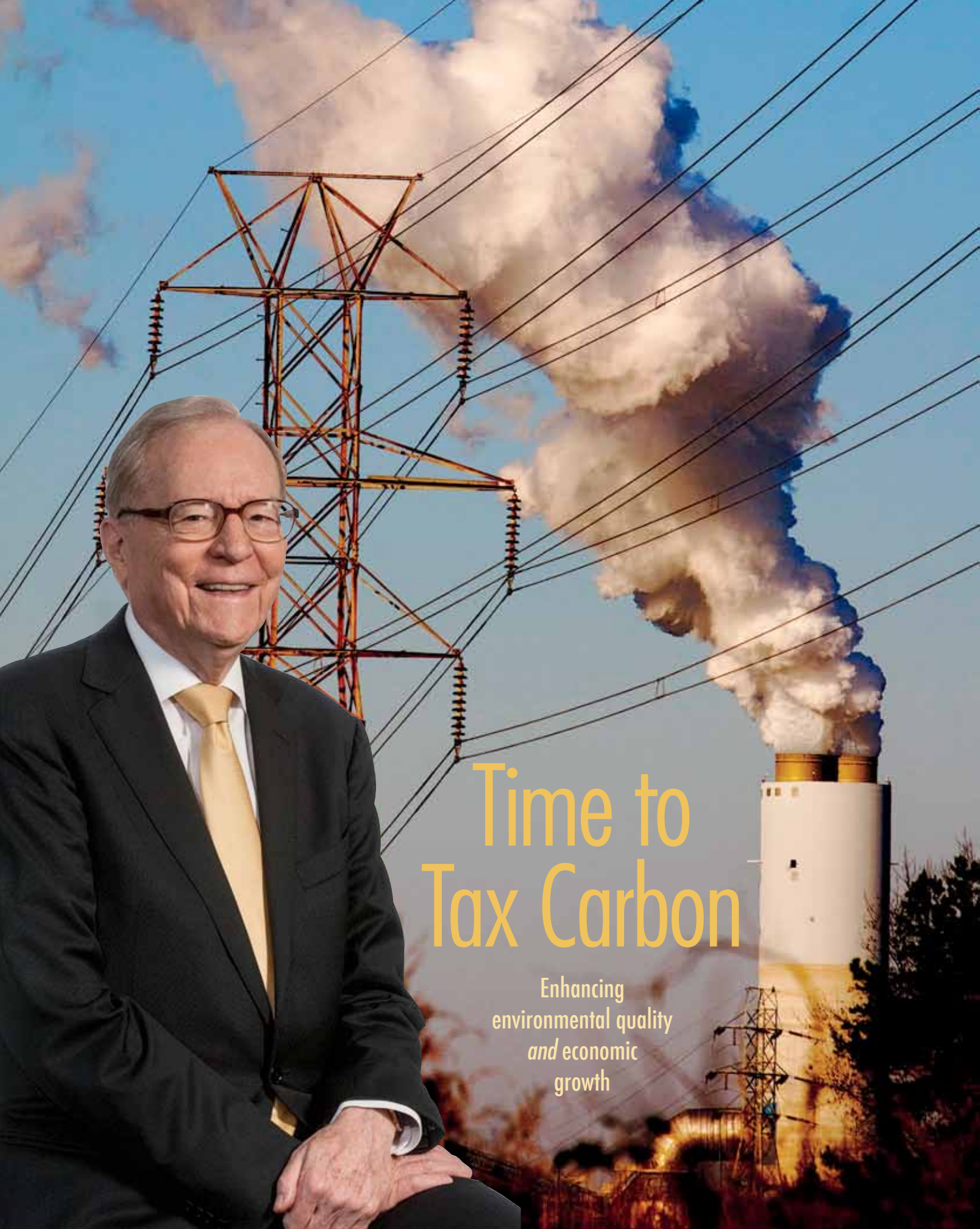

Time to Tax Carbon

Enhancing environmental quality *and* economic growth

Next year, representatives from nations around the world will meet in Paris to discuss a global climate-change agreement that would take effect in 2020. Central to those discussions will be setting a price on carbon and its equivalents—a figure that captures the social costs of releasing greenhouse gases into the atmosphere. The impacts of those emissions range from the health effects of burning fossil fuels, to inundation and adaptation of coastal cities threatened by rising seas, to extinction of plant and animal species as a consequence of rapidly changing environmental conditions. These costs amount to nearly $1.6 trillion annually worldwide, based on Yale scholars' estimates of the damages at $44 per metric ton of CO_2 and 2013 emissions of 36 billion metric tons.

As the no doubt fraught scientific and political discussion in the French capital nears, the work of Morris University Professor Dale Jorgenson, an economist known for his ability to marry theory and practice, is especially important. Jorgenson has studied the factors that drive economic growth, the relationship between energy and the environment, and the effects of tax policy on both. His 2013 book, *Double Dividend: Environmental Taxes and Fiscal Reform in the United States,* is the first to examine what would happen if revenues from a carbon tax—based on the price of carbon that will be the subject of debate in Paris—were recycled into the nation's economy. After examining four strategies for deploying the revenue from a carbon tax, Jorgenson and coauthors Richard J. Goettle of Northeastern University, Mun S. Ho, Ph.D. '89, a visiting fellow at Harvard's Institute for Quantitative Social Science, and Peter J. Wilcoxen, Ph.D. '89, of Syracuse University, found that one strategy in particular—reducing taxes on capital—leads to an *increase* in economic efficiency that improves economic well-being despite greater inequality, as well as a *decrease* in carbon emissions: the "double dividend" of the book's title. Jorgenson has also studied economic growth, energy utilization, and environmental quality in China, the world's largest emitter of carbon. There, and in other developing countries, he projects a triple dividend, because a carbon tax would also lead to major improvements in human health.

As a means of limiting greenhouse gases, a tax on the carbon content of fossil fuels competes with proposals for outright regulations (such as those advanced by the Obama administration) that would limit electric power-plant emissions, and with cap-and-trade systems that let such big polluters trade permits among themselves, always seeking the most efficient means of reducing emissions. No solution to this massive problem will make everyone happy, so the best outcome will involve striking an optimal balance. A carbon tax may do that because it raises revenue, and thus the additional possibility of redeploying those funds in ways that stimulate economic growth.

Harvard Magazine interviewed Jorgenson in June. An edited version of the conversation appears here. —*Jonathan Shaw*

Harvard Magazine: The premise of your work is that a carbon tax is a more efficient way of achieving reductions in carbon emissions than any other type of reform, such as cap-and-trade systems or new rules and regulations—like those just proposed by the Obama administration for electricity-generating power plants. Why is that?

Dale Jorgenson: The issue that surfaces when you talk about carbon taxes, that does *not* apply with cap and trade or rules and regulations, is what to do with the resulting revenue—because it is the only one that *does* generate revenue.

Cap and trade typically involves imposing a cap—a particular level of emissions or an emissions target—and then issuing permits that allow people to collectively achieve this cap by trading the permits. The question is how to allocate those permits. In legislative proposals, permits are given to existing polluters, and then the number is gradually ratcheted down to achieve a more and more stringent target.

That leaves out the possibility of generating revenue and using it to offset the impact of the tax (or the permit price, which has the same effect), which has imposed a cost on the economy. So in order to achieve the double dividend—curbing emissions while *simultaneously* achieving economic growth—you have to collect the tax and recycle the revenue. Then the question is, How do you make use of the revenue? That's the subject of *Double Dividend*. We considered a wide range of alternatives, and we ended up recommending that it be used for a capital-tax reduction.

Dale Jorgenson. Background: A coal-fired power plant, southern United States

HM: You compared four options: reducing capital-tax rates on incomes of businesses and individuals; reducing labor tax (i.e. income tax) rates on individuals; proportionally reducing both capital- and labor-tax rates; and, finally, redistributing tax revenues through lump-sum payments to individuals across the income spectrum.

Jorgenson: Yes, exactly right. The reason that reducing capital- tax rates is the most effective type of revenue recycling is that it has the effect of stimulating investment. In other words, it substitutes *capital* for the use of *energy*, as money that is returned to households and businesses in the form of lower capital taxes is used for saving and investment, rather than for expenditures on energy. The idea is to reduce the emissions from the use of energy by raising its cost. And capital, when deployed in place of energy, makes it possible in fact to *improve* the performance of the economy. That's the basic idea. You might ask, why doesn't reducing labor tax [income tax] rates do the same thing? The answer is that labor-tax reduction affects people's decisions about labor supply—when income taxes are lower, people work more and take less leisure time, and they consume more, too, while saving and investing less, and that turns out to produce a less favorable impact.

HM: Are you saying that when individual workers' income-tax rates are reduced, they increase the amount of time that they work in order to consume more? And this in turn lowers capital formation, slightly hurting savings and investment?

Jorgenson: Yes, that's right.

HM: There are probably hundreds of books on carbon taxes. What do they overlook?

Portrait by Jim Harrison. Photograph © Les Stone/Corbis Images

Jorgenson: They don't have the framework needed to analyze this issue of recycling the revenue. So that's the problem that we solved. We put a lot of effort into it.

HM: Isn't reducing capital taxes on property such as stocks somewhat regressive, with fewer benefits for people at the lower end of the income scale?

Jorgenson: Yes, that's exactly what we show. But on the other hand, the double dividend consists of a range of policies that enable you to simultaneously improve economic performance and reduce pollution. That involves separating the overall impact, which we call *welfare*, or people's overall well-being, into *efficiency* and *equity*. Taxing energy and reducing the cost of capital leads to large gains in the efficiency of the economy overall, as goods and services are produced less energy-intensively. For society as a whole, you end up with a positive impact on economic well-being because the large gain in the efficiency of the economy outweighs the increase in inequality.

HM: So because everyone gains when the economy performs better, both rich and poor would benefit on an absolute basis, but the rich would be relatively even better off?

Jorgenson: Not everyone would benefit, but higher economic growth as a result of the investment would have a positive impact on economic well-being through greater efficiency.

Taxing energy and reducing the cost of capital leads to large gains in the efficiency of the economy overall, as goods and services are produced less energy-intensively.

HM: If the U.S. economy were projected to grow 2 percent annually, adding the carbon tax and recycling revenue as you project would lead to annualized growth in GDP of 2.2 to 2.4 percent?

Jorgenson: Yes, it's a big gain.

HM: On the order of 10 to 20 percent faster growth, if annual growth in GDP were 2 percent?

Jorgenson: Right. Gross domestic product is a measure of efficiency. But it doesn't take into account equity—the differences in the way the benefits are distributed according to income, and therefore is not a measure of any particular household's overall well-being, or welfare. The impact on equity matters, therefore it's very important to consider both efficiency and welfare.

The Cost of Carbon

HM: You consider a range of carbon taxes from $10 to $50 per ton. What is the optimal price?

Jorgenson: That's a very important issue. The way economists usually approach it is to ask, "What would be the price in an international agreement where everybody in the U.S., in China, in Europe, and so on, had to pay the same price to mitigate carbon pollution?"

The answer has been worked out in great detail by many economists, but probably the most prominent is [William D.] Bill Nordhaus, [Sterling professor of economics] at Yale. He comes up with a price of about $30, right in the middle of the range of prices that we've considered.

That's optimal for trading off carbon emissions against the growth of the world economy. In other words, this level of taxation leads to a significant reduction in carbon pollution, without imposing too high a cost on global economic growth.

HM: That would raise about $150 billion of revenue in the United States—a lot, although not a large percentage of either GDP or the national budget. But what about the impact on individuals? Your book suggests that beyond a carbon tax rate of $20 per ton, the poorest households begin to experience small losses in overall welfare because as energy prices rise, they'll have to pay proportionally more of their total income for essential heating costs and fuel for electricity and transportation.

Jorgenson: The question is, What are you trying to achieve? You want a lower level of carbon in the atmosphere so that you can avoid global warming. That affects all individuals in the same way because everybody's exposed to the effects of climate change. So you have to ask yourself, what is the optimal rate for everybody, for the whole world economy? And so Nordhaus in his book, *The Climate Casino,* ends up with a path that's right in the middle of those we consider. He discusses how an international agreement would work, and what the carbon-price regime would mean for the world economy.

HM: How much carbon does the U.S. emit now?

Jorgenson: In 2000, emissions were around 5 billion metric tons. And in 2010, considerably less. Since around 2005, emissions have decreased by something like 13 percent. Part of that is the result of the economic downturn and the slow recovery, but a very important part is due to the unexpected availability of large amounts of natural gas from fracking—hydraulic fracturing to release gas and oil captured in subterranean rock formations (see "Fracking's Future," January-February 2013, page 24). That has resulted in a massive substitution within the electric-utilities sector away from coal, toward natural gas, as a fuel. The carbon-intensity of natural gas is about one-half that of coal—so that's had a huge impact as the plants that can be converted to burn gas (and most can be converted easily) have been converted at a prodigious rate to reduce the amount of coal that's used.

One of the big questions about the Obama administration's proposal to regulate power-plant emissions is, how much will this policy actually do? We've already had this 13 percent reduction in carbon dioxide emissions, due to the substitution of natural gas. The administration is talking about a 30 percent reduction between 2005 levels and those in 2030, 15 years from now. Over that period, we could have another very substantial substitution [simply because natural gas is so cheap], and in fact do away with a lot of the coal that we're using simply due to market forces.

These coal plants are generally close to the end of their economic lifetimes, in many cases. A lot of them were built during the boom period before the energy crisis of 1973. And so a lot of substitution from coal to natural gas, wind, or solar power will take

place anyway, likely leading to a reduction in emissions from that effect.

So a reduction of the sort the administration is talking about is certainly within the realm of feasibility already—it's not going to destroy the economy or cause major economic disruptions.

HM: What impact does a tax on carbon of $30 per ton have on the cost of a gallon of gasoline or home heating oil?

Jorgenson: A tax of $30 per metric ton of carbon dioxide is equivalent to a tax of 24.4 cents per gallon of gasoline.

Toward International Agreement

HM: Do you examine the effects of a carbon tax only on the United States, or are you thinking about the international realm, too?

Air pollution in Beijing, December 2013

Jorgenson: We're thinking about a situation where the U.S. is part of an international agreement. The context is that a series of about 20 international negotiations has taken place annually since the initial Conference of the Parties [COP 1] in Berlin in 1995, including the very important meeting in 1997 in Kyoto, resulting in the Kyoto Protocol. That proposed international agreement unfortunately did not attract the support of a large range of countries [including the United States, which signed but didn't ratify it] and didn't have much of an impact, but it has represented world climate policy until now.

The Kyoto Protocol expires in 2020, and the target for this international negotiating body is to reach a new agreement in Paris in 2015—next year. So their goal is to have a proposal like the ones in Nordhaus's book ready for discussion in Paris, and to include a carbon price that could be used as a basis for an international agreement that would attract a much broader base of support: the U.S., China, Europe. It's much more likely now to actually produce some kind of international consensus, as the economic costs of climate change have become clearer. I'm sure a lot of people will be left out, but I think there's going to be a much broader basis for agreement.

This is critical because unless you get the major polluters to agree, you'll have "leakage": the nations that don't agree won't have to impose any kinds of limits on emissions, with the result that economic activity will leak away from the countries that do impose the taxes to countries that do not. Economists refer to that risk as the free-rider problem. The purpose of these international agreements is to prevent free riding, to avoid leakage.

HM: You've worked in China for a decade, and last year wrote [with Mun Ho and Jing Cao, Ph.D. '07, an associate professor of environmental economics at Beijing's Tsinghua University] about the economics of environmental policies there [see chapter 9 in *Clearer Skies Over China, Reconciling Air Quality, Climate, and Economic Goals*, co-edited by Ho and Harvard China Project executive director Chris Neilsen]. What is happening in China?

Jorgenson: China has recently become the world's largest carbon polluter. Until three years ago, the U.S. was.

HM: China manufactures goods for countries around the world because they can do so more cheaply. Is this exacerbating carbon pollution?

Jorgenson: They *are* polluting on our behalf. About 80 percent of their energy supply is from coal. They use some oil, mainly for transportation, almost no natural gas. They want to move away from using coal, but right now, their economy is very coal-intensive, especially their system for generating electricity.

China has very modest oil resources and almost no domestic natural gas. That doesn't mean they couldn't develop it, but in terms of what they actually produce, most of their domestic resources are now based on coal. They mine a *lot*, and they import coal from Australia, Indonesia, and other places.

In our work there, we've been trying to design a system of taxes and revenue recycling that would enable the Chinese to participate in an international agreement and still continue their program of rapid economic development. Their traditional approach to economic policy has been to focus on growth, and they've had spectacular success since 1978, with the great reforms of Deng Xiaoping. They *want* to be convinced that it's possible to reduce their pollution and simultaneously maintain economic growth. So that's been the focus of our research.

We have a model of the Chinese tax system, just like the model of the U.S. system in *Double Dividend*, and we trade off a carbon tax against the other taxes that are used in China. In fact, China relies more on business taxes than we do, so there's a big payoff using an approach that involves revenue recycling.

India has a very coal-intensive economy, too. They're operating at a different level than the Chinese, with about half the level of GDP per capita, but their electricity generation is very coal-intensive, and they need to consider similar policies.

The starting point for these policies would be an internationally agreed-upon price for carbon, imposed by each individual country and used as a basis for generating revenue within that country. That way there's no *international* transfer of funds. And each country would choose its own revenue-recycling policy, depending on how the energy sector would respond to changes in the labor and capital taxes that we've been discussing.

These are major differences from the Kyoto climate treaty, and should prove to be key inducements to reaching a consensus: each country could make its own choice, determined on the basis of domestic considerations, not international ones. What would be agreed upon internationally would be the carbon price—that's what Nordhaus's book is about.

It turns out that by using a carbon tax, you can control air pollution very effectively if the economy relies, as China's does, on coal.

HM: What would induce the Chinese to participate?

Jorgenson: To put it very simply, China has a severe problem of conventional air pollution. It has nothing to do with carbon. It has to do with sulfur dioxide, particulates—in other words, components of smoke.

This has a huge impact on health. There are lots of sick people, there are lots of premature deaths—it's a very costly policy. They've been talking for years about what to do. It turns out that by using a carbon tax, you can control air pollution very effectively if the economy relies, as China's does, on coal—because most of the dirt in the air, whether it's sulfur dioxide or the particulates in smoke, is due to combustion of coal.

By the way, even though the Chinese get a lot more publicity, the conditions are equally bad in India. And in both countries, the effect of imposing an internationally agreed-upon carbon tax would be to deal with the domestic air pollution problems in a very effective way. That's what we show.

For the United States, on the other hand, given our relatively high standards and a long-established policy of controlling air pollution, such benefits are long since exhausted. We have relatively clean air. We can certainly improve it, but it's nowhere near as dirty as the air in China and India.

HM: Would a carbon tax obviate the need for regulations like the Clean Air Act, or substitute for some of them? Or would they just be layered on top of each other?

Jorgenson: The latter. In other words, I think that the carbon tax would be focused on *climate* policy in the U.S., and would have relatively modest impact on the *other* pollutants. Let me just say that I've had an opportunity to revisit the Clean Air Act amendments and they look even better in terms of effectiveness than they did 10 years ago. It was an expensive way to proceed, but it was very *effective*, and produced a lot of health benefits in this country. That's still a frontier in Chinese environmental policy, and in India. They don't have these kinds of regulations, and the result is that they have very dirty air and very severe associated health problems.

HM: Does your model take into account the possibility of carbon capture and storage [see "Fueling our Future," May-June 2006, page 40]?

Jorgenson: We considered that. Carbon capture and storage is on the drawing boards: the engineering and technology are pretty well understood. But no version to date has achieved any kind of commercial success. For that reason, we represent carbon capture and storage by providing an engineering description, as opposed to our work on other technologies, which is based on looking at the behavior of firms and individuals, and how they react to prices. We have a vast range of data on how people substitute between, say, coal and natural gas, depending on prices, or how electric utilities choose different fuels in response to prices. We have a lot of behavioral information about that we analyze, and *Double Dividend* puts it all together. We don't have that kind of information on carbon capture and storage. But we do show how to incorporate that potential development, and certainly it could be analyzed if there's a serious possibility of a commercially viable version.

We've tried to *(please turn to page 78)*

Smog in New Delhi, February 2013

Photograph © Altaf Qadri/Associated Press/Corbis Images

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study whether, with higher carbon prices, carbon capture and storage would be more attractive. The answer is no. It's still not commercially viable in the kind of scenarios that we're talking about.

World Problem, Regional Solutions

HM: Your book accounts for the health costs of climate change. Given recent science asserting that the West Antarctic ice sheet will inevitably melt, raising the sea level significantly, do you also consider the destruction of coastal cities?

Jorgenson: This is where we hand off the baton to Nordhaus and his colleagues. They have incorporated all the benefits of mitigating climate change, including avoiding property damage and health benefits and so on, in calculating the appropriate carbon price. That is a world problem, because of course if there's sea-level rise, it's going to affect coastal areas around the world, not just in the U.S. It's something you need to address when you're setting the appropriate carbon price at the world level.

HM: The choice of how to recycle the revenues from a carbon tax would be in the hands of each country. You've found that reducing taxes on capital would produce the best outcome for United States. Might one of the other strategies lead to better outcomes elsewhere?

Jorgenson: Choosing among these different alternatives does not affect the reduction in carbon emissions—the effects of these different taxes are almost uniform. Changing the carbon tax *rate* has a big effect on abatement, but choosing which recycling option to adopt doesn't.

There *will* be big differences in economic performance. That's our basic story. It's very important that each country consider very carefully how to do the recycling.

That's why we did a very detailed analysis of China, and another very detailed analysis of the U.S., because there are obviously huge differences in the two countries' economies—and so recycling will make a big difference. Given China's existing environmental regime and the fact that the air is so dirty, they get a very substantial *non-climate* benefit from imposing a carbon tax, too. As I mentioned, in the U.S., this benefit is relatively modest.

HM: So a triple dividend for China?

Jorgenson: That's exactly right. Better economic performance, control of climate change, *and* improved quality of the air.

HM: Would every country experience at least a double dividend?

Jorgenson: Yes, because carbon taxes have a relatively similar effect in advanced countries, which are by and large pretty energy-intensive. The effects in Europe, in Canada, in Japan are going to be similar to those in the United States.

> You're not going to get a story about climate policy that makes everybody better off—so you're going to have to figure out how to find a balance.

But of course the mix of fuels used to generate electricity differs from one country to another. People in Europe, for example, use a lot of coal. In Japan, they use a relatively modest amount of coal. They rely much more heavily on imported natural gas and a little bit on imported petroleum.

Summing up, if you think about countries at different levels of development—China, India, the United States—the differences are enormous in terms of the impact. Leaving the determination of the recycling strategy to each individual country makes sense because of these differences in levels of development, and also because of the nature of the energy sector and the way electricity is generated.

HM: But in each country, a tax and revenue recycling would be superior to something like cap and trade?

Jorgenson: Exactly. The reason is that the only way to achieve a double dividend is to have a tax that will control pollution *and* to use the revenue to mitigate the impacts on economic performance: achieving both improved economic performance and the control of pollution with the same policy.

HM: Do you recommend any accommodations for the distributive problems that arise when reducing taxes on capital, since those who have lots of property would benefit most? Or do you think it's not a problem overall?

Jorgenson: The ruling principle in introductory economics is that you endorse policies only if everybody's better off. Unfortunately, that doesn't take you very far on climate policy. So we introduced the idea of a social-welfare function that captures the impact on individual welfare: we weighed the impact on equity against the impact on efficiency to determine the net impact on welfare.

We are convinced that distributional considerations are important. Every country should be looking at both the equity and the efficiency impacts. You're not going to get a story about climate policy that makes everybody better off—so you're going to have to figure out how to find a balance.

We spent a lot of time on that issue because it's so central to climate change. Why? The answer is that poor households spend a much larger fraction of their income on energy, either directly or indirectly, in the form of energy-intensive goods.

Everybody needs to heat the house, everybody needs to have transportation, and therefore equity has got to be included in the story. That itself is unfamiliar, even to many economists. How do you incorporate equity into the evaluation of a policy? Governments will have to weigh it off against efficiency. We view that as central—not something that can be simply set aside.

HM: The new rules governing power plants proposed by the Obama administration are presumably not necessarily the most economically efficient way of controlling emissions. Why choose this approach?

Jorgenson: A little bit of history helps here. President Obama tried to pass a national cap-and-trade system in 2009, and unfortunately failed to attract any Republican support. In the final House vote, there were altogether four Republicans in favor. All of the support was from Democrats. And when this legislation went to the Senate, they couldn't even get to the point of taking a vote, even though the chamber was controlled by Democrats.

So now the president is taking an indirect approach, relying on the Clean Air Act.

The regulatory approach sets percentage caps for one industry only: the electric-generating industry. That industry generates about 35 percent of the greenhouse-gas pollution in the United States. So you're focusing specifically on that industry, and setting caps for every state except for Vermont, which has no fossil-fuel generation.

The traditional rationale for cap and trade is that all the polluters, through trade [in emissions permits], will end up paying the same cost for pollution. In other words, they will pay the same price to emit a ton of carbon. The new Obama proposal rules that out. It says that the price of permits is going to be different in every single state jurisdiction. That means it's a cap-and-trade system imposed by regulation: one that essentially goes against the rationale for the cap-and-trade system in the first place. The whole cap-and-trade theory, originally, was to have a *national* system where everybody pays essentially the same price—*and* to have the same principle apply at the international level: namely, that you could have a system of caps that would be determined for individual countries by agreement, and then a system of internationally tradable permits.

That seems to me to be rather unlikely. It's much more likely that countries could agree on a carbon price than that they could agree on a system of caps that differs like this one does among states.

It's worth noting that under the Obama proposal, cap and trade is only one option. Other options that could be used by individual states to meet their targets—it's up to them to choose—would be more renewable energy, more conservation (use less energy), and even the possibility that states could choose to impose a carbon tax.

No states have done that in the United States, but there are countries that have a carbon tax in Europe, such as Ireland, Sweden, and Norway. The province of British Columbia, in Canada, also has one. But none of these taxes so far focus on recycling the revenue, on integrating the tax with the rest of the fiscal system. That's the frontier.

Fundamentally, this Obama proposal is very much like the Clean Air Act: it's an inefficient way of achieving a desirable objective. At the moment, it's being offered without the framework of an international agreement. We're a long way from achieving an international agreement that would replace Kyoto, and we're going to hear a lot about this as the Paris negotiations approach.

Children protecting themselves from smog and pollution, New Delhi, 2012

HM: Will Obama's regulatory framework outlast his presidency?

Jorgenson: Environmental regulations are very rarely rolled back. If enacted, it's very likely that this regime will remain in place, just as the relatively inefficient approach in the Clean Air Act remains in place.

HM: If negotiators in Paris can agree on a price that reflects the cost of emitting a ton of carbon, what happens next?

Jorgenson: As the international agreement unfolds over the period between now and, say, 2020, when the Kyoto Protocol is scheduled to be replaced, every country should be doing this kind of analysis of revenue-recycling and of the potential ancillary health benefits. They'll have to if they're going to try to maintain economic performance while adhering to an international agreement.

I think that from the political point of view, the fact that taxing carbon is going to produce very substantial conventional improvements in air-pollution control will induce them to participate in an international agreement.

Once developing countries understand this, they should be champing at the bit to have an international agreement like this. That's the thrust of our argument about China. A carbon tax for the emerging economies has these ancillary benefits that are extremely important, and I think will drive an international agreement when we get around to the negotiations.

HM: How would your proposal for an international price on carbon interact with President Obama's proposed power-plant regulations?

Jorgenson: There's a period of public comment on those regulations for at least a year. That takes us very close to the Paris meeting. I think the hope for people who want to use an efficient approach is that a national carbon tax will be enacted in the meantime, replacing the proposed regulatory regime.

In other words, Congress will decide in its wisdom to legislate on this issue. I think having the prospect of a relatively inefficient system may stimulate a lot of interest in a carbon tax. There's already a sub rosa discussion going on in Washington. I think that will surface as this period of public comment unfolds. So I think we're going to have a big debate over this, and that all of this is going to be resolved in the next 12 to 18 months.

HM: That's an extraordinary prediction, given the recent congressional standoffs.

Jorgenson: I'm quite optimistic. That's why I spent a lot of time and effort making sure that this book got out so that we could be part of this discussion.

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