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The Economic Theory Behind the Global Climate Change

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Abstract

This article touches on several polarising subjects in the world environmental crisis. The author attempts to classify the main ideas that can have the same venomous level of disagreements, such as the issue of climate change or global warming. The argument is supported by a healthy majority of people who work in the field with a vocal minority of dissenters as well. The article starts with models about economic growth and the energy industry and how those interact to produce carbon emissions. The author tries to analyse models of how carbon emissions affect climate. Finally, the article outlays the models of how climate affects economic output and health projecting into the future. The research concludes by adding some additional models of how policy changes might affect all of this.

Keywords: greenhouse gas emissions, global climate goals, decarbonisation, global warming scenarios, green economy and investment, cost and benefit analysis of investments in the green economy, zero discount rate.
JEL Classification: F37

1. Introduction

Just to set the stage in advance what sorts of reaction we usually get when speaking on this subject. One group will come up and say mournfully or angrily that they are so sorry to see an otherwise sensible person by all the hype by greenhouse gas warming; when reasonable people all know it is a scam rather than environmentalists using it as an excuse to implement their anti-consumption and anti-growth agenda. The other group will come up and say mournfully or angrily that they are so sorry to see an otherwise sensible person raising questions about whether greenhouse gas warming is really a looming disaster. Because we all know that if we do not slash global carbon emissions right away, the level of the ocean will rise by 20 feet and the world economy will be destroyed by raging hurricanes and extreme weather. Therefore, the article is just going to brace itself against both of these sets of reactions and proceed by talking about the scientific argument for climate change (Boddin, Stähler, 2018).

The basic notion of the global climate change is that sunlight comes down, and it hits the Earth. Some of the sunlight is absorbed into the Earth as heat. Some are reflected or radiated back into space. If the amount being radiated back into space is reduced, then the Earth will tend to get warmer. Some gases absorb outward infrared radiation. Carbon dioxide is the most prominent of these gases. Others include methane, nitrous oxide and various chlorofluorocarbons. You can see around the Solar System. What happens when you get different build-ups of these kinds of gases? The Planet Venus, for example, has so much greenhouse-gas atmosphere that water cannot exist as a liquid on the planet. So, there is steam instead. Mars has so little greenhouse atmosphere that water cannot exist as a liquid on Mars. And if water does exist on Mars, it would be frozen. Earth is the godly luck's planet, not too little, not too much, just the right amount of these various greenhouse gases. Thomas Schelling, a Nobel laureate economist, who spent recent years in Maryland, has pointed out that the

science of greenhouse-gas warming really is not about greenhouses. The way actual greenhouse gases work, as Shelling points out, is they trap air that is warmed by contact with the ground, which is heated by the sun. In other words, greenhouses have nothing to do with carbon dioxide. A better illustration, Schelling has pointed out, is that citrus growers and wine growers use smudge pots, i.e. little pots that burn crude oil. When temperatures drop down in a way that would threaten their crop of grapes or another citrus, it is not the heat from the smudge pots that matters. Instead, on a still night, the pots produce a blanket of carbon dioxide that captures some of the heat radiating from the ground and thus keeps the fruit from freezing. However, the smudge-pot effect does not nearly have the public relations sing that climate change or global warming does. It is probably a two-way point than an alternative name to stick (Beetsma, Giuliodori, De Jong, Widijanto, 2016).

2. International Programs Aimed at Preventing Climate Change

The most prominent international organisation involved with the climate change issue is the Intergovernmental Panel on Climate Change (or the IPCC). The IPCC is in the news a lot both for its reports and because it won a Nobel Peace Prize back in 2007. The IPCC was set up by two organisations: The World Meteorological Organisation and the United Nations Environment Programme. With these parents, it is maybe fair to say the Organisation is a little conflicted. It describes itself as a quote "scientific intergovernmental body", which is a little bit like saying a very musical manufacturing plant. The two parts do not always go together all that well. The IPCC does a lot of scientists working with it, and it does have big meetings every few years with lots of government representatives present to hear all the reports that are produced (Cohen, 2012).

Sometimes worries leak out that their reports are tinkered with a little bit around the edges to suit the governments in one way or another. The middle range IPCC estimate based on various assumptions about economic growth, emissions, and climate is that world temperatures are right now on line to rise by 2.8 ˚C by the year 2100. If this happens, a lot of possible changes will result. There would be more precipitation at high latitudes, for example, less precipitation at tropical areas. There could be melting snow and sea ice. There could be extreme weather like more heatwaves, more droughts, more tropical cyclones. All of these weather patterns would involve costs, involving agricultural production, the potential cost to health, water supplies and coastal protection as well. The economic losses from this mid-range estimate of warming are smaller than maybe you might expect, at least for the world as a whole. The standard estimates are that 3 degrees of warming by 2100 could lead to a fall in world GDP of 3% at that point (De Haas, Horen, 2011). The reason that is so small is that warming helps some areas of the world but hurts others.

For example, it looks likely that say, Russia, North America and China could benefit from global warming as their climates became a little warmer while, say, Africa, Latin America, South Asia and Western Europe would probably suffer from global warming (Johnson, 2013). Also, a lot of the world economy just is not all that dependent on temperature and precipitation one way or the other, so, it is not strongly affected by the possibility of climate change. Because scientists take the lead in writing these IPCC reports, they acknowledge as scientific professionals that there is a range of uncertainty here. Temperatures could rise more or less than the middle of the estimate. Say, the range often cited is from 1.8 degrees up to 4 degrees Celsius by the year 2100. At the upper end you get a much greater risk of some difficult to describe extreme changes in weather, say, like change in circulation patterns in the Atlantic Ocean and cooling off Europe or a shift in monsoon patterns of South Asia, or perhaps melting the West Antarctic ice sheet in a way that could raise ocean levels around the world (Kadayan, 2014).

Standard estimates, the middle-level estimates are sort of an average. They assume in a way that the very worst outcomes are not going to happen, but if some of the more extreme events do occur, or say, if the weather helps facilitate the spread of disease, the costs of global warming and climate change could get much

higher in a hurry. It is fair to say, though, that for some analysts the main worry about global warming is not the mid-range scenario which can be dealt with in various ways, but it is hard to evaluate the risk of extremely high-costs scenarios. The costs of global warming rise over time as the extent of global warming increases. For example, one projection found that the costs of global warming would be something like 1 per cent of world GDP by 2050, then up to about 3 per cent of world GDP by 2100, rising to 13 per cent of world GDP by 2200 as the warming continued overtime (Dorrucci, McKay, 2011). Clearly, there is a lot of uncertainty in these kinds of discussions of what could happen with climate change. It might be the best we can do right now, but to put it mildly, it is some wiggle in these kinds of numbers. It is easy to find scientists on one side who argue that the IPCC forecasts are too mild and have been watered down to some extent by governments. It is easy to find scientists who claim the IPCC forecast are overstated and have been hyped up to some extent by governments.

The conclusion from all this controversy is the extent of uncertainty is probably understated. In other words, things could be better than the best IPCC scenario. It could be worse than the worst as well. A considerable number of climate scientists do believe that global warming is a real and dangerous phenomenon. A smaller minority disagrees. Maybe the tiny minority will eventually turn out to be right. It would not be the first time that a small minority turned out to be correct. But when the bulk of experts in a certain area believes something, it is wise to assume that there is at least some probability that the majority is correct. We can quarrel over that probability that they are right is 99% or 90% or 50% (Gourinchas, Obstfeld, 2012). But how one can reasonably say that there is zero probability that the majority of experts are correct about something. They probably are on to something. When there is a risk of something wrong happening, the standard economic response is to think about whether it is possible to buy insurance. In fact, policies about global warming are a kind of insurance. Just as you pay for insurance on your home or your car, and you hope the wrong thing does not happen or is not as bad as you feared. We need to think about what kind of insurance does it make sense to buy for global warming, in a public policy sense and of course we will hope that the wrong thing does not happen or is not as bad as we had feared. Of course, to makes sensible decisions about the insurance, you have to decide how bad is the risk, and how much insurance it makes sense to buy. It does not mean, of course, you purchase vast amounts of insurance against relatively small risks. But taking out zero-insurance is not usually a sensible approach if you confronted with risks that are real.

Evaluating the problem of climate change involves some difficult questions about how to value costs and benefits. Let us first talk about the general problem of how policy might deal with events that have maybe a relatively low probability of happening like some of the worst outcomes of climate change. Still, if they do occur, they have a very high cost. The underlying approach here following the standard IPCC estimates is to say the most likely scenario for climate change right now is one of moderate warming with moderate costs. We would deal with this with some combination of moderate strategies, a mix of, say, reducing energy usage and paying to mitigate some of the other problems that arise like flooding or changes in agricultural yields as they happen. If it is a middle-range problem, it is not a world-changing problem. But the IPCC evidence also suggests there is some lower probability chance that the most likely scenario is not what happens. There will be either very warming or very high costs resulting from moderate warming (Khan, Zhao, Zhang, Yang, Haroon, Jahanger, 2020).

3. The Catastrophic Scenario and Mega Risks in Global Climate Change

Much of the concern over climate change is not about the moderate scenario. It is about the risk if something perhaps less likely, but very, very bad happening. How do we think about these kinds of risks? Richard Posner, who is a Federal Judge and Law Professor of the University of Chicago, is well-known among economists for his writings in the area of law and economics, posed this question back in 2004 in a book called Catastrophe. It was about how you should respond to low risk,

high-cost events. He includes global warming as being in this category. He also uses the useful law-professor approach of trying out some other examples to draw out our intuition on the overall issues here. For example, what is a chance of a large asteroid hitting the globe in the next one hundred years? Maybe there is one chance in a hundred million of say 1.5 billion people dying. Small chance — large lousy outcome if it does happen. What about a chance of a severe bio-terrorist attack? Say, there is one chance in a hundred thousand that an attack like that will kill 100 million Americans at some point in the next one hundred years (Lane, Milesi-Ferretti, 2011).

What is the appropriate policy response to lower probability, high-cost events? Of course, one might make some generic statements here. If the probability of the event gets bigger, you should spend more to avoid it. If the probability is smaller — then spend less. If the potential cost is more significant — you spend more to avoid it. If the potential cost is smaller — you should spend less. You can also note that people are often not very good at thinking about these kinds of low-probability risks. People tend to either overspend because they base all their actions on the fear of the immense possible loss or else they brush it aside, and they spend nothing because they say there is not very much chance it is going to happen. A more rational approach has to balance these two possibilities, search for ways to reduce the mega risk because it is so big, but not try to eliminate all risk because there is a relatively low chance of that lower of the worst outcome happening. So, stick to relatively low-cost approaches in the present, but build up overtime.

For example, what one might do if one took the asteroid risk seriously? One might start an agency, for example, that would formulate a plan for disrupting the flight of an asteroid, who would begin early monitoring of possible asteroids so that we would know their coming sooner. Eventually, the goal of this agency would be to act in the time that we have available for early warming if we knew an asteroid was likely to hit. We might also have that agency think what steps the globe would take if an asteroid were on its way. They could produce an annual report for what concrete steps we might take for dealing with the aftereffects. These policies might have useful spinoffs. Monitoring asteroids might well have some scientific benefits. Emergency plans for an asteroid strike might also be helpful if, say, a significant tidal wave or an earthquake or a volcanic eruption occur. Notice this plan does not eliminate the risk of a massive asteroid strike. Maybe, instead of its being something that is one in a hundred million of happening, we could perhaps do something that would make it be one in a billion instead. Or instead of something that would cause 1.5 billion people to die, maybe only a hundred million people would die in the asteroid hit. But the risk does not go away.

One needs to balance the reduction in risk against the costs during occurring. In the realm of climate change and global warming, we need a sense of these catastrophe scenarios in this way. We need to do something to think about them. But nothing is particularly gained by making a really broad claim that most scientists agree the catastrophes are near-term and high probability. That is not what the IPCC reports say. Most scientists do agree that global warming is a real problem with high costs that extend off to the future. But that is very different from believing that it is a high-probability catastrophe just about to happen. So, the broad approach would be to balance the costs of action with reductions in risk and reductions in harm.

The costs of dealing with climate change are incurred relatively close to the present. The benefits are much further off in the future. In fact, the benefits might be hundreds of years into the future. One prominent report on climate change that came out in 2006 by very eminent British economist named Nicholas Stern estimated that climate change would reduce world GDP by an average of 1% per year over the next century. Still, the total loss overtime would be equal to 14 per cent of world GDP. How do you get from 1 per cent average over the next century to 14 per cent average overtime? (Milesi-Ferretti, Tille, 2011). It turns out when you look at Stern's calculations more closely that half of the losses he suggests will happen from climate change happen after the year 2800. It is eight centuries from now. So, yes, you ask yourself a question, if we are going to have costs of reducing carbon emissions right now and ask

if it is worth the benefits, should we be paying to benefits that are more than eight hundred years off in the future? While you definitely want to count benefits in the future, the further off the benefits are in the future, the less you want to count them. In other words, benefits that arrive next year or in a decade should be calculated as worth more than benefits that come several centuries off in the future. A lot of non-economists do not like doing this. How can you say life in the future is worth less than a life in the present? All lives are equal. You can hear the rhetoric. Other people say we just do not want to mess up the environment, not now, not ever. It does not matter to meet the timeline, or how of the future is. That view is something that people might not believe if they thought about it more closely. Do you want to place the same value on someone who lives three generations from now or fifty generations from now as you place on someone alive today? There are so many future generations out there. Is it really the problem of this generation to pay for every possible action that might affect the entire future of the human race? Sure, maybe we have a responsibility to start in the right direction. But do not they have some responsibilities too? After all, the odds are good that people in the future will have vastly better energy technology, considerably better health care, vastly longer lives and a higher standard of living. Should not they have some responsibility as well?

There is a funny line attributed to Groucho Marx. He says, why should you care about posterity? What has posterity ever done to us? Economists would say that Groucho ignores the future. He is discounting future benefits at a very, very high rate. But ignoring the difference between the near-term and the future does not make sense either. The amount by which you count the future less than the present is what economists call the discount rate. If you ignore the difference between the present and the future, basically you are saying your discount rate, the amount you discount the future is zero. As a result, anything happening eight centuries from now should count just as much to you as something happening this week. If you think this sounds a little crazy, you do not believe the discount rate ought to be zero. We can argue what the discount rate ought to be — 1 per cent a year, 2 per cent a year, but saying it should be zero is a very extreme choice (Obstfeld, 2011).

Let's use a calculation that is due to the eminent economist William Nordhaus at Yale University. Suppose, hypothetically, we discovered that all the costs of global warming would happen after the year 2200, and more specifically, suppose that after 2200, there is a 90 per cent chance nothing occurs as a result of global warming. Still, there is a 10 per cent chance that incomes for all the rest of the human future will fall by 0.1 per cent per year (Ostry, 2012). If you use a zero discount rate for the future, so that 10% chance of a 0.1 per cent fall as equally as bad that happens today, it would be worth paying something like 4 trillion dollars right now in the present to avoid the risk of something happening off in the future, even though it is only a 10 per cent chance if it is happening at all, even though it is only after the year 2200, because if you lose 0.1 per cent a year for the entire future of human history and you do not discount the future, that adds up to a lot of money over the millennia (Patil, Kulkarni, 2011). Here is another hypothetical. Imagine two policy actions can reduce climate change. They have equal cost. Let us say one of them saves ten thousand lives in ten years. Another saves eleven thousand lives, but only after 800 years. You need to choose which one to focus on. Save 10,000 lives of people currently alive, or save 11,000 lives of our descendants maybe thirty generations into the future.

Given those specific numbers, people would choose the present, because they place a higher value on the present lives than they do on those in the distant, distant future. Those who favour action on climate change tend to choose low discount rates for the future because it makes the benefits in the future look so prominent in the present. But it is worth thinking about where this logic goes if you really follow it out. For example, what happens, if someone says they fear nuclear proliferation or weapons of mass destruction? Some will argue that if we let this spread, then fifty or a hundred or two hundred years from now, we might have a devastating war. Suppose there is no discount in the future. In that case, we need to treat the future costs of that devastating war two hun-

dred years in the future as if they are happening right now, and that could easily just favour cost of short-term war right now, because of that risk of some catastrophe, many decades or many centuries in the future. Or put it another way, given the many social problems — health, education, nutrition in the US and around the world, would you favour a crash multi-trillion-dollar worldwide programme for dealing with the chance of an asteroid hitting a few centuries from now? If you do not discount the future, you pretty much have to say, well, asteroids can happen, see it some time, it might be 10,000 years, it might be 500,000 years. But with no discounting for the future, we need to face 100 per cent of those costs right now (Reinhart, Rogoff, 2011).

A zero-discount rate has a natural effect that makes it very important to deal right now with big problems that could be away off in the future. Almost any positive discount rate — 1, 2, 3 per cent a year — means that you end up just not worrying too much about anything that is several hundred years off in the future. What discount rate you choose is probably more important for your thinking about climate change policy. Then all the rest of the uncertainty in the economic and meteorological models about costs and benefits put together (Rousseau, Wachtel, 2011).

Another difficulty is climate and its effect on technological progress. A tropical climate tends to have certain economic consequences. Look around the world. Poverty is in general, pretty close to the equator. Wealthier nations tend to be further away from the equator with, of course, a few exceptions. Even within Africa, the high-income countries are the southern ones like South Africa. If you look in South America, the high-income countries Argentina and Chile are far to the South. Because there are high temperatures at the equator in Africa, people tend to live away from the coast where would be hot and up in the mountains and highlands, which, of course, made transformation costs for products even more stringent.

In an equatorial zone there tends to be less food production. A temperate climate with winter has various advantages over a tropical climate. Winter kills bugs and pests. It breaks up the soil. It helps to fertilise the soil. A cycle of freeze and melt and water flow makes the soil much more fertile. Plants tend to grow better when it is warm in the day and cool at night, not when it is warm in the day and the night. Areas that are right in the equator tend to have lower overall rainfall, especially in coastal regions and greater heat. The summer in temperate areas actually has longer days. The days get longer and shorter. In the winter, the days are shorter. But around the equator, all the days are roughly the same length. And that does not actually help growth very much. Around the equator there tend to be seasons of weighty rains and parched weather which tends to bleach out the soil. So, there are a lot of reasons why crops do not grow as well around the equator as they would in more temperate areas (Salisu, Akanni, 2020).

4. Global Reform of Agriculture

One last big area to talk about is a reform of agriculture. Agriculture is still the primary sector of output in most emerging economies. At the end of the 20th century, something like three-quarters of Africans earned a living in the agricultural sector, and they produced something like one-third of GDP. In a way, this is a sort of a pattern you expect that in very low-income countries at a much earlier stage of development. Here is a quick overview of a key fact. For most of the last three to four decades, the difficulty was that farmers in Africa did not earn very much. They did not earn very much partly because the price of food was low and falling overtime and partly because the governments in these countries often put price controls on food to keep the city dwellers who bought the food happily. With all those people working in farming are not earning much, maybe the fundamental problem about farming in Africa was it did not generate enough income. Farmers had to make a subsistence living. Staring in 2005 or 2006, and on for several years after that, the price of food rose dramatically all over the world. As a result, many farmers in Africa were getting a lot more income than ever before. The new problem is that the urban poor and countries that need to import food are having to pay a lot more in terms of higher food prices. So, the main problem for African

agriculture used to be low prices leading to low incomes for farmers. Now the question is high prices leading to a lack of affordability for food. Economists are always unhappy about something. From the long-run economic view, the story with agriculture is simple enough. Africa needs to get productivity up in agriculture. That will raise incomes. That will generate more food, and it will start the process of sectoral adjustment, where the country does not need as any farmers, and those folks can begin to work in manufacturing or services instead (Kasekende, Brixova, Ndikumana, 2010). There are a lot of technologies available to move beyond home technology or peddle power or animal fertiliser. However, a lot of research needs to be done on crops for African climates. There need to be more irrigation projects run and maintained by farmers. And it could also use a little more rural infrastructure like roads and electricity. Many African nations have made their gains in education and health, but there is a lot more to do. There are state-owned companies to be privatised.

Pollution, of course, is a real problem, but it is also a problem that can be addressed at some cost. For example, air and water pollution in the United States and Europe have in general been getting cleaner for several decades now. Apparently, an advanced high-income economy can afford to pay for lower pollution overtime. The big exception here is the risk of carbon dioxide emissions, and some other gases lead to climate change. There are conversations about fossil fuels and climate change, and someone says the world is just about to run out of oil and fossil fuels. Maybe in a few decades. And then about three sentences later, they worry about climate change, which is based on burning fossil fuels at rising rates, not only through the 21st century but for centuries beyond that. What is weird, of course, is that one worry is about running a fossil fuel in a few decades and the other is about burning it for centuries into the future. You cannot believe in both of these. If we are about to run out of fossil fuels, well, it really will help a lot with global warming. And if we are supposed to worry about climate change, because we are burning fossil fuels all through next century and the centuries to come, it is pretty clear that we ought not to worry about actually running out (Tripathi, Kaur, 2020).

The other significant source of demand for food products is bio-fuels. A bio-fuel is something like ethanol, a fuel that is made from farm products and then can be used as a partial or a complete substitute for gasoline. Ethanol is the most common biofuel in the US made from corn typically added to gasoline. Biodiesel which is made from corn and also from oilseed is the major biofuel in the European Union. In major high-income agricultural countries, about 20 to 50% of the production of corn and oilseed are actually going to make biofuels. In the US, for example, about one-quarter of the corn crop toward the tail-end of the first decade of the 21st century is now going to ethanol, and that share is rising over time. In 2005, actually, the US overtook Brazil as the leading producer of ethanol around the world. In the last few years, both the US and Europe have put billions of dollars of subsidies in place so that they could meet aggressive goals for increasing production of biofuels. In the late 2000s, the US incentives were worth about 7 billion dollars a year (Vayanos, Woolley, 2013). It is just an enormous change in food markets.

The promise of biofuels was two-fold. One was that it would be a substitute for oil and help reduce oil imports. The other was an environmental promise that it might reduce pollution and particularly greenhouse gas emissions. Roughly speaking, the image of biofuels was something like this. First, you grow the crops. And in growing the crops, they absorb carbon dioxide. You turn those crops into fuel. When you burn the fuel, you create carbon dioxide, but then when you grow the crops, you absorb it back into the crops again. It is kind of a mental image, but it does not quite hold true. After all, it takes energy to grow corn in modern agriculture. It takes oil-based fertiliser. It takes tractors. It takes energy to turn corn into ethanol. It takes energy to transport it. And it starts clearing extra land to grow crops for biofuels that carbon from clearing that land gets released into the air as well.

Agriculture also has several environmental costs like high chemical use or runoff going into streams and rivers. Moreover, ethanol does not have a mile per gallon that is good as pe-

troleum. So, you need more gallons when you are driving with ethanol. At the end of the day the study suggests that if you take corn-based ethanol and you displace a gallon of gasoline, it saves maybe 10% of the gasoline you displace. The other 90 per cent went into making the ethanol. Depending on whether the additional land was cleared, this is or awash for greenhouse warming, or it could in some cases even make the climate change the issues somewhat worse. There is also a very modest gain on oil here. If you used 100 per cent of US corn crop for ethanol, it would replace less than 15 per cent of the total fuel that is used for transportation in the country. And there is the very modest gain if at all in terms of climate change (Yu, 2014). However, turning to biofuels is a major contributor to higher food prices around the world and thus to undernourishment and hunger all over the world. There is one World Bank estimate which says that the amount of grain you need to produce enough ethanol to fill the gas tank of a typical sport utility vehicle is actually enough grain to feed a person in a low-income country for an entire year, so the next time you fill your tank with an ethanol mix feeling all good about yourself, you need to sort of mould that fact over. The criticism of biofuels here is really focused on corn-based ethanol and to some extent on oilseed used for biodiesel. It is just not the best crops for producing ethanol.

In Brazil, they have been making ethanol for a lot of time out of sugar. Sugar turns out to be a considerably better pay-off in terms of gas savings, and also better in producing carbon emissions. Nevertheless, pushed by aggressive legislative targets for biofuels in the US and Europe and lots of political pressure from farm producers, it seems pretty much clear that at least for a few years, biofuels will continue putting upward pressure on food prices all around the world.

5. Recommendations for Fighting Global Climate Change

What would climate change policy look like, a sensible climate change policy? It will have several dimensions. It should focus on market-oriented environmental tools. It should respect the time dimension of the problem. It should have an international dimension. Let us talk about those three. For economists, environmental policies fall into two broad categories. One set of policies are called command and control, and these kinds of policies, the government, specifies how much pollution can come out of a smokestack or what can be burned in an incinerator or precisely what can be released into a stream or lake? The government says how much pollution is allowed, and sometimes it specifies the pollution control technology to be used. This approach has had some successes but it also has some weaknesses. When you set the level like that, there is no incentive for anyone to go beyond the level the government sets or to be innovative about reducing pollution further. When you choose pollution control technology, the government regulators often choose something that is few years behind the times, and more generally, detailed regulations which can precisely emit or discharge what often get watered down by politics as they are put into place. For example, it is common to say new factories have to do one thing, but the old factories are going to be a grandfather dean under a different set of rules.

A market-oriented approach takes a different angle from command and control. The idea is the government provides broad incentives that reduce pollution and then lets companies and households adapt at they see fit. One example is a pollution tax. For climate change, you can think of a tax on carbon emissions. For example, you might collect that tax from oil refineries and coal companies and others who are producing things that will turn into carbon, and they, of course, pass that tax along to households and firms. But if anyone can figure out a way to emit or create less carbon, they will pay less of the tax. Incentives to innovate exist with pollution control technology. Another market-oriented idea is called cap and trade. The notion is that the government issues permits that allow firms to emit a certain amount of pollution like permits that will enable firms to emit a certain amount of carbon or to produce products like gasoline that emit carbon.

The total number of permits puts a cap on the total amount of pollution. Then the permit might require phasing down the amount of pol-

lution over time. The twist in the cap and trade is that these permits can be bought and sold. So, if someone finds a way to reduce pollution, they could sell their permits to someone else. Again, there is an incentive to reduce pollution, and there is an incentive to go beyond the basic level and find innovative new ways of reducing pollution in the future. A carbon tax basically sets the carbon price, and then you want to conserve to avoid paying the tax. Cap and trade since a quantity limit for carbon emissions, but because you can pay for permits, there is an incentive to conserve, because the permits become costly. Carbon taxes are more flexible in the output of carbon. They set a price. Cap and trade are more flexible about the price of carbon by setting an output level for carbon. But either one of these can be seen loosely or strictly with exceptions or no exceptions, just like any other form of pollution control. Politicians often like cap and trade because they like certainty over how much of a quantity of pollution will be emitted.

They do not like that nasty word tax which is, of course, kind of silly, because a carbon tax or a cap and trade approach both will tend to lead to higher prices for things that emit carbon. Indeed, that is their purpose of getting less of those things being used. You can have various variations and combinations too, mixing together pollution taxes and cap and trade policies. It is just that either market-oriented pollution control approach will reduce pollution at a much lower cost than a command and control approach. The time dimension of the climate change problem arises in this way. We know that the costs of climate change arise in overtime. If we have market-oriented policies to address climate change, and you phase in those policy changes over time, then they will tend to stabilise carbon emissions at a more modest cost.

The International Monetary Fund published a study in 2008 that looked at the policy of the carbon tax and cap and trade to stabilise carbon emissions. They estimated that the world economy if you put in a policy like this, would be 2 per cent in 2040 than it would otherwise be. But even though the world economy would be 2 per cent in 2040 than it would otherwise be, it is still true that in 2040, the world economy 2.3 times higher than it was in 2007. Their recommendations, sort of a hypothetical proposal, went like this: They said, start with one cent a gallon gasoline tax, and then announce it is going to go up two cents a gallon every three years in the foreseeable future. Frankly, any politician who claims to be worried about global warming, but will not support a slow phase of this kind of tax strikes me as fundamentally not serious about the problem. You say we are incredibly worried global warming will destroy the planet but not for ten or seven cents a gallon tax, let us not go crazy here, which is not a serious position to take. This sort of gradual phase-in policy works best when you think about it working along with technological progress. The idea is firms will see that gradual phase-in of higher taxes coming, and they will start to increase efforts to find ways to cash in. We strictly do not know how they will reduce carbon emissions, may be greater fuel efficiency for cars and buildings and houses, possibly alternative sources of energy that produce less carbon, perhaps what is called carbon capture sequestration where the carbon is injected down into the ground, so it does not end up in the air.

6. Conclusion

The philosophy on all this is pretty much umami. None wants to talk about the possibility. Climate change does seem to pose genuine risks, even if we can argue over the likelihood of those risks. So, people are interested in any and all possible answers to it. Another big area to think about in policy is international considerations. Carbon emissions are not equal around the world. Highly developed economies like the United States and those in Western Europe have traditionally been the biggest emitters of carbon. But now China has already become the biggest emitter of carbon among all the countries of the world. While carbon emissions are rising sharply from countries like India, Russia and Brazil as well. In fact, since the early 1990s, more than half of the world carbon emissions are from the developing nations of the world. Their emissions have been growing so rapidly that they are growing three times as fast as the rate of rich countries. If you do not get countries like China or India on board to at least hold down the rate of increase in their

emissions, so they are not burning coal and oil without limit, there is no conceivable carbon policy that can actually succeed.

Maybe once it was confirmed that the high-income countries of the world could address global warming on their own, but this is not true anymore. How do you get everybody on board? An obvious common proposal is to let us have an enforceable worldwide treaty where every nation will make commitments to reduce its emissions. Scientists admit this is a political judgement, not an economic one. They just think such a treaty is unlikely. More loose agreements are possible with goals and hopes, but at the end of the day, nations tend to act in what they perceive as their self-interest. Besides, it is not really fair to ask the low-income countries to pay a massive share of the cost for climate change policy. In many of these countries, children are dying from causes like malnutrition and the lack of clean water.

You have to put a zero discount rate on the future to say your main priority should be spending money on reducing smokestack emissions to reduce the risk that is decades off in the future when that economic growth might help you save people who are dying and in poverty right now. It also seems politically unlikely to me that high-income nations are going to send, say, tens of billions of dollars to China to help China reduce its carbon emissions. Maybe that is the most cost-effective way to get emissions down the fastest, but we are not going to send the money, and the Chinese government is not going to let a bunch of US firms crawl all over factories and install a bunch of pollution control devices. What does seem conceivable is a loose set of international agreements, maybe at the regional level, say, Latin America, East Asia, US, Canada, European Union and so on. One can imagine those countries agreeing on a shared price to tax carbon across countries or on certain versions of cap and trade proposals. One can imagine sharing a lot more technology about energy conservation, alternative energy sources and pollution control. But the test of seriousness on climate change is that high-income countries have to take the lead in reducing their own emissions.

It is all about concrete commitments in the present, even if they start small and build up. Until they start talking in the United States about profound long-term ways of raising the price of energy that leads to carbon emissions and spending more money overseas for pollution control, nobody frankly does take all the rhetoric or all talk on international treaties very seriously.

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Экономическая теория глобального изменения климата

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Аннотация. Цель статьи — проанализировать противоречия в современной экономике глобального изменения среды обитания. Автор делает попытку систематизации основных положений, которые отражают наиболее острый уровень разногласий в области науки по поводу глобального потепления. Аргументы автора поддерживаются работами многих специалистов, занимающихся вопросами окружающей среды и влияния производственной деятельности человека на нее. Статья начинается с анализа моделей экономического роста и развития энергетики, их влияния на выделение углекислого газа в атмосферу. В дальнейшем анализируются факторы изменения климата в результате выбросов парниковых газов. В завершение приведен анализ моделей обратного влияния изменения климата на экономический рост, здоровье человека в будущем. Итогом исследования являются дискуссии о потенциальных моделях, посредством которых решения в области политики могут обеспечить стабилизацию проблематики глобального изменения климата.
Ключевые слова: выбросы парниковых газов; глобальные климатические цели; декарбонизация экономики; глобальные климатические сценарии; зеленая экономика и инвестиции; анализ прибыли и издержек от инвестиций в зеленую экономику; нулевая ставка дисконтирования