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Economical Development Affected by Climatic Changes

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ABSTRACT

The Fourth National Climate Assessment, published in 2018, warned that if we do not curb greenhouse gas emissions and start to adapt, climate change could seriously disrupt the U.S. economy. Warmer temperatures, sea level rise and extreme weather will damage property and critical infrastructure, impact human health and productivity, and negatively affect sectors such as agriculture, forestry, fisheries and tourism. The demand for energy will increase as power generation becomes less reliable, and water supplies will be stressed. Damage to other countries around the globe will also affect U.S. business through disruption in trade and supply chains. A recent report examined how climate change could affect 22 different sectors of the economy under two different scenarios: if global temperatures rose 2.8˚ C from pre-industrial levels by 2100, and if they increased by 4.5˚ C. The study projected that if the higher-temperature scenario prevails, climate change impacts on these 22 sectors could cost the U.S. $520 billion each year. If we can keep to 2.8˚ C, it would cost $224 billion less. In any case, the U.S. stands to suffer large economic losses due to climate change, second only to India, according to another study.

KEYWORDS: *economy, climatic, supply, development, India, temperature, health, sectors, tourism.*

Introduction

"Science advances also give us more detailed spatial information to say which assets and operations are in harm's way with climate change-for example say, just how many buildings will be inundated due to sea level rise," said climatologist Radley Horton, associate research professor at Lamont-Doherty Earth Observatory. But the indirect economic impacts may be felt long before an actual disaster.[1] "For example, it's not just whether a building is underwater or not," he said. "What's important are the harder-to-define things like when does societal risk perception shift? It may be that buildings lose their value before the water actually arrives, once people realize that eventually the water's going to arrive. We need deeper thinking about the interconnection between physical and social systems. [2]"Here are some of the many ways that climate change will likely affect our economy, both directly and indirectly. The sector most vulnerable to climate risk is agriculture. Environmental economist Geoffrey Heal, a professor in the Columbia Business School, explained that although agriculture makes up a fairly small part of the total U.S. economy, "locally these effects could be big. There are about a dozen states in the Midwest that are very dependent on agriculture and they could take quite a big hit. [3]"

They already have. Extreme rainfall events have increased 37 percent in the Midwest since the 1950s, and this year, the region has experienced above normal amounts of rain and snowmelt that have caused historic flooding. Many fields have washed away and livestock have drowned; Nebraska alone lost $440 million worth of cattle, and as of March, Iowa had suffered $1.6 billion in losses. The National Oceanic and Atmospheric Administration (NOAA) expects the coming months to bring even more flooding, which could impact our food supply. To date, farmers have only planted 67 percent of their corn crop compared to last June,[4] when they had planted 96 percent. This lost yield could cause prices for animal feed and ethanol to rise, and potentially disrupt marketplaces at home and abroad. As a result of climate change impacts, the Midwest is projected to lose up to 25 percent

of its current corn and soybean yield by future. In addition to flooding, increased heat and drought will likely reduce crop yields. According to a 2011 National Academy of Sciences report, for every degree Celsius the global thermostat rises, there will be a 5 to 15 percent decrease in overall crop production. Many commodity crops such as corn, soybean, wheat, rice, cotton, and oats do not grow well above certain temperature thresholds. In addition, crops will be affected by less availability of water and groundwater, increased pests and weeds, and fire risk. And as farmers struggle to stay afloat by finding ways to adapt to changing conditions, prices will likely increase and be passed along to consumers. [5]

Much of our society's critical infrastructure is at risk from flooding. "Sea level rise could potentially cause a loss of value of assets in the trillions of dollars-probably anywhere from two to five trillion dollars-by the end of the century," said Heal. "That's loss from damage to housing, damage to airports on the coasts, damage to docks, the railway line that runs up and down the East Coast all of which is within a few feet of sea level, damage to I-95 which runs also along the coast. And that's just the East Coast. If you take a global perspective, this is repeated around the world." Much of this infrastructure will likely need to be repaired or replaced. Military bases are also vulnerable. According to a 2016 report published by the Center for Climate and Security policy institute, sea level rise could flood parts of military bases along the East and Gulf coasts for up to three months a year as soon as 2050. Inland military installations near rivers are also vulnerable, because they can overflow with heavy precipitation, which is expected to become more common as the atmosphere warms. Extreme weather will necessitate more maintenance and repair for runways and roads, infrastructure and equipment. [6]

In addition, our communication systems will be affected. A 2018 study found that over 4,000 miles of fiber optic cable as well as data centers, traffic exchanges and termination points - the lifeblood of the global information network - are at risk from sea level rise. According to NOAA's sea level rise projections, this infrastructure could be underwater by 2033 because most of it is buried along highways and coastlines. When it was built 25 years ago, climate change was not a concern, so while the cables are water resistant, they are not waterproof. New York, Miami and Seattle and large service providers including CenturyLink, Intelliquent and AT&T are most at risk. Threats to the internet infrastructure could have huge implications for businesses in the U.S. [7]

If temperatures rise 4.5˚ C by 2090, 9,300 more people will die in American cities due to the rising heat. The annual losses associated with extreme temperature-related deaths alone are projected to be $140 billion. Increasing warmth and precipitation will also add to the risk of waterborne and foodborne diseases and allergies, and spur the proliferation of insects that spread diseases like Zika, West Nile, dengue and Lyme disease into new territories. Extreme weather and climate-related natural disasters can also exacerbate mental health issues. [8] The most vulnerable populations, such as the elderly, children, low-income communities and communities of color, will be most affected by these health impacts. Temperature extremes are also projected to cause the loss of two billion labor hours each year by 2090, resulting in $160 billion of lost wages. Because of heat exposure, productivity in the Southeast and Southern Great Plains regions is expected to decline by 3 percent, and some counties of Texas and Florida could lose more than 6 percent of labor hours each year by 2100. According to a 2014 Rhodium Group study, the largest climate change-related economic losses in the U.S. will be from lost labor productivity. Two billion dollars could be lost in winter recreation due to less snow and ice. For example, rapid warming in the Adirondack Mountains could decimate the winter activity sector, which makes up 30 percent of the local economy. In addition, as water temperatures increase, water quality could suffer due to more frequent and more intense algae blooms, which can be toxic, thus curtailing recreational water activities and freshwater fishing. More frequent and severe wildfires will worsen air quality and discourage tourism. Sea level rise could submerge small islands and coastal areas, while deforestation and its destructive impacts on

biodiversity could make some tourist destinations less attractive. [9]

Climate change and its impacts across the globe will threaten the bottom line of businesses in a variety of ways. The frequency and intensity of extreme weather, both in the U.S. and in other countries, can damage factories, supply chain operations and other infrastructure, and disrupt transport. Drought will make water more expensive, which will likely affect the cost of raw materials and production. Climate volatility may force companies to deal with uncertainty in the price of resources for production, energy transport and insurance. And some products could become obsolete or lose their market, such as equipment related to coal mining or skiing in an area that no longer has snow. Whether in the U.S. or abroad, new regulations such as carbon pricing and subsidies that favor a competitor may affect a business's bottom line. A company's reputation could also suffer if it's seen as doing something that hurts the environment. And investors and stakeholders are increasingly worried about the potential for "stranded assets"-those that become prematurely obsolete or fall out of favor, and must be recorded as a loss, such as fossil fuels that many believe should stay in the ground or real estate in a newly designated flood plain. In 2018, the Carbon Disclosure Project asked more than 7,000 companies to assess their financial risks from climate change.[10] The CDP found that, unless they took preemptive measures, 215 of the world's 500 biggest companies could lose an estimated one trillion dollars due to climate change, beginning within five years. For example, Alphabet (Google's parent company) will likely have to deal with rising cooling costs for its data centers. Hitachi Ltd.'s suppliers in Southeast Asia could be disrupted by increased rainfall and flooding. Some companies have already been impacted by climate change-related losses. Western Digital Technologies, maker of hard disks, suffered enormous losses in 2011 after flooding in Thailand disrupted its production. PG&E became liable for fire damages and had to file for bankruptcy after its power lines sparked California's deadliest wildfire last fall. And GE cost its investors $193 billion between 2015 and 2018 because it overestimated demand for natural gas and underestimated the transition to renewable energy. "The movement away from fossil fuels will have a big impact which could affect banks and investment firms that have relationships with the fossil fuel industry," said Heal. "For example, the stock market value of the U.S. coal industry in 2011 was something like $37 billion. [11]Today it's about $2 billion. So anybody that lent a lot of money to the coal industry 10 years back would be in trouble. One of the things worrying those in the financial field is that this could happen to the oil and gas industry. So people who have invested in them or lent money to them are potentially at risk. "The good news is that climate change also presents business opportunities. The Carbon Disclosure Project reported that 225 of the world's 500 biggest companies believe climate change could generate over $2.1 trillion in new business prospects. There will be more opportunity in clean energy, resilient and green buildings, and energy efficiency. Hybrid and electric vehicle production and the electric public transit sector are expected to grow. Construction of green infrastructure and more resilient coastal infrastructure could create many new jobs.[12] Carbon capture and sequestration and uses of captured CO2 present opportunities, especially in light of the new 45Q federal tax credits. In addition, there are forward-thinking new businesses-witness the dramatic rise of Beyond Meat, the company selling plant-based burgers at Carl's Jr. and A&W. As the Arctic sea ice melts, new shipping lines will open up for trade, substantially cutting transport time. The warming Arctic could also offer more prospects for oil and gas drilling. Weather satellites and radar technology will be in demand to monitor extreme weather. Air conditioning and cooling products will be needed around the world. Biotech companies are developing new crops that are resistant to climate change impacts. Pharmaceutical companies expect increased demand for drugs to combat diseases such as malaria and dengue and other infectious diseases. And the market for military equipment and private security services may expand because the scarcity of resources could trigger civil unrest and conflict. [13]

Individuals need to consider the implications of climate change when choosing where to spend and invest their money. And be aware that while a particular risk may not seem to be factored into prices

yet, things could turn on a dime when the realization of risk sinks in, resulting in a massive redistribution of wealth. So it's best not to buy or move to an area near wild lands, which have a higher risk of wildfires. Don't move into a flood zone or buy real estate in an area that's vulnerable to sea level rise. And in any case, purchase flood and fire insurance, and diversify your investments. Individuals should also think about different opportunities in terms of new places that people are moving to. And, if possible, people who work outdoors in construction, agriculture or tourism should consider alternative jobs within the sector or new industries to work in. Businesses need to scrutinize their operations carefully. "There's a groundswell towards the view that any companies that fail to study their exposure to extreme weather and fail to disclose the types of vulnerabilities, including indirect ones, are going to have a hard time in the future," said Horton.[14] "Are companies looking at what's coming down the road and making strategies to deal with it? I think investors are going to demand that and the companies that don't do that are going to have trouble getting underwriting, getting infrastructure funded by the Moody's of the world, and getting insurance." He added that he's seen a change in the last three or four years in what his students are demanding and believes that young people in the future will not work for companies that are not thinking about climate change. Banks and funds need to analyze where their investments are and see if they are vulnerable to climate change. Have they invested in someone who has coastal property, or given a loan to a fossil fuel company or in agriculture operations that might be affected by climate change? Sixty-three percent of financial risk managers surveyed now believe climate change is a major concern. As a result, "The total value of funds that have integrated environmental, social and governance factors into their investment process has more than quadrupled since 2014, rising to $485 billion as of April," reported the Wall Street Journal. [15]

They should be investing in resiliency measures such as hardening infrastructure, improving water resources, building redundancy into important systems, moving people out of harm's way and improving health care services. "You want to do it before the disaster but you also need to be cognizant that the only time people will listen seems to be right after a disaster," said Horton. "Those are also the times when money's available to rebuild. "Government leaders are currently debating whether the country can afford the Green New Deal (an ambitious plan to address climate change) or something like it. The question should be, 'can we afford not to afford it?' Nobel Prize-winning economist Joseph Stiglitz, a professor at Columbia University, wrote in an op ed, "We will pay for climate breakdown one way or another, so it makes sense to spend the money now to reduce emissions rather than wait until later to pay a lot more for the consequences… It's a cliché, but it's true: An ounce of prevention is worth a pound of cure. "[16]

Discussion

This is hardly the first attempt to reconcile the climate agenda with that of economic development. The United Nations' Sustainable Development Goals are significant for defining a dual agenda where development targets for people and planet sit alongside each other in a unifying framework. [1] Much commentary focuses on the compatibility of the two agendas. A radical and specious view pits progress on climate change and economic development as strict substitutes and calls for no less than the unravelling of economic development to save the planet. [2] Cooler heads point instead to their complementarity: the critical role of economic development in supporting adaptation and the recognition that investments in the green transition will propel economies rather than sacrifice living standards. [17]

In contrast, this essay takes as its starting point that the goals and salience of economic development are immutable. The question posed here is how the quest for economic development changes in a world gripped by a changing climate. The essay argues that climate change will force three major changes: a reappraisal of the causes of and prospects for development, the rebirth of the economics of transition, and a reformulation of the problem development is trying to solve. In a final section, it

asks what these changes could mean for international security and for the community of national and global actors who set policy and strategy in this field.

Why are some countries richer or poorer than others? This is the motivating question that underpins the study of development economics.[4] A rich literature has sought to identify the "deep determinants" that best explain comparative economic performance over the long term. That search has increasingly boiled down to a focus on geography and institutions.[5] A country's geography affects its economy through multiple channels including agricultural productivity, disease vectors, and proximity to markets. A country's institutions, defined here as the rules and norms that govern society-including those imposed by external actors-affect the incentives individuals face to engage individually or collectively in productive activity.[18] Which of the two is the dominant factor cannot be definitively resolved empirically, and so it is partly a matter of opinion. Nevertheless, the majority opinion, and the weight of evidence, backs institutions.[6]

Could climate change shift the dial toward geography?[7] Recent research, focusing specifically on the effects of climate change on average temperatures, points in this direction. Temperature has been found to affect income via agricultural yields, the physical and cognitive performance of workers, demand for energy, as well as the incidence of crime, unrest, and conflict. By one account, in the second half of the twentieth century, an average temperature rise of 1°C in a given country and year caused per capita income to fall by, on average, 1.4 percent. [8] Critically, the effect persisted once the temperature shock was over, thus affecting a country's economic performance over time.

Subsequent research has shown that the relationship between changes in temperature and income is nonlinear. [9] Thus, while global warming could spell greater economic productivity for countries whose average annual temperatures are low, rising temperatures augur increasingly dramatic falls in productivity in countries with already warm climates. [10]

These studies suggest that future analyses on the deep determinant of economic performance could find a larger role for geography, with geography proving especially important in determining countries' economic fortunes during the current and future era of climate change. Furthermore, they indicate that economic prospects for today's poor countries will disproportionately decline, since those countries, on average, begin with higher temperatures and are forecast to record especially large increases in temperature [11]

Climate change's impact on economic performance will not be limited to its effect on average temperatures. Other extreme weather events such as droughts and fires, as well as sea level changes, seem just as, if not more, relevant.[12] One way to think about these effects is to consider how extreme weather events will shape "growth episodes." Economic performance in the medium to long term is episodic in nature for all but the richest countries that remain at the technology frontier.[13] Virtually all countries have experienced periods of rapid economic growth and periods of dismal growth. Comparative performance is explained by the superior ability of some countries to sustain growth; poor countries have a greater propensity to reverse.[14] In other words, shocks, and how they are managed, play a large part in explaining comparative economic performance.[19]

If climate change augurs a world of more frequent and intense shocks, sustained episodes of fast economic growth-so-called growth miracles-will become harder to pull off. The result will be fewer poor countries succeeding in converging on rich country income levels, compared to a world without climate change. This comes at a time when convergence has become more commonplace since the start of the twenty-first century.[15]

Dimmer prospects for economic convergence are exacerbated by the weak institutions that characterize today's poorest countries. Institutional weakness is associated with deeper growth decelerations, which implies that poor countries face a harder road to recovery after any given shock.[16]

One countervailing factor that could raise the economic fortunes of poor countries is the longer-term possibility of ubiquitous and abundant energy, on the assumption that the marginal cost of renewable electric power continues to fall. This would drive down the cost of business in poor economies, not to mention materially improving the lives of their people. Such an outcome hinges on investments in renewable infrastructure and access to renewable technology by developing countries.[20]

Every country today faces the challenge of undertaking a green transition: the switch to a zero-carbon economy with its far-reaching consequences and demands on land, planning, infrastructure, investment, technology, jobs, and social justice. The attendant disruption will play out over the next decades, in addition to the disruptive effects of a changing climate. For a minority of countries whose economies are organized around fossil fuel extraction, a more fundamental overhaul beckons. There are twenty-one economies for whom coal, petroleum, and natural gas account for a majority of merchandise exports; in six of these countries, fossil fuels represent more than 90 percent of those exports.[17] Even in a world where some nonrenewable energy generation continues, the economic models of these countries will require reinvention. This will emerge as a central project for economic development in the years ahead. Here, the economics of transition, which describes the metamorphosis of dozens of economies from a centrally planned to a market-based system in the late twentieth century, offers both a partial analogy and playbook.[20]

Central to that analogy is the anticipation of a drastic drop in income. For countries from the former Soviet Union, economic contractions ranged from 10 to 50 percent in the initial years of transition, marking a period of painful adjustment with social, political, and psychological dimensions.[18] Reductions in output of a similar order of magnitude can be expected for the twenty-one fossil fuel–export economies, though spread over a longer time horizon.

Fossil fuel exporters can also be expected to undertake some of the same reforms required of transition economies. This includes redefining the role of the state in the economy, from serving as a source of growth and rent capture via state-owned enterprises to an enabling role that embraces greater liberalization, including through the removal of price controls and subsidies connected to the energy sector. Among the fossil fuel-exporting economies, an average of 3 percent of annual income is devoted to pretax subsidies for fuel, compared to under 1 percent in all other countries; in Libya, that share is an astonishing 17.5 percent. [19] Taken together with the anticipated drop in income, these reforms signify the need to recalibrate the social floor to an affordable level and redefine the social contract. [21]

Such reforms are hardly straightforward. Indeed, the process of economic transition proved to be a humbling experience for the economic profession. [20] The prevailing wisdom that faster policy adjustment was better has been challenged by the relative success of more gradual reforms in East Asia, in contrast to the Big Bang approach advocated and adopted in Eastern Europe. The slow recovery from transition in many countries has prompted analysts to place greater emphasis on the importance of forging institutions to support economic development-though the absence of a practical set of policies to support institution-building is telling. The impending transition for fossil fuel exporters is likely to entail a similarly daunting and poorly signposted course.

As fossil fuel exporters reduce their reliance on nonrenewable natural resources to spur their economies and generate export revenue, a new generation of countries are poised to take their place: those endowed with significant natural wealth in the precious minerals and metals that are central to renewable energy production, transmission, and storage.[21] How should we assess their prospects in the green transition?

Extractive industries present irresistible opportunities for generating income as well as inescapable tests of governance. The stakes are heightened when the natural resource in question is easily transported and truly scarce and so is capable of yielding large economic rents, as has been the case

for oil. Such resources can translate into vast geo-economic power or leave countries stricken by the resource curse. [22]

On the surface, this would appear to characterize many of the metals and minerals involved in renewable energy as the green transition intensifies. The production of several such metals and minerals is more geographically concentrated than fossil fuels, and in many cases, proven reserves are insufficient to meet forecast demands under a net zero global economy. [22]

On closer inspection, however, a different picture emerges. There are multiple technological pathways open to the generation and storage of renewable energy, which should allow some substitution between one natural resource and another. In the case of rare earth metals at least, geographical concentration does not reflect genuine scarcity but rather the limited commercial interest in extraction and processing. In addition, minerals and metals are recyclable, unlike fossil fuels. On this basis, natural resource wealth in precious minerals and metals is unlikely to play a determining role in the future fortunes of developing economies-or exert the same economic power that oil wealth does today. [23]

The past three decades represent an era of historic development progress. That progress is commonly illustrated by the changing share of the world population living in extreme poverty, which has emerged as a universal measure and proxy of global economic development. This indicator stood at 38 percent in 1990 and has since fallen to a mere 8 percent. [24]

The above sections suggest that climate change will act as a brake on economic development-but that does not mean that the pattern of global poverty reduction is destined to end.

While climate change may reduce economic output in poor countries, this effect is measured against the counterfactual of a world without climate change; other factors could outweigh the impact of climate change so that the net effect remains one of ongoing economic progress. Moreover, we may be arriving at a structural juncture that challenges this inference. [24]

Climate change augurs a fundamental evolution in what is understood as the core challenge of economic development. Historically, that challenge was one of deprivation. Households, communities, or governments lacked the resources they required to meet people's basic needs and enable them to thrive. Today, the challenge is increasingly one of insecurity. In an era where shocks, whether localized or global in scope, have become more frequent and intense, households, communities, and governments lack the means to protect themselves and the resources they've accumulated.

Results

We see some evidence of this changeover in divergent-and seemingly incongruous-trends, as climate change takes effect. Over the last decade, the share of people in the world living in extreme poverty has continued to fall, albeit at a slower rate than in the prior two decades. Meanwhile, the shares of people facing severe food insecurity-that is, having run out of food or been forced to go without meals for a day or more-and requiring life-saving humanitarian support have both been trending up. Since 2018, the share of people facing severe food insecurity has exceeded the share living under the global poverty line. [25]

Deprivation and insecurity are, of course, linked. A significant share of the world's extreme poverty is understood to be a transient phenomenon; in Africa, transient poverty is 50 percent more common than chronic poverty.[25] In 2010, 97 million people-equivalent to 1.4 percent of the world's population-were estimated to have been thrown into extreme poverty by out-of-pocket health spending alone.[26] Indeed, the number of people that will remain in extreme poverty in 2030 is forecast to be 32 to 132 million higher as a result of climate change.[27]

However, the impact of climate change on poverty may turn out to be one of its less salient features- and quantifying this impact shouldn't be necessary to validate the importance of climate change in understanding economic development. Rather, the emergence of climate change should force a reassessment of what indicators we rely on to capture development progress and what policies are prioritized to promote it.

The preceding sections describe how climate change will alter the pursuit of economic development in poor countries. These changes have ramifications far beyond both poor countries themselves and the field of global development. Below are seven hypotheses describing possible implications for international security. These are intended to provoke discussion rather than to be conclusive, but they point both to the breadth of these effects and their relevance to the international security community. [26]

- A growing sense of grievance among the world's poor countries, pitting the winners and losers of climate change against each other. This could include the re-emergence of the Non-Aligned Movement and Group of 77 as prominent factions in the multilateral system.
- Increased salience of failed states that are deemed incapable of development as a result of climate change and thus impervious to foreign investment. Failed states act as an overlapping source of global instability with climate change. [25]
- Spheres of global risk defined more prominently by geography. Strategies for managing risk will have to respond accordingly, with greater emphasis put on weather patterns and linkages drawn across national borders.
- Instability in economies whose exports are dominated by fossil fuels. The green transition in these countries should be expected to generate economic, political, and social upheaval, with effects potentially reverberating beyond national borders. [26]

Conclusions

Power derived less from control of natural resources and potentially more from control of transmission routes for renewable energy and intellectual property of green technology. Norms regarding the use of green intellectual property are not set in stone and will determine whether such power is manifested or not. More regular deployment of national and international security forces to assist communities affecting by crises. The normalization of post-disaster reconstruction, alongside humanitarian relief operations, will place greater demands on security forces and make their work more visible to civilians. Increasing application of methods and tools (such as scenario planning and risk management) drawn from the security field into economic planning and global development. This has the promise of bringing greater alignment between the two policy communities. [27]

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