissions by 2050 requires tripling the value of global trade in critical minerals and boosting global trade in hydrogen to 1,500 times its negligible level today.

The challenge for US officials is thus to ensure that the Inflation Reduction Act sparks a virtuous cycle of competition rather than a vicious cycle of protectionism. Countries around the world must vie with one another for leadership in the massive clean energy industries of the future, driving down costs and accelerating clean energy deployment in the process.

To realize this opportunity, American trade and climate officials should strengthen their commitment to the rules-based trading system and cooperation with free-trade partners to diversify clean energy supply chains. The reality is that we cannot produce everything domestically, but diversifying supply sources makes good sense to improve energy security and counter the influence of China, which today dominates certain industries—such as solar panel and battery manufacturing and critical mineral refining and processing—because of its own long-standing government programs to build domestic industries.

Climate cooperation

More specifically, US officials should leverage strong domestic climate action to bolster climate cooperation with other countries worried about the competitiveness of their domestic industries. The recent agreement of Group of Seven countries to form an alliance of nations that benefit from preferential trade terms if they achieve certain environmental standards is one example. The US may now be able to join with or mirror the EU's plan to impose a carbon fee on imports of high-emitting goods. The US is also in a stronger position to

implement a recent deal with the EU to restrict imports of steel and aluminum from Asia and elsewhere if they do not meet emission standards.

More broadly, the new law presents an opportunity to engage with partners to create special trading rules that support clean energy. A rules-based trading system remains critically important: it would call for strengthening the hollowed-out World Trade Organization and for foreign policy and trade officials to build new mechanisms for economic cooperation.

It will require deft trade policy and diplomacy to avoid trade wars that stymie the energy solutions we need.

The COVID-19 pandemic and Russia's invasion of Ukraine are painful reminders of the importance of securing supply chains, diversifying supplies, and boosting domestic production, particularly for strategically important sectors like energy. Moreover, while the Inflation Reduction Act may be an example of industrial policy, it's admittedly nothing compared with China's efforts to promote and protect its own industries, so the US (and others) should not unilaterally disarm.

At the same time, these new imperatives heighten already rising risks to the global economic order. Geopolitically and geo-economically, globalization is in retreat: powerful new forces of fragmentation are spawning new geostrategic alliances and weakening global economic integration. If not carefully managed, industrial policy measures such as the new US climate law can exacerbate trade tensions, which would undermine a clean energy transition requiring much more, not less, trade in clean energy materials and products.

If done right, however, shoring up our energy supply chains can both stimulate new domestic industries and establish more durable trading arrangements. But it will require deft trade policy and diplomacy in the years to come to avoid trade wars that stymie the energy solutions we need. **FD**

JASON BORDOFF is the director of Columbia University's Center on Global Energy Policy and a former special assistant to President Obama.



PHOTO: NOAH BERGER

Questioning Assumptions

*Peter J. Walker profiles Berkeley's **Emi Nakamura**, who delves into details to answer big questions*

One of Emi Nakamura's favorite movies growing up in Alberta, Canada, was the 1987 docudrama *The Race for the Double Helix*. Fast-paced and infectious in its enthusiasm for the scientific method, it tells the story of how James Watson and Francis Crick discovered the structure of DNA. "There's nothing worse than a wrong fact," quips Crick in the movie, exasperated by all the incorrect theories clouding his thinking (before Rosalind Franklin's X-ray images of DNA led him and Watson down the right path). It is a quote that Emi recalls her economist parents repeating to emphasize the importance of sound data.

Now a professor of economics at the University of California, Berkeley, the 42-year-old Nakamura is best known for investigating macroeconomic questions using micro data—data that provide information about characteristics of individual people, households, and businesses. She has long been seen as a rising star in economics. In 2018, *The Economist* listed her among the decade's eight best young economists. A year later she won the John Bates Clark Medal—awarded to the most influential American economist under the age of 40—for her research on fiscal stimulus and price stickiness, a measure of how often prices change.

"Emi's work has illuminated foundational questions in macroeconomics—for example, on price setting, the nature of inflation, and the effects of fiscal policy," Berkeley professor and former IMF chief economist Maury Obstfeld tells F&D. "The

hallmarks of her work are painstaking attention to data and a seamless melding of theory with empirical methods, yielding more convincing identification of economic mechanisms."

Before joining Berkeley in 2018, Nakamura was professor of economics at Columbia University, and earned her PhD at Harvard University. Nakamura and her husband, fellow Berkeley economics professor Jón Steinsson, met when they were undergraduates taking graduate econometrics at Princeton University. "She was clearly extremely talented, and intellectually she was very mature for her age," recalls Emi's Princeton advisor, Bo Honoré. "I had no doubt that she would be highly successful no matter which area of economics she specialized in."

Nakamura's personal and professional lives are closely intertwined. She routinely coauthors papers with her husband, and from time to time with her parents, Alice and Masao Nakamura. They are economists, too—Alice at the University of Alberta and Masao at the University of British Columbia.

Alice and Masao met at Johns Hopkins University in 1969 while Masao was on a Fulbright scholarship from Japan. Both have had stellar academic careers. Alice is a leading scholar on labor economics and economic measurement, while Masao is well known for his work on international business and Asian economies. Cross-generational collaboration began long ago with kitchen table conversations about how to construct statistics on measures like GDP and inflation.

Buried treasure

The question of how to measure big things would become the bedrock of Nakamura's academic mission. One solution is to answer macro questions using micro data, something that "seems to be a reflex for me," she says. "There often aren't enough data points in the macro data to make convincing arguments about causality. Looking at micro data is a natural way to expand the data set."

One of Nakamura and Steinsson's first major forays into extending data sets involved using micro data related to price stickiness. "Price-setting assumptions are key," she says. "Whether prices are sticky or completely flexible is a big dividing line between neoclassical models of the economy where monetary policy has no effect and Keynesian models where monetary and fiscal stimulus have large effects. It seemed natural to look at micro data to get more information on these questions."

A previous study by the University of Rochester's Mark Bilal and Stanford University's Peter J. Klenow (2004) found that prices change more frequently than previously estimated, with half of prices lasting less than 4.3 months—but while theirs was the first study using Bureau of Labor Statistics (BLS) micro data, they used only an extract of the data for two years, 1995–97. In "Five Facts about Prices" (2008), Nakamura and Steinsson's most-cited paper, they used actual BLS micro data and expanded the data set to cover 1988 to 2005.

It was a painstaking task that involved sifting through reams of dusty paper in a windowless room at the BLS, but by distinguishing between temporary price cuts for sales and regular pricing, they found that regular prices were stickier than Bilal and Klenow estimated. In other words, when promotional discounts were taken out of the equation, prices were shown to change less in response to supply and demand than their predecessors had estimated.

"Price changes in the data were much more complicated than in macro models," Nakamura notes. "A lot of these price changes were temporary sales that returned to the original price—so they didn't look like the kind of *perfect price flexibility* that people imagined. At the same time, if you looked at *regular* prices excluding sales, things lined up well with the predictions of some of the models. Prices changed much more frequently in times of high inflation." These findings have several implications, including for how to accurately monitor economy-wide price changes and for the

importance of policy intervention in managing the economy.

The analysis related to price changes and inflation was tempered somewhat by the fact that the database spanned a relatively low-inflation period. A decade on, in "The Elusive Costs of Inflation" (2018), Nakamura, Steinsson, and coauthors examined the higher-inflation period between 1977 and 1988. In this case, data collection was even more onerous and involved commissioning a custom-made microfilm converter, but the effort paid off. The researchers conclusively confirmed that regular prices were indeed adjusted more frequently in periods of higher inflation, in line with standard models.

They have returned to the topic of inflation in their most recent work, "The Slope of the Phillips Curve" (2022). The study's genesis lies in analysis carried out by the Macro Policy Lab, which conducts data-driven and policy-relevant research on macroeconomics, and of which Nakamura and Steinsson are both principal investigators. Going back to 1978, along with their coauthors they find that the slope of the Phillips curve, which shows the relationship between unemployment and inflation, is small—and has gotten only modestly smaller since the early 1980s.

The implication is that the early 1980s disinflation was less about higher unemployment and more about people's inflation expectations—which were anchored thanks to the new monetary regime instituted by Federal Reserve Chairman Paul Volcker. "The relevance of this for the present context," Nakamura concludes, "is the emphasis that it puts on long-term inflation expectations and confidence in the monetary regime—maintaining these is key." And today, as central banks attempt to rein in inflation while growth dwindles, these messages carry special weight.

Goal-oriented

Nakamura and Steinsson are no strangers to investigating the issues of the day, as was the case when they illuminated the debate on fiscal stimulus. The Great Recession put fiscal stimulus back on the table, but "in the academic world it was striking how little people knew, and the evidence was really limited," Nakamura recalls, so they set about addressing these gaps in "Fiscal Stimulus in a Monetary Union" (2014).

They identified US military spending as the ideal area to focus on because while it varies by

region, it is also possible to isolate the effect of spending on growth—the fiscal multiplier—given that US regions have a common monetary and tax policy. They were eagle-eyed in their attention to detail, taking note of 40 years of military purchases ranging from the repair of military facilities to the purchase of new aircraft carriers. Nakamura says, “our paper provided evidence in the direction that the fiscal multiplier could be large,” in that fiscal stimulus could significantly boost growth.

While much of their research is focused on the US, Nakamura and Steinsson frequently look abroad. For instance, in “The Gift of Moving” (2022) they drew inspiration from Steinsson’s native Iceland to study a natural experiment related to social mobility. On January 23, 1973, there was a volcanic eruption on the Westman Islands off the south coast of Iceland. It forced the immediate evacuation of all inhabitants. After the eruption, most inhabitants returned, but those whose homes were destroyed were much less likely to do so.

Nakamura, Steinsson, and Jósef Sigurdsson, of Stockholm University, tracked how parents and their children fared economically over the subsequent 34 years. They did so by studying detailed data on income, education, and genealogical linkages available for the Icelandic population. They found that while children who moved had higher levels of education and earnings than if they had stayed put, their parents earned slightly less. A broader, universal implication is that these large costs experienced by parents may discourage them from moving, thus acting as a barrier to social mobility.

Children’s improved life chances were somewhat surprising given that most moved to lower-income areas. As Nakamura explains, “the Westman Islands is an amazing place to be if your skills line up well with the opportunities on the island—the fishing industry, which yields very high incomes—but, if you are a computer genius or a great legal mind, then this will not be the place where your skills will yield the highest returns.”

In terms of what comes next, Nakamura and Steinsson are currently working on studies examining how exchange rate depreciations affect economic activity, the economic effects of unemployment insurance extensions, and the impact of seasonal adjustment methods used for government statistics.

Working together

It could be said that in their studies Nakamura and Steinsson achieve more together than they could alone.

For his part, Steinsson points to Nakamura’s meticulousness. “The overwhelmingly most common response when one tries to explain something to Emi is, ‘I don’t understand,’” he says. “It is harder to explain things to Emi than to anyone else I know. But this really reflects her high standards for what it means to understand something and her dedication to not cut corners when it comes to understanding the important issues in our research.”

“Jón is always introducing me to new ideas and is also fantastic at killing ideas,” Nakamura says. “When I convince Jón to work on something that he didn’t originally think was interesting, the idea becomes unquestionably better because of having to think about how to get around his critiques. These can be difficult conversations—I sometimes think they would threaten our relationship as coauthors if we weren’t married!”

Nakamura has fostered constructive academic partnerships with her students as well. One of the PhD students she supervises, David Bruns-Smith, recalls that when he switched to economics from computer science, Nakamura scheduled a meeting right away to share ideas and identify funding, even though he lacked prior relevant work in economics. Something that shines through for him is that “since Emi has a laser focus on substantive economic meaning, she never seems dogmatic about any particular formal framework—only what the formalism is supposed to represent in the world—and that’s perfect for me since I combine ideas from both computer science and economics.”

Nakamura used to be the one seeking guidance. As a student, she recalls sitting on a sofa in Bo Honoré’s office at Princeton and pondering a sign that said, “Question Assumptions.” In a moment of déjà vu, she would see the same sign again almost 20 years later when being interviewed by Berkeley professor Jim Powell. “Jim explained that the sign wasn’t originally intended from a scientific perspective, but instead came from the hippie counterculture in Berkeley,” she says. “But I still consider it to be great advice.” [FD](#)

PETER J. WALKER is on the staff of *Finance & Development*.

CHILE'S BET ON GREEN HYDROGEN

The country aims to be the world's cheapest producer of the alternative fuel

John Bartlett

Tucked between fjords and islets on the blustery shoreline of the Magellan Strait, the tiny city of Punta Arenas sits at the tip of South America, just above the Antarctic Circle.

Wind tears at the flags on the façade of the regional governor's offices as locals traverse the main plaza, seeking refuge in the saloons and restaurants around the center of town.

Magallanes, Chile's southernmost region, whose capital is Punta Arenas, is sparsely populated and largely unspoiled. But this pristine swath of Patagonia could soon be the beating heart of a global transition toward renewable energy.

Chile, a country of 19.5 million people, is positioning itself at the forefront of this shift, and Patagonia's strong winds offer one of several tantalizing possibilities.

"Our country's conditions are favorable to continue leading the way in the development of renewable energies," says Diego Pardow, Chile's energy minister. "Our technical renewable potential is among the best in the world."

From fierce solar radiation in the Atacama Desert to the blustery plains and valleys of Patagonia, Chile's renewable potential is indeed vast. Strong ocean currents, geothermal energy, and hydroelectric power from the rivers rushing through the central and southern valleys are also being harnessed.

And added to that, almost half of the world's known lithium reserves—crucial for battery technology—sit under the salt flats in Chile's arid north. A series of shallow turquoise and blue pools sit on the surface, evaporating lithium-rich brine to be refined and exported.

As such, Chile has made some ambitious promises.

It has committed to carbon neutrality by 2050 and pledged to close or repurpose all of its 21 coal-fired power plants by 2040, and its energy matrix is steadily becoming cleaner.

According to the energy ministry's latest figures, in August this year, 58 percent of the nearly 30,000 megawatt capacity of the national grid came from renewable sources. That proportion will reach 62 percent next month with several projects coming online imminently.

However, the centerpiece of the country's ambitious bet on renewables is "green" hydrogen, a clean fuel source with the potential to revolutionize global energy supply.

The International Renewable Energy Agency estimates that hydrogen will account for as much as 12 percent of global energy use by 2050 and has identified Chile, Morocco, and Namibia as countries that could emerge as green hydrogen exporters.

"Chile holds a comparative advantage for the production of green hydrogen because it has great

A decorative background at the top of the page featuring a topographic map with contour lines in shades of gray, set against a white background.

potential for generating renewable energies with extraordinary levels of efficiency,” explains Pardow.

To split the molecules into hydrogen and oxygen, a current is passed through water in an electrolyzer. The energy released is fed into the national grid; the hydrogen is captured, stored, and transported to be used in zero-emission fuel cells—or combined with carbon dioxide to make synthetic ammonia for fertilizers or methanol as a gasoline substitute.

The “green” element refers to the source of the energy—in this case, renewable.

Currently, 95 percent of the world’s hydrogen is produced using energy derived from hydrocarbons—known as “gray” hydrogen. But Chile’s plentiful renewable energy sources make it a potential hub for the sought-after green variety.

An ambitious national green hydrogen strategy, presented in November 2020, aims for Chile to be producing the world’s cheapest green hydrogen by the end of the current decade—and to have broken into the top three exporters globally by 2040.

Yet at present, Chile doesn’t produce any green hydrogen on an industrial scale. And while consensus on the need for the energy transition is broad, not everyone is as enthusiastic about what could happen to the regions where this potential is set to be realized.

“Tierra del Fuego could become a sacrificial zone,” says Diego Luna, 49, a Uruguayan conservationist who arrived in Chile 26 years ago. “We need to be very careful how we go about this.”

Luna is concerned about wind turbines placed in the flight paths of up to 60 species of migratory birds. Dolphin and whale populations could also be affected by an increase in maritime traffic if exports take off.

In 2021, Chile’s government estimated that 13 percent of the world’s green hydrogen could eventually be produced using wind energy from Magallanes and Chile’s Antarctic claim—amounting to 126 gigawatts.

According to Luna’s estimates, that would require the installation of at least 13,000 square kilometers of wind turbines.

But despite reservations, Patagonia’s hydrogen rush could already be underway. Companies are beginning to use Chile as a proving ground for green hydrogen technology.

“This is a gigantic area to develop hydrogen as a viable and realistic option to decarbonize the planet,” says Fernando Meza, the business

development manager at Enel Green Power Chile, a subsidiary of Italian energy giant Enel.

The company is one of the leaders in the sector, with nine wind farms operating in Chile. By the end of the year, it will open its Haru Oni pilot project, with the aim of producing an annual yield of 350 tons of synthetic methanol and 130,000 liters of gasoline—it will be an important step in assessing the feasibility of Patagonian green hydrogen.

The next phase, says Meza, is to push ahead with the 38-square-kilometer Faro del Sur wind farm at Cabo Negro, just north of Punta Arenas. The \$500 million, 65-turbine facility would generate 325 megawatts of green hydrogen energy, although it was withdrawn from Chile’s environmental evaluation system recently because of “exceptional demands.”

However, Meza expects it to go ahead following negotiations with authorities.

“Defining limits and ways of developing the industry sustainably is a job for both the public and private sectors,” he says, adding that he hopes for further support from the government.

In December, the Chilean government pledged \$50 million in grants to six green hydrogen projects the length of the country, including \$17 million granted to the Faro del Sur project.

The energy ministry projects that, through a mixture of public and private funds, investment in green hydrogen and other derivatives could reach \$45 billion by 2030—and \$330 billion by 2050.

But the infrastructure required will have a significant effect on Punta Arenas, which, barring a detour through Argentina, cannot be accessed by land. Most supplies arrive by boat, and schools, hospitals, and other services will be stretched by even a modest wave of workforce arrivals.

For now, Magallanes remains wild. But change could be just around the corner.

Meza says that within two to four years, Enel will have a good handle on the feasibility of green hydrogen in Patagonia.

“If all of this investment comes to pass, we are looking at a radical change to the Magallanes we know today,” says Luna, the conservationist.

“Socially, culturally, physically, and economically this place will be unrecognizable. And I’m not sure we’ve thought about that enough.” **FD**

JOHN BARTLETT is a journalist based in Chile.



Pardinan Sakerebau and family at home.

INDONESIA'S SOLAR FUTURE

The archipelago must overcome many challenges to wean itself off fossil fuels

Harry Jacques

In 2017 Pardinan Sakerebau's family home in Pukurayat, an off-grid hamlet in Indonesia's Mentawai archipelago, received electric lighting for the first time from four lamps powered by a rooftop solar panel. During the same year, surfer Pete Anderson invested more than \$10,000 in photovoltaic equipment for his home on a small island 15 kilometers north of Pukurayat.

Today only one of Sakerebau's lamps is functioning; the batteries are broken. Anderson's solar panels have been repurposed to hang laundry after a lightning bolt scorched the system's \$5,000 inverter, which is needed to convert solar-generated energy to alternating current.

"It's cheaper for me to buy a generator every year and just run gasoline—I'm bummed," said Anderson, a Californian fine arts graduate.

Perceptions that photovoltaic energy is expensive and high-maintenance explain in part why Indonesia—a sprawling archipelago of 17,000 islands bisected by the equator, with fairly constant year-round sunshine—has the least installed solar energy among G20 countries. This is despite the country's international commitments to reduce carbon emissions and wean itself off fossil fuels.

Several communities on the 70 islands that make up the Mentawai island chain, one of more than 60 regions of Indonesia defined by the government as underdeveloped, received electricity for the first time from basic solar technology.

But despite having more potential solar energy than all the world's power plants combined, photovoltaics accounted for less than 200 megawatts on electricity grids across the world's fourth-most-populous country in 2021. That was less than 0.1 percent of total installed capacity.

Fabby Tumiwa, head of the Indonesian Solar Association and a former climate change negotiator, attributes such low solar energy use to the political economy of coal, which is plentiful in Indonesia and can be extracted cheaply.

"Coal was seen as the cheapest form of energy," says Tumiwa. "Renewables were forced to compete—it was hard to compete with coal."

Indonesia is the world's largest exporter of thermal coal, and the state grid, Perusahaan Listrik Negara (PLN), relies on domestic supplies to power two-thirds of electricity generation.

In outlying islands, where coal power stations are not economical, smaller plants provide electricity by burning millions of liters of diesel at a cost of

up to 22 cents a kilowatt-hour, accounting for about 7 percent of Indonesia's electricity capacity.

To attract investment, PLN offered independent power producers long-term contracts, which locked the state-owned grid into guaranteed coal payments even as electricity supply outpaced demand.

Questions remain over how the decommissioning of old coal plants will be financed. This year, State-Owned Enterprises minister Erick Thohir said that retiring 15 gigawatts of coal capacity by 2050 could cost \$600 billion.

In the near term, PLN plans to trim emissions from its coal fleet by co-firing coal with biomass, such as sawdust and household waste. But Putra Adhiguna, an analyst at the US-based Institute for Energy Economics and Financial Analysis (IEEFA), said that this will require a dedicated biomass industry to be built from scratch.

Brighter outlook

Indonesia's solar industry hopes a brighter outlook is around the corner as photovoltaic costs continue to come down and reforms improve the business case.

In 2015 President Joko Widodo opened what was then the country's largest solar power plant, in eastern Indonesia; the electricity it generates costs a steep 25 cents a kilowatt-hour.

Since then several new facilities have come online on islands east of Java. This year, PLN signed power purchase agreements at less than 6 cents a kilowatt-hour for 50 megawatts of solar power in Bali.

In August the government added a multibillion-dollar solar project in the Riau Islands to the docket of national priority projects. If it is built, the project could export clean energy to Singapore and catalyze a domestic solar manufacturing industry, analysts say.

Last year, Indonesia's energy ministry approved a new 10-year business plan in which renewable projects make up more than half of planned new capacity, up 25 percent from the previous blueprint.

Indonesia's energy ministry has introduced improved terms for rooftop on-grid solar capacity, cutting permit times and increasing the export allowance from 65 percent of excess electricity generated to 100 percent, although how PLN implements these changes on the ground will be crucial, analysts say.

The 2021 regulation also set a target of 3.6 gigawatts of rooftop solar capacity by 2025—equivalent

to more than 1,000 large-scale wind turbines—which the government hopes will support more than 100,000 jobs and prevent 4.6 million tons of carbon emissions.

According to the Jakarta-based Institute for Essential Services Reform, conversations with about 30 developers indicated that 3.3 gigawatts of rooftop solar capacity was set to come online by the end of next year.

Indonesia has been “relatively successful” in bringing rudimentary electrification to remote off-grid areas like Pukurayat using basic solar panels and batteries, says the IEEFA's Adhiguna.

Despite the high solar potential on Indonesia's dominant Java-Bali network, smaller grids reliant on diesel in eastern Indonesia are expected to see quicker solar uptake in the near term as the government seeks to retire thousands of diesel plants.

In June 2019, PLN reported that solar energy accounted for 0.1 percent of the electricity generated on Lombok, one of the Nusa Tenggara Islands, in southeast Indonesia. However, by the end of that year the share had increased to 2.8 percent.

“Nusa Tenggara has the best solar reserves in Indonesia,” says Tumiwa. “It should be dominant there.”

The regional government wants renewable sources, mainly solar, to drive 35 percent of electricity generation in the province of about 5 million by 2025—higher than the central government's national target of 23 percent.

Indonesia has committed to cutting emissions 31.9 percent by 2030 under plans Widodo submitted to the United Nations Framework Convention on Climate Change in September.

But the arrival of renewable energy can mean a more immediate reduction in harm in communities like Pukurayat and much of eastern Indonesia.

Indoor combustion of fuels such as firewood and kerosene causes thousands of pneumonia deaths every year among Indonesian children under 5, according to UNICEF, the children's charity.

Prior to receiving four lamps and a solar panel in 2017, Sakerebau's family lit their home using an open container of kerosene, a homespun candle known in the Mentawai Islands as an *alito* that is a well-known cause of air pollution and house fires.

“We used to be afraid,” said Sakerebau. **FD**

HARRY JACQUES is a journalist based in Southeast Asia.



KENYA TAPS THE EARTH'S HEAT

The country's geothermal industry has the potential to power much of the country

Will Brown

For many visitors, Hell's Gate National Park in Kenya triggers an uncanny sense of déjà vu. Much of the 1994 film *The Lion King* was inspired by the park, and thousands of tourists still come every year to see the rugged cliffs that gave rise to the childhood classic. But three decades on, the park is becoming famous for something far below the surface.

Hell's Gate, which lies about 50 miles northwest of the capital, Nairobi, is the center of a renewable energy revolution in the east African nation. All around, steam billows out of vast geothermal plants, and water pipes snake across the bush, past herds of giraffes, buffalo, and gazelles.

One of two people in sub-Saharan Africa has no access to electricity, and some large economies—such as Nigeria and South Africa—rely

heavily on fossil fuels to supply their booming populations. But Kenyan engineers say that on a good day, about 95 percent of the national grid's power comes from renewable sources, with anywhere from a third to half of that coming from geothermal wells.

"It is something the world can learn from us. It is possible to move towards green energy, to reduce the carbon footprint and make the world a better place to live and for future generations," says Peketsa Mangi, general manager of geothermal development at the government-run Kenya Electricity Generating Company (KenGen).

Kenya is the world's seventh top producer of geothermal energy. Part of its success comes down to its geography. The country of 53 million people lies in the Great Rift Valley, a series of geographic

The background of the page features a topographic map with contour lines, rendered in a light gray color. The lines are more densely packed in some areas, indicating steeper terrain, and more widely spaced in others, indicating flatter land. The map covers the entire width and height of the page, serving as a subtle, thematic backdrop for the text.

trenches and lowland areas spanning 4,300 miles from Lebanon to Mozambique.

Africa is slowly breaking apart along this fault line as the tectonic plates move away from each other, and scientists think that there will be a new ocean running through this area in some 5 to 10 million years.

But for now, the Rift Valley area in Kenya is an incredibly cost-effective place to harness the Earth's heat. On average, engineers around the world need to drill down about 3,000 to 4,000 meters to make a geothermal well, but some wells in Kenya are only 900 meters deep, says Mangi.

Still, Kenyan companies like KenGen must pay major up-front costs. It takes roughly K Sh 600 million (\$5 million) to drill one well in the area around Hell's Gate, with an average 5 megawatt (MW) potential. You need about 20 to 30 of those wells for a 140 MW power plant.

Taking the lead

Renewable energy has been a priority for the government since the 1990s. Kenya already boasts the largest solar project in the region and the largest wind project on the continent. Engineers say they are developing the largest geothermal plant on earth, Olkaria VI, in Hell's Gate.

The country has exploited close to 950 MW of geothermal energy so far, enough to power about 3,800,000 homes, through a combination of state and private commercial projects.

"A developing country having close to 90 percent of renewable energy power generation is quite unique," said Tobias Rasmussen, IMF resident representative in Kenya. "Renewable energy has the potential to be a major growth driver for Kenya going forward."

The new president, William Ruto, has pledged to keep developing this geothermal capacity and move to 100 percent clean energy by 2030. The government estimates there is 10,000 MW of untapped geothermal energy, enough to power Kenya's current peak demand five times, spread out across two dozen sites in its Rift Valley region.

Experts say that this is helping Kenya to develop in several ways. "You have no emissions with geothermal. That enables Kenya to access cheap climate finance to pursue its own development agenda," says Henry Paul Batchi Baldeh, director for power systems development at the African Development Bank.

"Geothermal contributes to power generation. The more you electrify your country, or you give people access to clean cooking alternatives, the more you find deforestation and charcoal burning declines," continues Baldeh. "That obviously helps women in particular and improves their health and livelihoods."

Kenya is now exporting its technology and know-how across the region. "We're in Ethiopia and Djibouti providing technical support for drilling. But we're also looking at providing surface studies to other countries, like Rwanda and Comoros," says Mangi.

Displacement

However, it is not a completely rosy picture. Indigenous populations and rights groups allege that many of Kenya's renewable energy projects are blighted by abuses and land grabs. People interviewed in communities around Hell's Gate allege that officials and geothermal companies preyed on their illiteracy, isolation, and lack of colonial-era legal documents showing that they owned the land.

"The geothermal companies took the ignorance of the communities here and used it," said one 40-something goat herder from Narasha, a village of about 500 people near one of the geothermal plants. "It was [ethnic] Maasai land. We didn't get anything."

KenGen reported "good working relations" with the surrounding communities and that it had even built houses for those it resettled and given local people jobs. Locals disagreed with this statement. "We have geologists, we have engineers—new graduates—but they are not employed. They give the jobs to people who are not from here," said a local community activist from near Narasha, who asked not to be named.

Academics and conservationists have also raised concerns about the damage done to the natural environment and wildlife around the Hell's Gate site.

Kenya has shown itself to be a world leader in geothermal energy. But to progress equitably, KenGen and geothermal companies will need to work hard to include local communities in their work. **FD**

WILL BROWN is a foreign correspondent based in Nairobi for the *Telegraph* and a senior associate with the Center for Strategic and International Studies in Washington, DC.

ENERGY TRANSITIONS

We need much more than just solar and wind to achieve a clean energy transition

The world is in a race against time to cut its reliance on fossil fuels and have a fighting chance of limiting a temperature rise to 1.5°C.

Thanks to wind and solar, the share of low-carbon energy has accelerated recently to reach 17 percent of total primary energy needs. However, this is hardly enough, as fossil fuels still make up 77 percent, just as they did 20 years ago.

The energy transition required today is like no other in history (see “Bumps in the Energy Transition,” in this issue of F&D). Energy transitions of the past were really just energy additions because the world was consuming more of different forms of energy.

Achieving net zero emissions by 2050 means not only increasing low-carbon energy rapidly but also decreasing fossil fuel use at the same time.

The challenge is that while per capita energy consumption has peaked in many advanced economies, it is growing in those that are still developing, and as the map below shows, it must increase in low-income countries to lift people out of poverty and raise living standards. Low-income and

developing countries are also where most of the population growth is happening.

This is why the world needs a lot more than just wind and solar for the transition. Other renewables like bioenergy and green hydrogen will be key, but so too will things like carbon capture and storage—and, as the IEA’s Fatih Birol points out, doing more with less through greater energy efficiency.

Green shoots

Low-carbon energy consumption has been accelerating.
(contributions to primary energy consumption by renewables and nuclear)

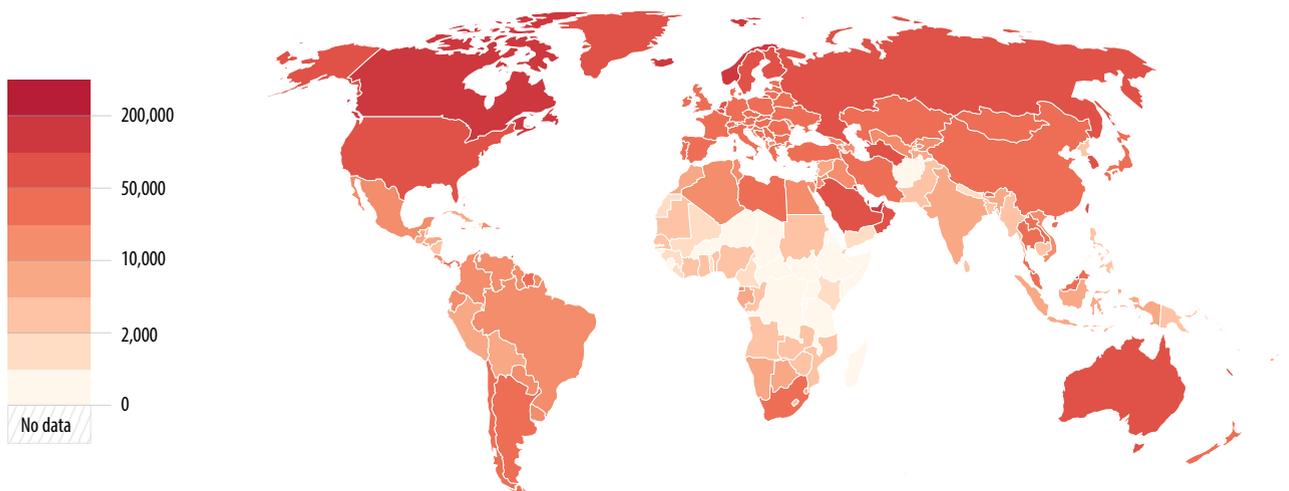


Source: Our World in Data based on Vaclav Smil (2017) and BP.

ANDREW STANLEY is on the staff of *Finance & Development*.

Powering up

Energy use varies: the average person in some countries consumes as much as 100 times more than the average person in some of the poorest countries.
(energy use per person, 2021, kilowatt-hours)

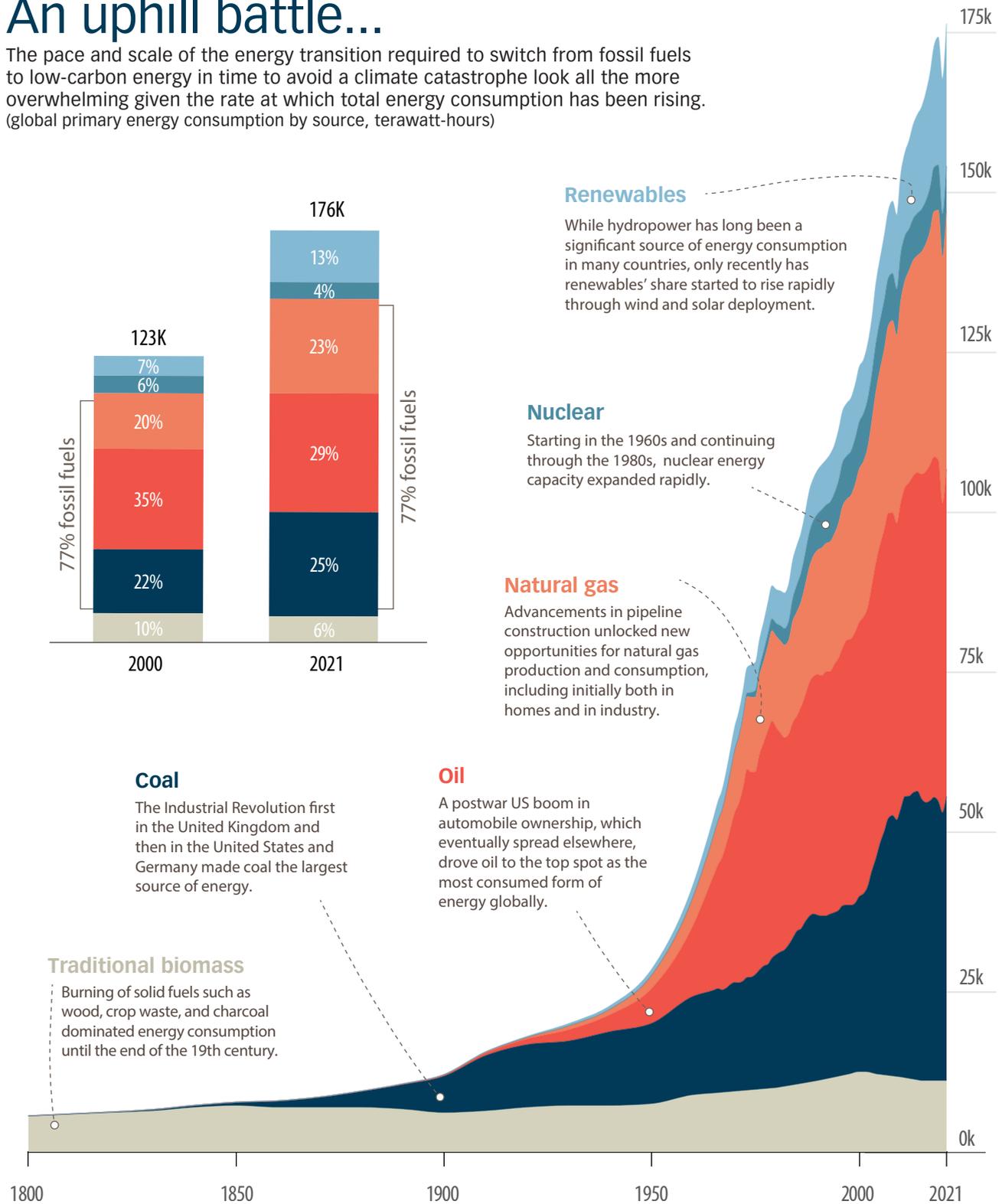


Sources: Our World in Data based on the BP *Statistical Review of World Energy*; and the Shift Project’s data portal.

Note: The map shows primary energy consumption per capita. The boundaries, colors, denominations, and any other information shown on the map do not imply, on the part of the IMF, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.

An uphill battle...

The pace and scale of the energy transition required to switch from fossil fuels to low-carbon energy in time to avoid a climate catastrophe look all the more overwhelming given the rate at which total energy consumption has been rising. (global primary energy consumption by source, terawatt-hours)



Sources: Our World in Data based on Vaclav Smil, *Energy and Civilization: A History*; and the BP *Statistical Review of World Energy*.

Note: Primary energy is calculated according to the "substitution method," which takes account of the inefficiencies in fossil fuel production by converting nonfossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.



THE DIGITAL GENDER GAP

A bigger role for women in digital finance can enhance company performance and economic growth

Purva Khara, Sumiko Ogawa, Ratna Sahay, and Mahima Vasishth

The advent of digital financial services—such as those that use mobile phones or the internet to conduct financial transactions—is transforming people’s lives, helping the underserved gain greater access to financial services. But not all segments of the population are benefiting equally.

Women continue to be significantly underrepresented in both finance and technology. Take traditional financial services. Previous research has documented an association between a higher share of women on commercial bank boards and greater resilience and stability in the banking system. Yet women hold fewer than 25 percent of board seats in traditional banks and bank supervision agencies (Sahay and Čihák 2018). Increasing the access of both men and women to traditional financial services reduces income inequality within countries, but the benefits are larger when more women have access (Čihák and Sahay 2020). Despite these substantial gains for countries, gender gaps in financial inclusion persist. Globally, 65 percent of women have an account with a financial institution, compared with 72 percent of men, as women continue to face socioeconomic, cultural, and technological barriers to financial services (Demirgüç-Kunt and others 2018).

Our new study on digital financial services confirms the findings related to traditional financial services—greater inclusion of women as users and leaders of digital financial services has benefits beyond addressing gender inequality. We find that narrowing the gender gap in leadership would foster better performance of firms in the digital financial services industry, which is critical to economic growth.

Using a novel fintech firm-level data set across 97 countries, we find that women represent less than 13 percent of leadership—both as founders and as members of executive boards of fintech firms—even less than their representation in traditional banking and technology companies. As Chart 1 shows, these numbers have hardly moved in the past 20 years. Chart 2 shows the considerable regional variation, with the highest shares of fintech companies founded by women in the Western Hemisphere and Asia and Pacific regions and the lowest in the Middle East and Central Asia.

But does it really matter whether women are fintech industry leaders? We find a positive relationship between more women on executive boards and the revenue earned by the respective fintech firm as well as the funding they receive for future investments. A 10 percent higher share of women on executive boards is associated with roughly 13 percent higher revenue and funding earned by a firm. There is a documented positive relationship between gender diversity in a firm and the firm’s performance (Christiansen and others 2016). Firms with a higher share of women executives earn higher revenue and receive more funding.

In contrast, we find that firms founded by women tend to make less revenue and receive less funding than those founded by men. This may reflect women’s greater risk aversion when making investment decisions or it may result from gender bias among investors (mostly men) funding the firms.

What about women’s participation as users of digital finance? Growing evidence suggests that increasing digital financial inclusion, including women’s access to and use of financial services, is positively associated with economic growth, which in turn benefits society (Khara and others 2021). When more women access financial services they participate more in the labor force and contribute to business activity, thereby directly increasing GDP. And when more diverse talent enters the labor force, it is likely to help productivity grow and reinforce economies’ output growth (Ostry and others 2018).

Sahay and others (2020) find that fintech is indeed helping narrow financial inclusion gender gaps in several countries by removing some obstacles that particularly affect women—such as mobility and time constraints—for example, by giving women access to financial accounts from home. Moreover, digital services circumvent interactions with bank branch agents: this makes a difference where social norms constrain interactions between men and women. Still, in some countries, although women’s digital financial inclusion is increasing, men’s is increasing faster and the gender gap is widening further. For instance, in 31 of the 52 countries in the authors’ sample gender gaps were

narrowing in digital financial inclusion between 2014 and 2017; in the other 21, they widened.

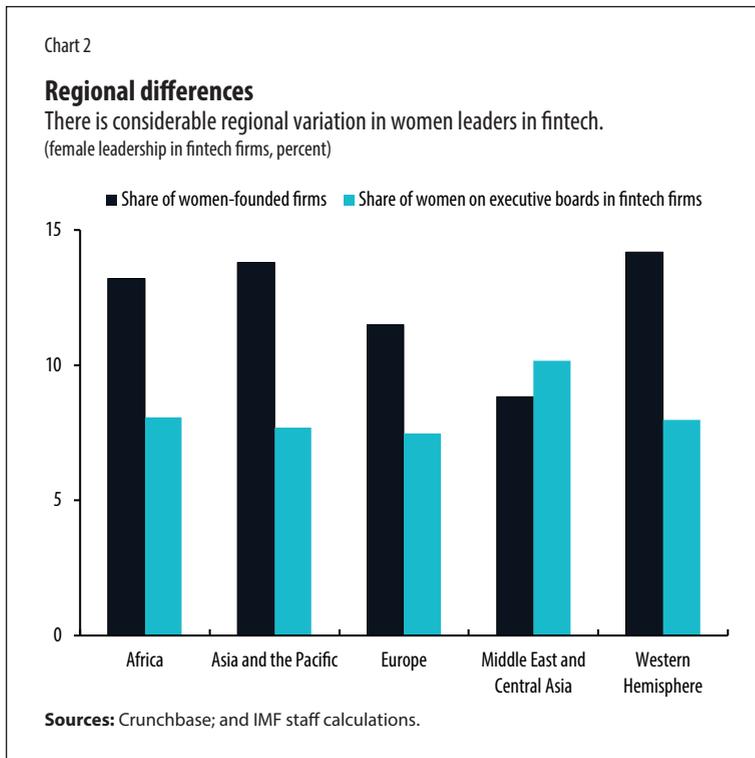
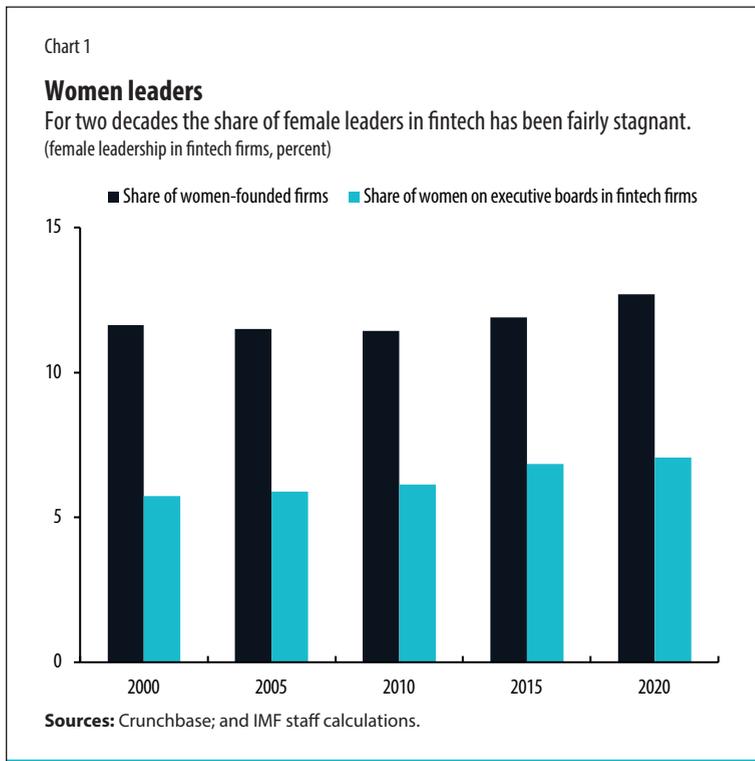
Women’s financial inclusion is one of the many powerful levers that can boost gender equality and, at the same time, raise economic growth, financial stability, and income equality. But we can’t make progress if we don’t truly understand the realities of women’s lives. So what fuels gender disparity in the use of digital finance? We find three key drivers:

- Women often lack the basic means to access digital services—such as mobile phones and the internet.
- Cultural norms in some countries limit women’s financial literacy, as measured by the share of women who have completed upper secondary education.
- Women’s digital and technology-related literacy, measured by the share of women in STEM (science, technology, engineering, and mathematics) fields, remains low at about 15 percent globally.

Our findings strengthen the case for higher inclusion of women—both as users and leaders in the digital finance industry—to enhance economic growth. As the adoption of digital financial services further accelerates in the post-COVID era, there is an emerging risk of new sources of financial exclusion due to the digital gender divide. Investing in digital and financial literacy should be high on the agenda of governments. Consumer protection agencies and regulators can play an active role in the prevention of explicit or implicit biases.

At the same time, we need more research and better data to identify the conditions that facilitate the entry of women into leadership roles in the digital financial industry, which could in turn have implications for narrowing gender gaps in financial inclusion. Interestingly, in our study we find preliminary evidence of a positive correlation between women leaders in fintech firms and the use of digital financial services by women. This likely indicates that women’s greater representation in leadership positions in the fintech sector is spurring development of financial services and products more targeted and tailored to women. More rigorous and in-depth work on this topic could help efforts to further improve financial inclusion. **FD**

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Reading the Tea Leaves on Household Debt

Amir Sufi talks about the state of household debt and why he doesn't foresee a severe global recession

Paulo Medas

A SIGNIFICANT RISE in household debt—encompassing all consumer debt and mortgage loans—has historically signaled the possibility of a looming economic recession.

In an interview with IMF economist Paulo Medas, Amir Sufi, professor of economics and public policy at the University of Chicago Booth School of Business, discusses what the state of household debt tells us about a possible recession, the risk from rising inequality, and his prediction on when we'll return to low levels of inflation and interest rates.

F&D: During the pandemic, debt in the private sector and the housing market did not explode the way it did during the global financial crisis. Why?

AS: Two major differences can explain that. First, in the lead-up to the pandemic, there wasn't any noticeable expansion in credit, and the COVID-19 recession was obviously something that happened

for reasons unrelated to the financial sector. It just didn't have the same kind of boom-bust dynamics that are typical of credit-driven recessions.

The second main factor is that the government, at least in the United States, made very dramatic policy interventions to try to mitigate household financial distress. For example, mortgage forbearance policies were quite aggressive here. The major fiscal stimulus also helped to soften the blow of COVID-19 on household balance sheets and default rates.

F&D: We currently have rapidly rising inflation, an economic slowdown, and rising interest rates. Are you concerned we may see more negative economic effects, for example, if house prices fall and unemployment rises?

AS: The environment today remains quite different than historical economic business cycles. The reason is that current inflation is very directly tied to both fiscal stimulus and cost shocks, in particular those from energy and supply chain issues. The channel that usually arises is households having a lot of debt—some of that debt is sensitive to interest rates. Interest rates rise, and that leads to a broad slowdown in consumer spending.

But this time is different—household balance sheets in the United States are actually quite healthy, and that's partially a function of the strong fiscal stimulus. So the rise in interest rates is going to have less effect than it usually would.

Inflation does seem to be having an effect on spending, judging by earnings calls from CEOs of retail firms—they're saying they are already seeing quite a strong decline in consumer spending due to inflation. And then, of course, increases in interest rates do affect the more interest-rate-sensitive parts of the economy, in particular housing and auto purchases.

But overall, I don't think we have the ingredients that we typically see in really severe recessions—very elevated debt levels in the private sector and a collapse in investment and spending.

F&D: Are some countries more vulnerable than others?

AS: I've been saying for the last couple of years that China will experience quite a deterioration in its economic conditions. Not just because of the COVID-19 lockdowns, which have been getting a lot of attention, but also because of the property

market. They have followed a path that typically does lead to a severe recession. I would not be surprised if the property problems in China continue to be a major drag on their economy.

F&D: Some argue that we're entering a period of higher inflation and higher interest rates—potentially increasing vulnerabilities to homeowners. Others would argue we are going back to low natural interest rates. What are your views?

AS: My view is that we'll be back to a low-inflation, low-interest-rate equilibrium three to five years from now. Secular factors will continue to push down interest rates or keep them low. What we're going through right now is primarily a product of very aggressive fiscal stimulus and cost shocks—in particular, energy prices and supply chain disruptions. Central banks have been quite clear that they're going to raise interest rates to try to affect inflation expectations, and I think they'll be successful.

Longer-term yields on government bonds remain low, the yield curve is inverted, and the market's expectation is that, in the long run, long-term interest rates will probably continue to be low.

The caveat is if the war in Ukraine and climate change do spur a big rise in military spending and in green investment, respectively, then that could actually put upward pressure on interest rates and inflation over the next few years.

F&D: There is great interest in understanding how much room governments have in their budgets during a crisis to support households. Could you talk about that?

AS: The main advantage of government debt is that people are willing to hold debt at an interest rate that is below market interest rates on other securities, and that gives governments who want to run deficits an advantage.

Many people say that, as long as the nominal interest rate is below the nominal growth rate, you have a free lunch. You can increase your deficit and never have to pay it back. And we make the point that that's not accurate. Because as you saturate the market with government debt, people value the government debt less, and so the interest rate on the government debt has to rise.

If you raise deficits by too much, the nominal interest rate will go above the nominal growth rate, and you will have to cut deficits.

F&D: In many countries, we saw private and public debt surge during the pandemic. What risks does this pose?

AS: The risk prior to COVID-19, which has probably only been amplified, is kind of the Japan-style risk—very long-term depressed growth, debt burdens that get larger, depressed interest rates, and depressed inflation. And the expansion of government debt, if it's not used in a productive way, just adds to that risk.

To get growth that can start to eat away at those debt burdens, you have to think of ways of increasing productivity growth. You have to find ways of reducing income inequality in a productive manner, like boosting middle-class wages in a way that can actually add to demand and that can hopefully get firms to invest more. Post-pandemic, it will be even more important to find ways of boosting productivity growth and reducing income inequality.

F&D: Housing prices have been falling in some countries. Will this make high debt levels more difficult to manage?

AS: Higher debt is a symptom of an underlying problem, which is that the economy cannot generate enough demand given the rising income share of the people at the top. That's really what I view as the main risk of really elevated debt burdens.

The rise in income inequality globally is pushing up asset prices and pushing down interest rates. This is leading to insufficient demand, and the only way we can get the demand is to have middle- and lower-income households borrow more.

And so the real risk is a long-run stagnation trap, in which you're stuck in a high-debt, low-interest-rate, low-household-spending equilibrium.

F&D: What would you advise governments to do in that context?

AS: Infrastructure spending makes a lot of sense, especially if it can boost productivity and middle-class wages. Because interest rates are low, governments can borrow and spend on infrastructure—and you can potentially get good productivity growth. **FD**

This interview has been edited for length and clarity.

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CITIES AFTER THE PANDEMIC



The lure of urban life remains strong, but some cities could benefit at the expense of others

David M. Cutler and Edward Glaeser

What impact will the double blow of the COVID-19 pandemic and the remote-working revolution have on cities, the heart of the world's economy?

Humans are a social species, and live interactions are particularly valuable for transmitting complex and nuanced information as well as for enjoying life. As long as we don't face a new and deadlier pandemic in the near future, the cities of the developed world will largely recover; their appeal to knowledge-intensive industries and younger workers is that strong. The cities of the developing world have already come back, but they may suffer future costs if reduced global business travel leads to a decline in foreign direct investment.

As we have seen, pandemics can be enormously costly—both in lives lost and economic disruption.

The central lesson of COVID-19 is that the wealthy world should invest more in public health and medical care systems to prevent future pandemics. This must also mean more investment in the poorer parts of the planet.

Cities connect people, and urban proximity brings many economic and social benefits. Urban connections have enabled collaborative creativity ever since Socrates and Plato bickered on an Athenian street corner. People earn more in cities than in rural areas, and cities have long been places where the dispossessed and displaced seek and often find economic opportunity. Cities also abet the pleasures of proximity, including the ability to share a meal at an urban café or share the cost of a museum or arts venue. Suicide rates are lower in cities than in rural areas, perhaps reflecting better mental health.



The pandemic has led to a feeling of geographic freedom not experienced for some time.

From Athens to New York

But there are downsides to density; contagious disease is the most terrible of these. Humans have millennia of experience with urban epidemics. The first well-documented urban plague struck Athens in 430 BCE. It helped Sparta defeat Athens in the Peloponnesian War and brought an end to Athens' golden age. As Matthew Kahn (2005) has documented, natural disasters do far more damage when they strike weaker societies; the same is true of epidemics. The Plague of Justinian, which hit Constantinople in 541 CE, may have done even more harm. It helped plunge Europe into centuries of darkness, widespread poverty, and political chaos. The effects were so bad because it struck a continent that was already teetering on the brink.

Epidemics, terrible as they are, can have favorable aftereffects for those who survive. The Black Death killed perhaps one-third of Europe's population in the 14th century. But the survivors were richer, because labor shortages led to higher wages. The resulting increase in per capita wealth helped spur the urban renaissance of the 15th century.

The beginnings of globalization in the 19th century hastened the spread of diseases like yellow fever and cholera. Each killed a vastly higher share of the population than COVID-19. Yet despite the deaths, cities continued to attract migrants by the millions. Rural life was difficult and not rewarding economically. The very poor will do most anything to escape poverty, which explains why COVID-19 will likely do little to deter urbanization in poor countries. Nineteenth century cities also continued to grow because they invested in clean water and sanitation. The great public health investments, such as New York's Croton Aqueduct, marked a hinge of history, when governments started to save lives rather than merely killing their enemies.

Those investments helped usher in the fortunate century that lasted from 1919 to 2019, at least in the rich world. HIV devastated much of sub-Saharan Africa, but it had much less impact elsewhere, especially after the development of antiretroviral medications. Sexually transmitted infections inherently cause less concern than airborne infections. Sex can be avoided but breathing cannot. Further, potential outbreaks such as SARS, MERS, Ebola, and swine flu were contained without severe damage. That history helps explain why the rich world treated the risk of global pandemic so cavalierly before 2020. Unfortunately, we are far from confident that the human and economic harm wrought by COVID-19 will persuade policymakers to invest more seriously in plague prevention.

The wealthy world's experience of COVID-19 was shaped by the technologies that allowed many of us to socially isolate and still earn a paycheck. In May 2020, when remote work was at its height, two-thirds of Americans with advanced degrees were working from home. Google mobility data show that visits to workplaces in the United States were still down by 28 percent in August 2022 compared with the pre-pandemic period. In Manhattan and London, workplace visits were down by more than 45 percent.

This shift to remote and hybrid work raises the specter of permanently empty offices and a downward cycle for cities: fewer workers reduce demand for local services, which leads to unemployment and less spending on public services, which causes more workers to flee. To be sure, individual cities are at risk, especially if they allow crime to shred urban quality of life. The pandemic has led to a feeling of geographic freedom not experienced for some time.



The world seems to be engaging in a deadly science experiment in which it is waiting to see what new plague will emerge.

Dynamic benefits

But there are at least four reasons we believe that cities as a whole—in both rich and poor countries—will survive and even thrive. First, the hypothesis that technology will make face-to-face contact obsolete is old and has been discredited many times. The late journalist Alvin Toffler predicted empty offices in 1980, but for most of the past 40 years, the problem has been too few offices, not too many. Technological change does more than just enable long-distance communication. It radically increases the returns to learning, which is fostered by being around other people.

One sees the dynamic benefits of bringing people together in the productivity data. Nicholas Bloom (2015) and his coauthors showed that when Chinese call center workers were randomly sent home, their productivity, measured in calls per hour, actually improved. More recent work by Natalia Emanuel and Emma Harrington (2020), who look at US call center workers, finds essentially no change in productivity from working at home. But both papers also find that the workers' chances of promotion fell more than 50 percent when they worked remotely. If call center workers are alone, how are they going to pick up tips about doing their job more effectively, and how will their boss learn that they can handle more complex cases?

In the same vein, José Morales-Arilla and Carlos Daboin Contreras (2021) documented the decline in new hiring for remote work during the COVID pandemic. Even though Microsoft concluded that its programmers were just as productive when they went remote, new ads for programmers on the Burning Glass Aggregate, an online job board, dropped more than 40 percent in the course of 2020. That drop is compatible with the view that employers don't think new workers can learn the company's work culture when they don't interact with other employees. More recently, Microsoft researchers reported that "firm-wide remote work caused the collaboration network of workers to become more static and siloed," with "a decrease in synchronous communication and an increase

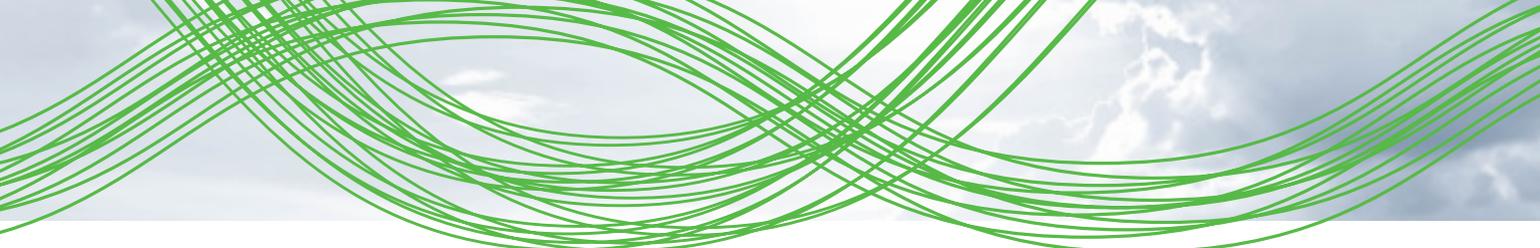
in asynchronous communication," which together "may make it harder for employees to acquire and share new information across the network." And a host of evidence documents that remote learning was disastrous for children.

Sharing costs

Second, cities thrive as places of consumption as well as production. Urban agglomeration produces better restaurants as well as better accountants. Cities allow people to share the fixed costs of museums or concert venues. Between the 1970s and the 2000s, urban prices went up much faster than urban wages, which is compatible with the view that people increasingly wanted to be in cities for the amenities they provide. While some older people have decided never to return to in-person office work, plenty of younger people have shown enormous hunger to get back to face-to-face social interactions; a job can be a source of enjoyment as well as income.

Third, prices will adjust to ensure that offices don't remain permanently empty, at least in cities where there is reasonable demand for office space. Before the pandemic, commercial real estate was in very short supply in cities like New York, San Francisco, and London, and many smaller, newer, or less profitable businesses were priced out of these markets. Landlords with unoccupied offices will cut rents and eventually find firms eager for that space. Of course, in some lower-end markets, which were near the edge of survival before COVID, demand may fall to the point where landlords prefer to walk away from their buildings rather than rent them out at bargain-basement prices. They can be turned into housing or, worse, left empty.

Fourth, much of the world remains poor, and for the poor, the economic appeal of urbanization easily overwhelms fears of health costs. Google mobility data show that workplace visits are substantially higher now than they were before the pandemic in cities such as São Paulo, Brazil, and Lagos, Nigeria. Moreover, skilled workers in poorer cities will actually benefit because videoconferencing makes it easier to connect to the wealthy world. The



slowdown in business travel may, however, reduce foreign direct investment in developing-world cities. Before the pandemic, air links between cities were significant predictors of financial ties (Campante and Yanagizawa-Drott 2018).

Winners and losers

Even if cities as a whole remain robust, individual cities may still suffer. In some ways, the patterns of urban success since 2019 look like postwar America on steroids. Sunbelt cities such as Austin, Texas, and Phoenix, Arizona, have done extremely well, measured by growth in housing prices, employment, or housing construction. Indeed, housing markets in these areas may have overshot and could easily experience a correction in the near future.

Meanwhile, rust belt cities have particularly suffered. For firms in cities like Chicago and Detroit, teleconferencing may be more important as a tool for communicating with suppliers and customers than it is as a way to enable remote work. Firms that once located in Chicago's Loop because it gave them easier access to accountants and lawyers may now find it just as easy to be in Miami and use the service industry there. The most important meetings may still need to be face-to-face, but more routine interactions can certainly take place online. Hungry start-ups tired of Silicon Valley prices are far more likely to relocate to Austin than to just give up their offices entirely and work from home. This logic suggests that the war for global talent has intensified, which will benefit areas with amenities particularly appealing to skilled workers.

Even though developing-world cities are back to work, in many cases their economies remain depressed. Unlike the United States and other advanced economies, these countries couldn't afford to pump trillions of dollars of stimulus funds into their economies to mitigate the impact of the COVID-related slump. In poor countries, borrowing is more difficult, which means internal resources matter more. Africa's GDP fell by 2 percent during 2020, according to World Bank data, and that may understate the true economic damage for many communities. Even more worrisome, vaccination rates in the poorer parts of the planet remain low.

These low vaccination rates are intrinsically problematic because they mean that more people in poor countries will die from COVID-19. And there is the risk that new COVID variants will

start in the poor world and spread widely from there. In the past six decades, the bulk of "spillover events"—health-related events that spread disease beyond a country's borders—have originated in some of the poorest parts of the planet.

In regions plagued by poverty, people often have more contact with disease-carrying wildlife, vectors such as mosquitos survive longer, and sanitation is more limited. Consequently, the world seems to be engaging in a deadly science experiment in which it is waiting to see what new plague will emerge from the relatively unmonitored and under-resourced regions and spread globally.

What can be done to reduce the risk of another pandemic? The IMF provides a model of how richer countries can aid poorer countries in exchange for policy reforms. That model could be readily adapted to prevent future pandemics. A natural path forward is for the rich world to engage in a massive health exchange with the poor world. In exchange for significant aid for public health infrastructure, recipient countries would agree to measures that keep humans away from animal carriers of disease, better monitor new illnesses, and commit to rapid response and containment.

Fortunately, the world and its cities seem to have survived COVID-19 largely intact. We may not be so lucky next time. The result of complacency in 2020 was millions of deaths and enormous economic disruption. The world must heed this warning and invest in the entire world's hygiene or risk being hit by a pandemic that is even worse. **FD**

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Pipeline Diplomacy

Piotr Naimski explains Poland's decision to pursue energy independence

AS A STUDENT in Communist Poland, Piotr Naimski helped organize help for workers who had been fired or imprisoned for taking part in strikes and protests against the Soviet-backed regime. After the fall of Communism, he was among the few voices in Europe to warn against dependence on Russian natural gas. As head of the bureau of state security in the early 1990s, he conceived of a plan to find alternative sources of energy. That plan bore fruit in September 2022 with the inauguration of the Baltic Pipe linking Poland with Norway's offshore natural gas fields—months after Russia stopped deliveries to Poland. Naimski, who holds a PhD in natural science, served most recently as government plenipotentiary for strategic energy infrastructure. He spoke with F&D's Chris Wellisz in late August, as Moscow prepared to cut gas flows to western Europe in retaliation for sanctions punishing Russia for its invasion of Ukraine.

F&D: In 1991, when your government was elected, you decided that the country needed to free itself from dependence on Russian natural gas. How did that decision come about?

NAIMSKI: We entered office by the end of the year, and suddenly at the beginning of January, supplies of [Russian] gas started to be lower and lower. At that time, gas was already a substantial part of our energy supplies. We convened a special committee to evaluate which industrial installations should be cut off from our energy supplies in case of necessity.

The Russians at that time were very disorganized, because in December 1991, they had dissolved the Soviet Union. In Moscow, they kept telling us, "Don't worry, this is only because of our organizational problems." And by mid-January they resumed supplies.

But this was really a sign for us of what could happen in the future. At the time that Russians had decided about a certain new strategy for central European countries—which were going out of the Soviet sphere of influence—they decided on this plan to "replace tanks with pipelines."

So we started to look for other solutions for diversification of the supplies.

F&D: After a few false starts and changes in government, in 2016 you started talks on the construction of the Baltic Pipe. How important is that for Poland's energy security, and for Europe's?

NAIMSKI: The Baltic Pipe will have 10 billion cubic meters of capacity per year. This is about half of Polish demand and will replace 100 percent of Russian deliveries. Together with an already operational LNG [liquefied natural gas] terminal and recently commissioned interconnectors with Lithuania and Slovakia, Poland will be free of Russia's hostile gas maneuvers. This is especially important today, when Europe has to confront Russia's weaponizing of hydrocarbon deliveries.

F&D: How serious is the energy crisis, and how long will it last?

NAIMSKI: The impact of this crisis, in my opinion, will be as deep as the impact of the crisis in the '70s. It will take some time to introduce new plans, to commission new investments, to diversify not only gas supplies to Europe but energy policies in Europe. The crisis will be longer than just one winter. This will go for the next two, three years.

As we phase out coal, we need baseload production of energy just to balance renewables. Because renewables themselves are not enough.

F&D: How quickly and to what extent can Poland free itself from dependence on coal, which generates about 70 percent of its electricity?

NAIMSKI: We still have coal as a necessity for the next 20, 30 years. But as we phase out coal, we need baseload production of energy just to balance renewables. Because renewables themselves are not enough.

We'll be phasing out coal very carefully, still keeping in mind the security of energy supply. And also, I really believe that technologies connected with chemical processing of coal toward liquid fuels and toward others—that this will, with time, occur probably effectively.

F&D: Will Europe have to change its goal of net-zero carbon emissions by 2050?

NAIMSKI: The decarbonization strategy accepted on the EU level probably will be discussed once again. This is possible and probably necessary. They could introduce some amendments, and some commonsense approach should be added to this.

F&D: Is it possible to have a single energy strategy encompassing all of Europe?

NAIMSKI: Some practical approaches are necessary to accept differences in national strategies. Because the situation is different in Poland, and different in Germany, different in France. It's not possible to have one plan for all European states.

It's very clearly said, in the European treaties, that energy is the responsibility of the member states' governments rather than European policies. But the European Commission tries to go beyond treaties. And this is the area where we will have hard discussions.

F&D: What is the outlook for nuclear energy in Poland?

NAIMSKI: We expect to have a first operational nuclear unit in Poland by 2033. In 20 years we

would like to have six of them. And by the mid-'40s, we will have about a quarter of our energy from nuclear. Twenty-five percent of baseload production would allow us to include much more renewable energy in the mix.

F&D: Is there a political consensus in Poland in support of nuclear energy?

NAIMSKI: We do have very deep political divisions in Poland. But we don't have a dispute over nuclear energy.

F&D: Do you see the goals of decarbonization and energy security as being compatible, or not?

NAIMSKI: It could be that the security of supplies will be on a necessary level and smoothly follow this decarbonization path. But it's a question of tactics. We shouldn't phase out coal too fast.

F&D: Most existing gas pipelines run east to west. You have talked often about the need for north-south pipelines. What is the rationale?

NAIMSKI: This is important because, if we want to really diversify our sources and means of transportation for central Europe, we have to construct transmission lines completely differently from what was executed by Russian—or Russia-dependent—institutions, governments, or economies.

This is why we are commissioning a pipeline interconnected between Poland and Slovakia. And the Slovaks, they have already interconnected with Hungary, and they have plans to finally complete a link with the Romanian system. And actually, this idea of linking Świnoujście [on Poland's Baltic Coast] with Krk Island [on the coast of Croatia] was the basis for these north-south gas transmission strategies. The Baltic Pipe is part of this new possibility. **FD**

This interview has been edited for length and clarity.

What Is Sovereign Debt?

It plays a pivotal role in the world economy but comes with risks

S. M. Ali Abbas and Alex Pienkowski



WHEN EDWARD III of England ran out of money to finance the Hundred Years' War with France, he turned to the banking families of Florence. The loans they gave him were extremely expensive, and when Edward failed to become king of France, he was unable to repay the debt in full. Over the centuries, the sovereign's debt became sovereign debt: the multitrillion, multinational, multicurrency network of debt obligations that we know today.

Why do sovereigns borrow?

Governments borrow to spend beyond what they can or want to raise through general taxation. There are several economic motives for this. When tax revenues are down, such as during a recession, governments will borrow to pay for existing spending commitments. This is better for the continuity of public services such as schools and hospitals and means that the government is not forced to cut spending when the economy is already weak—something that could make the situation worse.

This is known as “tax smoothing.” Governments may go a step further and actually increase spending, or reduce taxes, during a recession to try to boost growth. This “fiscal stimulus” is financed by issuing sovereign debt.

But these reasons cannot typically explain the high level of debt seen in many countries. Another motive to borrow is to invest in the future. Governments might borrow large sums to help build a major new highway, power plant, or subway system. The up-front costs can be extremely high, and so repayment is spread over many years. But hopefully these investments boost longer-term growth, justifying the borrowing. As well as physical capital, governments can also invest in human capital, such as education and health. Again, the long-term benefits should outweigh the cost of borrowing.

Who do they borrow from?

Governments can be very creative in finding potential lenders, as they seek out those who might charge them the lowest interest rate. There are often trade-offs associated with this choice of lender, however. For example, sovereigns can borrow from within their own country or from abroad. Domestic borrowing—from local banks and asset managers or directly from households—can be a steady and reliable source of financing. But often there is a limited amount of money available and repayment maturities tend to be short. And so governments also borrow from international capital markets, in larger amounts and usually at longer maturities. These markets can be fickle, however, especially for lower-income countries. It can be dangerous to assume that these lenders will always provide a readily available source of finance.

A diverse range of private sector entities lend to sovereigns, too. Asset managers, such as pension funds, typically hold a large amount of government debt. They need relatively safe long-term assets to match their long-term liabilities. Banks also hold large amounts of sovereign debt, especially of governments in the countries where they are

based. But this “bank-sovereign nexus” has caused problems in the past. During the 2010–12 euro area sovereign debt crisis, for instance, troubled banks reduced their funding to governments, raising sovereign borrowing costs. This led to a vicious cycle of further tightening of financial conditions that aggravated the economic recession and problems in the banking system. Today there is greater understanding of these risks on both sides.

Finally, governments can borrow from other governments or international organizations. Often this form of lending is not motivated primarily by commercial objectives (although the lender may not say this in practice). One government might lend to another to strengthen bilateral ties. The World Bank or African Development Bank might lend money to a country to help build a sanitation system, fund vaccinations, or reform the power sector. And the IMF can provide financing if a country finds itself facing balance of payments difficulties.

How do they borrow?

There are also various contractual ways for a government to borrow. Loans are a familiar form of financing. They are normally arranged bilaterally, or through a syndicate of lenders, and repayment is often spread out over several years. By contrast, bonds are issued to hundreds or thousands of creditors, and the entire amount normally needs to be repaid at once. In addition, there are many exotic instruments through which a sovereign can borrow, but these tend to be much smaller in scale.

Governments seek to minimize the cost of their borrowing—the interest rate—while preventing the structure of their debt from becoming too risky. For example, many governments find it cheaper to borrow in US dollars or euros than in their own currency. But this can cause problems if their currency depreciates, as this increases the real burden of the debt. Similarly, some governments prefer to pay a fixed rate of interest on debt, as this ensures debt-service costs are stable. But it can be cheaper (at least initially) to issue debt that is linked to a variable interest rate or consumer price inflation. Yet this too can be risky if these variables move in an unexpected and unfavorable direction.

A prudent public debt structure can help keep sovereign borrowing costs low over the long run. But many other factors also influence a sovereign’s creditworthiness and its borrowing costs, such as its level of economic development,

the size of its financial markets, its record of honoring its obligations, and its vulnerability to external shocks, as well as global financial conditions. Many of these factors are beyond the control of governments. Sovereign rating agencies and international institutions, including the IMF, maintain elaborate models that continuously assess sovereign creditworthiness.

What happens when they can’t pay?

Like people and companies, sovereigns can struggle to repay their debt. This could be because they borrowed too much or in a way that was too risky—or because they were hit by an unexpected shock, such as a deep recession or a natural disaster.

In these circumstances, the sovereign needs to restructure its debt. But unlike people and companies, there is no bankruptcy court for sovereigns that can compel the debtor and its creditors to resolve the issue. Instead, it becomes a negotiation: creditors want to recover as much of their money as possible, while the sovereign wants to regain “normal” status in financial markets, without paying out too much.

These restructurings are often costly for both the debtor and for creditors. This makes them relatively rare events. Well-known examples include Russia (1998), Argentina (2005), Greece (2012), and Ukraine (2015). Costs are normally much smaller when an agreement can be reached before a sovereign defaults, by missing a payment on its debt. These preemptive restructurings are usually resolved quickly and have smaller spillovers to the rest of the economy and financial system. But once a sovereign defaults on its debt, the subsequent restructuring process can be long and expensive.

Sovereign borrowing has come a long way since Edward III’s military forays into France. It has become larger, more sophisticated, and more international, and it plays a pivotal role in the world economy by allowing governments to keep their economies afloat during recessions and other unexpected shocks and to finance investments that lift productivity and growth. But the risks—overborrowing and potential default—remain with us to this day. **FD**

S. M. ALI ABBAS is an advisor and **ALEX PIENKOWSKI** a senior economist in the IMF’s European Department. They are co-editors of *Sovereign Debt: A Guide for Economists and Practitioners*.

Gender Discrimination in Economics

GENDER DISCRIMINATION and the associated biases and barriers to career advancement are unwelcome realities for many working women, and the economics profession is no exception. Almost half of the female respondents in a 2019 American Economic Association (AEA) survey said that they had been discriminated against based on their sex, compared with just 3 percent of male respondents, and male students in US economics PhD programs outnumber female students 2 to 1. These statistics paint a dismal picture for “dismal scientists.” Ann Mari May’s compelling and well-researched book, *Gender and the Dismal Science*, offers a rich historical narrative on the long-standing sources of such gender gaps.

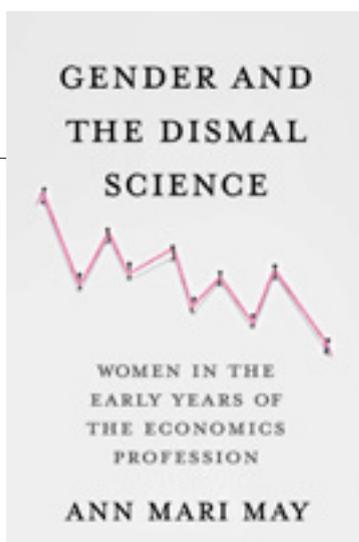
persisters”—May also incorporates personal perspectives and tales of triumph.

Covering the late 19th century through the post–World War II period in the United States, May delves into the underpinnings and evolution of gender discrimination. With male enrollment in colleges and universities declining during the US Civil War, and more girls than boys graduating from high school, the pressure to allow women to enroll was building. Yet many universities were reluctant to admit women, viewing their presence as a “dangerous experiment” or posing a direct challenge to men’s livelihoods. The first female economics students faced challenges such as segregation in the classroom, unequal access to libraries and laboratories, and doubts about their inherent abilities to complete a rigorous course of study.

Upon completion of their degrees, women seeking employment in the field of economics continued to encounter obstacles and exclusion. May’s exploration of AEA membership data, starting in 1886, shows a vast gap in professional representation: women comprised only 5 percent of AEA membership over the first six decades of the association’s existence. Social norms and views on the incompatibility of marriage with a career as an academic further stymied women’s efforts to contribute fully to the field of economics. Women also struggled to publish in academic journals, and May’s empirical analysis of publications in the *American Economic Review* and *Quarterly Journal of Economics* examines the importance of network connections, something women certainly lacked. And throughout the chapters, May carefully considers the importance of intersectionality, offering sobering statistics on how women of color have been marginalized and remain vastly underrepresented in economics.

By the end of the book, May succeeds in pushing the reader to confront the disconnect between a profession that has long examined the harmful effects of monopolies and discrimination and the reality that the profession itself is rife with both. The stories of champions, advocates, and “tenacious persisters” should spur all economists, regardless of gender, to break down glass walls and glass ceilings and aim to diversify a far-too-homogeneous profession. **FD**

LISA KOLOVICH, senior economist in the IMF’s Strategy, Policy, and Review Department and coauthor of the paper “IMF Strategy Toward Mainstreaming Gender”



Ann Mari May
**Gender and the Dismal
Science: Women in
the Early Years of the
Economics Profession**

Columbia University Press,
New York, NY, 2022, 256 pp., \$32.00

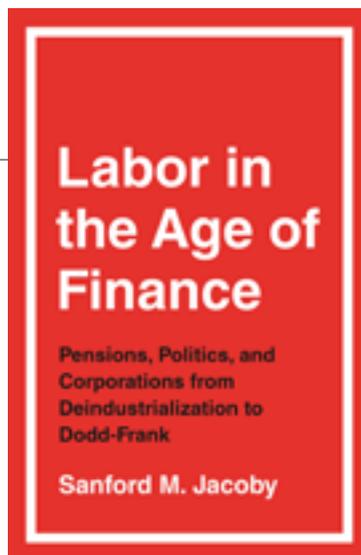
Drawing on AEA archives and a wide range of empirical data, May traces the evolution of social norms and institutional barriers, as well as overt exclusion and discrimination in hiring and promotions, publishing, and participation in professional associations. Weaving in the stories of female trailblazers—or, in her terms, “tenacious

Financial Markets and the Common Good

IN THE 1970s, labor activists came to believe that if US unions mobilized the enormous latent financial leverage in the growing pension funds they had won for their members, they might transform American capitalism, using labor's investing power to modify corporate behavior. Nor were activists the only believers. Even management guru Peter Drucker predicted that "the accumulation of pension assets would bring socialism to the United States." In this fine book, the first history of US labor's foray into capital strategies, economic historian Sanford M. Jacoby explains why such grand dreams never materialized.

Jacoby's narrative shows how a combination of obstacles, contradictions, and unintended consequences limited unions' capital strategies. One obstacle was the fiduciary duty of union pension fund trustees to maximize returns on investments in order to ensure secure retirements for union members. The more union membership shrank after the 1970s, the fewer the number of unionized employers who paid into pension funds, creating increasing pressure on trustees to maximize returns. This surfaced a contradiction: pensioners' interests did not align neatly with those of active workers and unions. Indeed, ensuring pensioners' retirement security could conflict with activist investing to an extent that neither labor activists nor Drucker had anticipated.

Yet Jacoby's most interesting tale concerns unintended consequences as revealed in the experience of the nation's largest public employee pension fund, the California Public Employees' Retirement System (CalPERS). CalPERS pioneered the strategy for labor's activist investors by codifying a set of principles of corporate governance in the 1990s that Jacoby calls the "cookbook." CalPERS and other pension funds alleged that corporations were poorly run and failed to maximize shareholder value because executives so thoroughly dominated their compliant corporate boards. In response, the funds pooled their influence to advance the cookbook's principles: limits on CEO pay, board member independence from CEOs, and greater transparency in corporate financing.



Sanford M. Jacoby
Labor in the Age of Finance: Pensions, Politics, and Corporations from Deindustrialization to Dodd-Frank

Princeton University Press,
 Princeton, NJ, 2021, 354 pp., \$35.00

That approach, Jacoby shows, yielded decidedly mixed results. Pension fund activism failed to narrow the growing compensation gap between executives and their employees. Instead, it helped shift executive compensation from salary toward stock options. Stock options in turn incentivized executives to downsize and outsource work as means of inflating stock prices (and their incomes). Meanwhile, the pension funds' embrace of shareholder activism further legitimized the "shareholder value" worldview that gripped the nation's equity markets.

There were bright spots of financial activism, to be sure, Jacoby notes. Some unions—such as the Service Employees International Union, through its Justice for Janitors campaign—were able to deploy labor's financial leverage to achieve breakthroughs. Overall, though, the achievements of labor's financial strategies fell far short of grand 1970s dreams. How far short was revealed by the 2008 crash; the Great Recession; and the 2010 Dodd-Frank financial regulation legislation, which largely failed to rectify the dysfunction that labor had fought for decades to correct.

This smart and sober volume is unsurpassed as a starting point for anyone who seeks to understand both the urgent necessity and the enormous difficulty of making financial markets more accountable to the common good. **FD**

JOSEPH A. MCCARTIN, history professor at Georgetown University and executive director, Kalmanovitz Initiative for Labor and the Working Poor

For the Love of Cricket

Barbados' \$5 banknote pays tribute to the man who united West Indian cricket

Analisa R. Bala

WHEN THE CENTRAL bank of Barbados was thinking through which features to prioritize as part of the redesign of its banknotes debuting this month, the top priority was that the notes be authentically Barbadian. “Each note talks about our history, geography, and culture,” says Octavia Gibson, director of the bank’s currency and payments oversight department.

And what could be more Barbadian than cricket? It’s a sport the country has traditionally excelled in.

Barbados’ top cricketers play for the West Indies cricket team, a multinational men’s team of mostly English-speaking Caribbean countries

administered by the West Indies Cricket Board. The WICB joined the Imperial Cricket Council (the sport’s international ruling body, now called the International Cricket Council) in 1926, and the team played its first official international match—called a “test”—in 1928. Unofficial world champions by the 1970s and ’80s, the team set a record streak of 11 consecutive test victories in 1984—one of the best in the sport’s history.

Cricket administrator and educator Jeff Broomes attributes their success to the leadership and performance of Barbadian players. “The school that has produced the most test cricketers is right here in Barbados,” he said at an event promoting his book, *The West Indies Cricket Journey and Its Barbadian Influence*. The statistics bear him out. Of the 385 men to play test cricket for the West Indies since 1928, 90 are from Barbados. “Almost every district that you walk in, you will find people on the road playing cricket,” says Gibson. “Not only on the road, you also see them on the beach. It’s one of the first games introduced to children.”

With cricket so much a part of the culture, it’s fitting that the Barbadian \$5 note features cricket legend Frank Worrell. Together with Everton Weekes and Clyde Walcott, Worrell was one of the famous “Three W’s”—the strongest middle-order batters in the world at the time. All three were born in Saint Michael, Barbados.

Worrell was the first Black man to captain the West Indies cricket team for an entire series and was an exceptional manager, insisting on fair play, both on and off the field. The team lost just 3 of the 15 tests under his leadership, making him one of the most successful skippers in its history. Shortly after retiring, he was knighted by the late Queen Elizabeth II for his contribution to the game and was the first sportsman to be honored with a memorial service at Westminster Abbey when he died in 1967 of leukemia at age 42.

Uniquely Barbadian

This is not the first time Worrell has been featured on the country’s banknotes, but unlike



IMAGE: COURTESY OF THE CENTRAL BANK OF BARBADOS

Barbados' new banknote series is the first to be printed on polymer.



Barbadian cricket legends Frank Worrell (left) and Everton Weekes (right) heading out to bat against Cambridge University in 1950.

in previous series, the design is now vertical, and Worrell is in his cricket gear rather than a suit. The back of the note has an image of Worrell at the pitch in front of the “3Ws Oval,” a cricket facility on the Cave Hill Campus of the University of the West Indies. The ground was upgraded and renamed in honor of the country’s three cricket legends when the West Indies hosted the 2007 Cricket World Cup.

The new banknotes—all with portraits of historic Barbadians—will be printed on polymer, a plastic substrate, which makes them more durable than cotton-based banknotes; new security features mean they will be harder to counterfeit.

On the \$2, \$5, and \$10 notes, a clear plastic window has been added with a vignette of the image featured on the back. These vignettes are reproduced as holograms on the \$20, \$50, and \$100 notes. The top of every note also has a small broken trident, which when held up to the light reveals the notes’ denomination. “The tridents

signify that we broke away from being a colony and are now independent,” adds Gibson.

Gareth Evans, country director at De la Rue, the company that helped design the enhanced security features, thinks the map lines are what’s most unique about the series. When all six denominations are grouped together, a map of Barbados is revealed under ultraviolet light.

The other major design consideration was to ensure that Barbadians who are visually impaired or fully blind can differentiate between denominations. In consulting with representatives of the Association for the Blind and Deaf, the team came up with a set of tactile marks in the form of a distinct shape. The \$5 note, for example, has a triangle and the \$100 a square.

The banknotes are inscribed with lines from the national anthem. Above an image of Worrell batting are the words “We write our names on history’s page, with expectations great.” **FD**

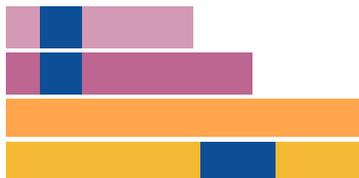
ANALISA R. BALA is on the staff of *Finance & Development*.

INTERNATIONAL MONETARY FUND

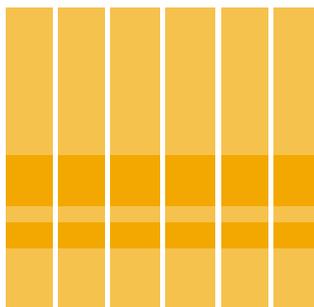


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