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THE AUDACIOUS DR. NORDHAUS

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Much has been and will continue to be said about the extraordinarily important intellectual insights that Bill Nordhaus has contributed to several fields of economics, including, but not limited to, environmental economics. Happy to join the enormous chorus of appreciative fans.

But there's another dimension of Bill's work that deserves acknowledgment. Beyond the intellectual insights, something should be said about the daring, indeed the *audacity*, in the way Dr. Nordhaus has approached important challenges. I'm going to focus on that.

Let's start with Bill's life-changing (and world-changing) decision to apply economic analysis to the phenomenon of climate change. The decision met with surprise and resistance. From the mid '70s to the late '80s, Bill spent a lot of time at the International Institute of Applied Social Analysis (IIASA), a research institute devoted to a range of global problems. Bill had been offering advice on IIASA's model of the global energy system. It was there that Bill first sought to view the climate system through an economic lens. He took some initial steps to introduce the climate system in IIASA's energy model, which hitherto included no climate component. Not long after Bill began this effort, the leader of the energy model's program, a nuclear physicist, ordered Bill to stop the work, seeing little value to a focus on climate. (Nuclear power issues, on the other hand, were very important.) Undeterred, Bill went to the director of IIASA and got permission to focus on CO_2, largely on his own. What initially was to be a new component of IIASA's energy model became Bill's own baby.

Of course, the idea startled economists as well. About 30 years ago, when Bill disclosed at a Brookings conference that he'd begun to do research on the economics

of climate change, the reaction was puzzlement and skepticism. This type of reaction was typical early on. Climate change was not on economists' maps, and addressing it with economic tools seemed bizarre. It takes courage to risk ridicules from your colleagues.

It was courageous enough for Bill simply to decide to apply economics to the climate change problem. But the manner in which he chose to represent the climate system was equally bold. Around 1990, Bill approached climate scientist Stephen Schneider at the National Center for Atmospheric Research. NCAR was perhaps the leading US institution involved in the development of climate models: models that connected CO_2 emissions to changes in CO_2 concentrations in the atmosphere and oceans, and linked these changing concentrations to changes in global surface temperature and in patterns of precipitation. These climate models were really, *really* big — often with (literally) millions of equations. Bill indicated to Schneider that he wanted to include the climate system in his new model. Specifically, he mentioned — and here's the audacity — that he wanted his new integrated climate-economy model to capture the climate system . . .*in less than a dozen equations*. Years later, Schneider confessed to me that initially he questioned Nordhaus's sanity. It attests to Schneider's breadth of intellect that he soon came to appreciate Bill's unusual aspirations. He helped Nordhaus come up with the eight-equation climate system in the original DICE model.[1] The two developed a lasting professional connection as well as a strong friendship.[2]

Then there's Bill's taking transparency to the extreme. When introducing his very young DICE model in workshops in the early '90s, he would display the model's equations and state, without apology, "It's a model you can write down on one page." This was in a decade in which enormous advances in computer memory capacity and computation speed had spawned the production of very large, high-dimensioned macroeconomic models. Bill had the courage to buck the macro model trend: the complete DICE model consisted of 14 equations. Was this a virtue? It was, big time. DICE's transparency has helped researchers around the world reproduce the model as well as modify or extend it. This has conferred huge benefits to the research and policy communities. Beyond transparency, Bill's work exemplifies accessibility. In addition to the model's structure, DICE's computer code and all the data have been fully disclosed from the beginning, routinely included in Bill's papers as well as his first DICE book.[3] So, with minimal effort, researchers have been able to replicate the results and explore how changes in data, parameters, or structure influence the outcomes. Enormously beneficial to climate policy researchers!

[1]See Table 2.2 of Nordhaus's *Managing the Global Commons: The Economics of Climate Change*. Cambridge, Mass., MIT Press, 1994.

[2]Bill admires and speaks very fondly of Schneider, who died in 2010 of lymphoma. He credits Schneider and his collaborator Starley Thompson with a key breakthrough that made climate-change modeling possible: the reliance on radiative forcing as the bridge between CO_2 concentrations and temperature change.

[3]Nordhaus, *Managing the Global Commons, op. cit.*

Let us not forget the importance of a name. I can't claim that Bill revolutionized model-naming, but he sure displayed a talent for it. His name for the climate-economy model — "Dynamic Integrated Climate-Economy Model" — is brilliant. The associated acronym sticks to your memory and yields an image that connotes a central feature of the climate change problem: uncertainty. Am I going overboard here, conferring too much importance to a name? I ask you to consider if instead Bill had christened the work, "Model Connecting the Climate System and the Economy." The acronym is unpronounceable. Referring to the model would have been a chore. Showing appreciation where it is well deserved, Bill has remarked that he's always loved the model's name.[4]

Another display of boldness relates to Bill's seminal paper with Rob Mendelsohn and Daigee Shaw on the impact of climate change on agriculture.[5] Breaking with tradition for economics research papers at the time, the paper presented key results in color. It contained multi-colored maps showing the projected impact of climate change on the profitability of agriculture across counties throughout the continental US. Somehow, the authors persuaded the *AER* to retain the color in the published article. I believe this was the first time the *AER* printed one of its articles in color. Isn't this accomplishment as important as the insights offered in many highly cited economics papers?

For my final example of daring, I'll venture outside of the climate economics domain. For economists who wish to measure real economic growth, it is essential to get price indexes right, since these indexes are needed to express the actual value to consumers of the goods and services that can be enjoyed from given nominal wages or incomes. This is not a trivial challenge because production methods, product quality, and product variety change a great deal over time, complicating the translation from goods to value (money-equivalent of utility). Around 1990, when Bill was concentrating hard on the price-index problem, he surmised that existing studies failed to capture all of the dimensions that lead to reductions over time in real prices — and that as a result these studies understated the reductions in real prices and understated economic growth. To address this issue empirically, he focused on illumination services — that is, light. Existing studies typically employed data that spanned a century at most, but Dr. Nordhaus decided to consider a time-span of . . . *1.4 million years*. The well documented time series he developed stretched from the production of light by fire (in caves by our early human ancestors) to lamps, candles, and compact

[4]In an unpublished note, and with considerable flourish, Bill indicates how the acronym connects with the formidable trade-offs that characterize the climate problem: "[The word] DICE also conveys a shiver of risk and danger. It alluded to the Faustian bargain that we make as we continue down the path of unchecked climate change, the Walpurgis Night of reveling without reckoning on how the devil of damages will come to drag us to a hellish future."

[5]Mendelsohn, Rt, WD Nordhaus and D Shaw (1994). The impact of global warming on agriculture: A Ricardian analysis. *American Economic Review* 8(4), 753–771.

fluorescents. Needless to say, this gigantic departure from traditional empirical work took one helluvalotta nerve. The results from the study[6] are as stunning as the length of the time-series. Bill estimated that the energy efficiency of light production — lumens per watt expended — had increased by a factor of about 30,000 since prehistoric times. After accounting for these enormous efficiency improvements as well as the changing characteristics of light over time, Bill arrived at what he considered to be a truer measure of the price of light. According to his measure, from 1800 to 1992, the real price of light declined by a factor of over 900, while a conventional approach as

defined in the paper would indicate it declined by a factor of just 3–5. The paper made a compelling case that for other goods and services, existing studies had seriously understated the extent to which their real prices had declined — and thus had understated real wage and real income growth.

Bill is most proud of this paper. Every Nobel laureate is asked to make a gift to the Nobel Foundation that represents his or her contribution to his or her Science. Bill gave them a lamp from antiquity, an allusion to his Light paper. It is shown above.

One wonders whether Bill would have won the Nobel, had he not been extraordinarily daring as well as brilliant. I'm sure Bill wouldn't shy away from answering this question.

Thanks, Bill, for your audacity.

Acknowledgments

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[6]Nordhaus, WD (1998). Do real output and real wage measures capture reality? The history of Light suggests not. Cowles Foundation Paper No. 957, Yale University. Reprinted in RJ Gordon and TF Bresnahan (eds.), *The Economics of New Goods*. University of Chicago Press, pp. 27–70.