

Defending against Climate Risk

Defending against Climate Risk:

*Lessons and Stories from a Foot
Soldier in the Climate Wars*

By

Gary Yohe

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To my wife, Linda, whom I will love forever. You made it all possible with your belief in my commitment to fighting climate change and your support of my efforts.

To my daughters, Marielle and Courtney, whom I also loved from minute one and for whom an earlier, less intelligible draft of this book was a Christmas present in 2018.

Finally, and most importantly, to my granddaughters. Linda and I were there within 8 hours of your birth. Katie and Carrie Madigan, I wish that my work combined with the efforts of thousands of scientists from around the world (many of whom I know) would have left you a healthier world and a more robust planet to inherit. It was not for lack of trying.

I have enormous faith that you will do better.

TABLE OF CONTENTS

THE ASTERISKS ARE INTENDED TO LEAD YOU TO THE STORIES –
MORE ASTERISKS MEAN MORE STORIES

THE REAL STORIES OF MY CLIMATE LIFE ADVENTURES
ARE IN CHAPTER 13

List of Illustrations	x
List of Tables	xii
List of Abbreviations	xiii
Preface **	xiv
Chapter 1 **	1
Basic Training – The Value of a Liberal Arts Education	
Chapter 2 *	11
Prices versus Quantities Under Uncertainty	
Chapter 3 *	20
Very Early Carbon Emissions and Concentration Trajectories	
Chapter 4 *	31
Sea Level Rise	
Chapter 5 *	45
More on Sea Level Rise.	
The state of current tipping point science in Antarctica.....	48
Depicting and reporting the Thwaites ice sheet	50
Is there a potential for financial contagion?.....	53

Chapter 6 *	55
Reasons for Concern	
Chapter 7 *	64
Determinants of Adaptive and Mitigative Capacities	
Chapter 8 *	73
The IPCC and the Meaning of Consensus	
Chapter 9 **	79
Iterative Risk Management	
Chapter 10 *	87
Making Iterative Risk Management Workable in a Changing Climate	
Chapter 11 **	99
Snowmass Integrated Assessment Meetings	
Chapter 12 *	105
The Social Cost of Carbon (and Methane and Nitrous Oxides)	
Chapter 13 ****	114
The Climate Experience on a Personal Level	
Chapter 14 **	140
My Last IPCC Hurrah	
Chapter 15 *	142
The Nobel Peace Prize	
Chapter 16 *	145
Insuring Against Risk	
Chapter 17 **	149
Detection and Attribution	
Chapter 18 **	157
Engaging in the Public Discourse	
Chapter 19 **	162
The Nobel Prize Again	

Chapter 20 **	171
My Time with Stephen Schneider (1945-2010)	
Chapter 21 **	178
Mentors	
Appendix A	191
My January 2023 CV with numbered references in the text.	

LIST OF ILLUSTRATIONS

Figure 3-1. Results from the NAS analysis.

Figure 3-2. Projected emissions ranges with medians highlighted in bold for major heat-trapping gases: carbon dioxide, methane, and nitrous oxides.

Figure 4-1. A schematic of a global emissions model.

Figure 4-2. Representative global carbon dioxide emissions scenarios.

Figure 4-3. Corresponding representative global carbon dioxide concentrations.

Figure 4-4. Percentile specific expected costs from SLR over time and across the United States with no foresight in \$billions (1990).

Figure 4-5. Present value of expected US costs without and with foresight in \$billions (1990) for different levels of SLR through 2100.

Figure 4-6 Panel A. Regional coastal losses along a business-as-usual scenario or a mitigation trajectory that holds increases in global mean temperature below 2 degrees Celsius.

Figure 4-6 Panel B. Regional coastal losses mitigation trajectories that hold increases in global mean temperature below 1.5 or 3 degrees Celsius, respectively.

Figure 5-1 Projections of global sea level rise from anthropogenic climatic change.

Figure 5-2 Panel A. SSPs mapped into the challenges to space of contrasting challenges to mitigation or adaptation.

Figure 5-2 Panel B. Ranges of population, GDP, and urbanization characterizing the SSP.

Figure 5-3. The joint influences of evidence and agreement on assessed confidence.

Figure 5-4. Illustrative and representative SLR trajectories

Figure 6-1 Panel A. The first reasons for concern figure with its caption.

Figure 6-1 Panel B. The first reasons for concern with “burning embers” coloring.

Figure 6-1 Panel C. Reasons for concern with full captioning reported from the background documentation from the Fifth IPCC Assessment Report.

Figure 6-2. Transient temperature scenarios displayed over the #171 judgements about levels of concern about RFC1.

Figure 10-1. Confidence assessments depend on the quality of the underlying evidence and on agreement in understanding underlying processes that can be contingent on a wide range of possible futures.

Figure 10-2. The conceptualization of risk as the product of likelihood and consequence can be portrayed by a two dimensional matrix.

Figure 10-3. Reported deaths from Asian flu per 100,000 people across 50 states.

Figure 12-1. Distributions of estimates of SC-CO₂ contingent on the discount rate with the justification of a high rate associate with high aversion to risk.

Figure 13-1. Coincidental climate vulnerabilities across Africa.

Figure 13-2. Evidence for the human impact on physical and natural systems.

Figure 16-1. Correlations between confidence in detection and confidence amplified by process understanding in attribution.

Figure 18-1. Pictures in an exhibition from Stockholm.

Figure 20-1. Selected mentors over a lifetime.

LIST OF TABLES

Table 3-1. Indices of sensitivity of atmospheric concentrations in 2100 to uncertain about key parameters (100 represents the maximum effect; all others are proportional).

Table 4-1. Total annual damages to coastal property across the U.S. coastline along the contiguous 48 states (\$1b).

LIST OF ABBREVIATIONS

ACC	America’s Climate Choices from the NAS
CDC	Centers for Disease Control (and Prevention)
CFC	Chlorofluorocarbon
CNN	Cable News Network
CO ₂	Carbon dioxide
COP	Conference of the Parties (of the UNFCCC)
COVID or COVID-19	The novel coronavirus
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EU	European Union
FDR	Franklin Delano Roosevelt
GHG	Greenhouse gas(es)
IPCC	Intergovernmental Panel on Climate Change
MIT	Massachusetts Institute of Technology
NAS	National Academy of Science
NASEM	National Academies of Science, Engineering and Medicine
NCA	National Climate Assessment
NIH	National Institutes of Health
NOAA	National Oceanographic and Atmospheric Administration
NPCC	New York (City) Panel on Climate Change
NRC	National Research Council (U.S.)
OSTP	Office of Science and Technology Policy
RFC	Reasons for Concern
SCC	Social cost of carbon (or carbon dioxide)
STEM	Science, Technology, Engineering, and Mathematics
U.S.	United States of America
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
WCRP	World Climate Research Program
WGI or WGII or WGIII	Working group I, II, or III in an IPCC Assessment

PREFACE**

Why did I write about the climate “wars”? Why did I think that I was a foot soldier? Why was my life an attack on climate change?

I wrote this book because many people were, and are still, dying with increasing frequency in “projectable” floods, storms, fires, heat waves, and other extreme events all around the world. It makes me think that we were not sufficiently persuasive. Other people, like Steve Schneider who died on an airplane on one last trip to try to maintain defenses against people who would rather make things up for their own wellbeing than save some unknown person’s life, whether that be today or sometime in the future.

Failing in the ability to defend themselves publicly against Steve and others, these opponents of climate action would make threats online and in other media against anybody who appeared on their radar screens. Precise details will not be forthcoming, but we are the foot soldiers.

Ben Santer endured the threats and the kidnapping of his son; he is a high-ranking officer in the climate change army.

Michael Mann never blinked.

For me, though, Stephen Schneider was the general.

I am not in the same category as these people, but I have been a soldier in their army. I am still alive, and opponents have failed to damage me and what I have been writing for more than 40 years. They have also failed to damage my family, though they have threatened to do so.

I think that the lessons that follow are important. They reflect what I learned and contributed to the body of knowledge that supports the need for climate action to be taken today. The stories are more fun, though. They reflect what I did, with whom I did these things, and where I was.

I think that I contributed to the common global good, and I hope that you will think that such a view is not a delusion on my part. I had a good time

through thousands of experiences with hundreds of people who are now good friends, colleagues, and collaborators from six (maybe seven) continents.

Most importantly, I am still around for my granddaughters. They ask, “Papa, what did you do? What are you doing now?” I think that this book is a pretty good answer to the first question. I am still working on my answer to the second.

What could be better than that? I am alive to know them. They are extraordinarily engaged at a young age, and I can tell them that I tried.

What follows are memories, as well as highlights, of my contributions to the greater good, organized in chapters of unequal length.

CHAPTER 1

BASIC TRAINING – THE VALUE OF A LIBERAL ARTS EDUCATION

The lede here is that the value of a liberal education cannot be overstated.

Speaking to climate colleagues from many disciplines has been a challenge for me, spanning over more than 45 years since graduate school, but knowing a little bit of their vocabulary and recognizing that their perspectives are just as valid as mine turned out to be very important.

This first chapter is ultimately about the academic freedom that allowed me to “follow my nose” from the “other side of the desk”, leading me from economic theory to climate change. That is an enormous gift from Wesleyan University and my family, but I was prepared for that future by accidents that happened during my undergraduate and graduate educations.

I learned the vocabulary and the value of scholarship from wherever it came from in my random course selections at Penn. I majored in English, then Philosophy, then Chemistry, then Chemical Engineering, and then Mathematics, with a passing grade at graduate level Physics (where the lowest possible grade for an undergraduate was a C).

Some of my decisions were based on my participation in D-1 athletics; I played varsity golf for all four years. Some of my decisions were based on looking forward to what I might be doing at age 40; I did not know then that I would also be doing the same thing when I was 70+ years old. Why? Because it is still fun. Here are some of the highlights:

- My roommate Fred (Sanfilippo now at the School of Public Health at Emory University) and I were taking organic chemistry together during our sophomore years. We worked together on everything but exams. We were separated in exams because I learned so much from Fred’s exam prep sessions that they thought we were cheating when we both blew out the curve on the first two exams. The truth is, we

had taught ourselves enough that all we needed was access to the periodic table of elements. That table was always hanging on the classroom wall. Since we could see the table, Fred and I thought that we could cope with just about anything that would be thrown at us on an exam - and we were right. Persistent grades above 95 percent were not expected from anybody when the median was around 50.

I learned from our study technique. As we studied, Fred would suggest some patterns in the chemical equations of interest, and I would check their implications against our notes and the textbook. Sometimes Fred's magic worked, and sometimes we would argue. By the time we took the exam, we had discovered maybe 5 or 6 patterns that were the truth, and that was all we had to remember (as long as they did not put a sheet over the periodic table – then we had to remember more).

The Chemistry Department was so sad that neither of us wanted to major in chemistry.

- I played intercollegiate golf (D-1) during my four years at Penn. I qualified for the NCAA tournament in 1968, but did not make the cut. In my junior year, in the spring of 1969, we had 22 away matches in the month of April. We traveled away from Philadelphia so much that I was on campus for only one day the entire month.

This was before the internet, but fax technology worked so that I could get my assignments to my very gracious professors on time. I kept up in five courses (even though the normal load was 4) and earned 5 A's.

I was elected to Phi Beta Kappa in my senior year - to my surprise and despite my interest in golf. It was the 1960's, so the rules were different. But the PBK rules were about performance. To be honest, I did not even know about PBK until I got their invitation letter.

- I learned some important lessons from commuter train rides back and forth from my parents' home at the end of the "Main Line" during my years at Penn. There were so many sad faces on the morning train from Paoli to Penn Station in Philly on Monday mornings when I traveled back to campus from weekend visits with my parents so that I could spend 12 hours a day on the practice range.

Most of the riders were reading something like National Geographic for relaxation and distraction, but they looked like they were about to be hung – so sad to be going to work that it was unbearable to watch.

I decided then that I did not want that. I did not want to ride that train. I wanted work to be fun. I wanted to be able to say that I never did anything at work that was not fun. Looking back over 50 years, I can say that that objective was accomplished.

- A job in academics seemed like the plan to avoid those train rides. There was, though, difficulty conveying what that meant to my educator parents – a high school principal and a kindergarten teacher. They did not understand that I was not just going to be a teacher. They did not understand that research did not mean going to the library to read what somebody else had already written. I was going to be a researcher for whom the expectation was that I would expand the knowledge frontier of whatever discipline I happened to choose. My task would be to write something new.

They never really got it. When I was an Assistant Professor at SUNY Albany in 1976, I accepted my first invitation from another campus to give a talk about my work. I would be speaking at Lehigh University in Bethlehem PA. I spent the night before the talk with my parents in their home in Hershey's Mill just outside West Chester, PA. When I got up for breakfast, my father joined me. I remember nothing about what we ate, but I do remember his question when I was collecting my things, my thoughts, and my nerve to leave to give a talk about the general equilibrium implications of environmental policy on real relative wages for labor in a steel town. "Why do they want to listen to you for, anyway?" was his question for me as I left the house.

Thanks, dad. I was already nervous enough.

The talk was not well received, but that was not a surprise. What was well received was its rigor in applying techniques from papers by Paul Samuelson. I had not created a new approach, but I had adequately applied some existing ones.

- Having ultimately majored in mathematics, I went to grad school in mathematics at SUNY Stony Brook. I loved math and the isolated worlds that it built. They protected me from the violence across the outside world (MLK and Bobby Kennedy had been shot). I was about to go to work for Bobby's campaign in CA and would have some responsibilities during the Democratic Convention. Then, he was killed.
- Then I just wanted to retreat into my own world, and mathematics was an option.

I really wanted a job on the other end of graduate school, though. I worked hard for two semester in a graduate math department. I was a good student. But some of my classmates were much better than I. They saw everything intuitively. They did not, it appeared to me, work at all, except for a few hours early Wednesday mornings (listening to Simon and Garfunkel at 3AM?) because assignments were generally due on Thursday. Still, they got everything right and laughed about it. I got it right, but it was difficult.

I knew that they were going to get jobs as mathematicians wherever, and I learned that I was the academic mechanic who could push through the proof and get the same answer as they one week later. I was pretty sure that I would drive a taxi and they would put men on the moon. And so, I changed majors again – to economics in the middle of graduate school.

- After some advice from the SUNY math department, I switched to economics (with one first semester intro econ course at Penn to my name). I applied to PhD programs in economics (not business) at Penn, Harvard, Princeton and Yale. (Stony Brook had told me that I could just switch fields, so I had a safety school. I was accepted at Penn and Yale.

Penn offered a full ride. Yale offered no support other than no tuition and a graduate teaching position starting in my second year if I could prove that I could teach undergrads. I chose Yale, even though I did not realize how good the Yale Economics Department was. Turns out that there four Nobel Laureates in the house.

The Yale Economics Department admitted me as part of an experiment crafted by Herb Scarf and Joseph Stiglitz* (an asterisk will henceforth indicate somebody who has won a Nobel Prize in Economics). They pushed the Department to admit to me and Andy Rosenberg – both math major from different schools, but each with minimal economics backgrounds.

When I arrived at Yale, or as I would say on the train “New Haven for graduate work”, the economic vocabulary was foreign. It follows that I was ahead in the running for “who, from my entering class, will learn the most economics?” I could teach the math to my peers while they taught me the economics. Willem Buiter and Robert Wilson and I would become the last (as far as we know) to complete Yale PhD program in economics in 4 years.

I am the last by actual count, since Willem and Bob got their degrees minutes before I did (alphabetically, Buiter before Wilson before Yohe).

- But let’s take a look at what that education involved. I learned microeconomic theory from Joseph Stiglitz*. I learned macroeconomics from James Tobin*, with copious notes provided by teaching assistant Janet Yellen. I learned mathematical economics from Tjalling Koopmans* and Herbert Scarf. I learned environmental economics from William Nordhaus* and Tjalling Koopmans*. Martin Weitzman would be the inspiration of my dissertation, even if he did say “you can’t do that, it is too hard.”

When I took my qualifying orals to move into the dissertation stage of my time at Yale, my examination committee included Joseph Stiglitz*, James Tobin*, Richard Cooper and Richard Becker. After my two-hour exam, I waited outside the exam room for their decision. Did I pass????

An hour later, Stiglitz stuck his head out the door and told me to come to his house tomorrow morning (Saturday) at 10 AM. My future wife, Linda, was waiting for me to hear the news. We did not speak much during the walk back to the Hall of Graduate Studies.

A sleepless night later, I arrived the Stiglitz house on Livingston Street to find the future Nobel Laureate aerating his front lawn with

a rake. He was happy to stop when he saw me. We sat on his stoop, and he told me that the examination committee had decided that they would not pass me until I learned everything in the Samuelson's* introductory economics textbook. They would reconvene in the fall to examine my understanding of the principle or economics.

Their decision was the right one, but very unprecedented. It seems that I got all the hard questions right, but I got all of the easy ones wrong. "Come back in 4 months and then we will examine you on that material in Samuelson's* intro textbook. Nothing else, but don't forget the footnotes". It turns out that I actually wrote study guides for subsequent editions, but that is another story.

I read and worked through the text carefully over the summer, and I passed easily in the fall.

For somebody without an undergraduate background in economics, it turns out that this was the best thing that ever happened to me. It gave me the skills to teach at Wesleyan, and it made my academic papers better. I got into the practice of teaching my latest academic paper to be submitted to world class journals because, if I could not make it make sense to engaged and intelligent undergraduates, then I did not know what I was talking about. I now work to communicate issues surrounding climate change to lay audiences, but I can do that because what they took the time to teach me. I have learned again that you have to be able to reach back to first principles – and that was the lesson that the members of my examination committee were teaching me.

The names in the last paragraphs were ordinary in my life in New Haven. I saw them every day. Those without asterisks include Richard Cooper, who had recently been Undersecretary of State for Economic Affairs under Jimmy Carter; Herbert Scarf, who brought fixed point theory to economics and should have won the Prize; Martin Weitzmann who would bring the black swan dark tails of outcome distributions to climate change economics; and Janet Yellen, who would become Janet Yellen. ALL of the rest have asterisks next to their names because they would eventually win Nobel Prizes.

Yes... All of them. Nobody knew at the time, but I was at Yale and what did I know. The culmination of my education there was like calling on Mariano Rivera to pitch in the 9th inning of a 1995 post-season game for the Yankees. He was good. He was engaged. He had a spectacular slider. But was not yet “Mariano”.

Linda and I married in September of my 4th year. I played in the USGA Amateur Championship at Ridgewood Country Club in New Jersey the week before. I lost in the first round, but I had qualified the two weeks earlier with the lowest score in the highly respected Philadelphia region. I shot 140 for 36 different holes. If anybody is counting, that was 4 under par.

It was not easy to qualify out of Philadelphia, and Linda had a role. I was feeling pressure and I barely bogeyed the 9th hole of the second round. I was leading but this was just the time for a collapse. Linda, who was not allowed to follow me around the course because women were not allowed on the grounds of Philmont Country Club, caught up to me at the tenth tee (which was close to the terrace where she could spend her time without being able to order anything). She knew what had just happened. “Time for a birdie” she hollered when I approached the tenth tee. On a 240 yard par three. Yeah. Right. A birdie picks up two shots on the field. I agreed and smiled. She had broken the tension. I hit a 239 yard one iron within 3 feet of the hole – I scored her birdie 2 with some jittery nerves even though it was a straight-up hill put.

It was easy from there because Linda had given me my confidence back.

Nonetheless, Linda was not amused about the USGA National Amateur Championship that occupied my attention during wedding preparations. I lost in the first round.

She was not, however, about to stand in the way of my completing on something that mattered. Later that year, she insisted that I would complete of dissertation on time (4 years after I entered the Yale program and, in the view of my parents, the minimum even after we were married. She was not going to be blamed for my “failure”.

I wrote on a “desk” in our apartment in Albany (where I had taken a job to pay the rent) that was simply a panel door placed on top of boxes of books. Linda protected me from students (who lived nearby since we were living in low rent housing. She supplied coffee, and I worked on the arithmetic support of “prices versus quantities under uncertainty” (that is now known as taxes versus cap-and-trade, but more on that later).

When I had to get my dissertation typed, Linda and I and our two cats stayed (in an infirmary room thanks to Willem Buiters) when we (not I) went to New Haven to consult with William Brainard (my dissertation adviser) and my typist.

Brainard would never admit to reading anything that I had written I preparation for these meetings – one chapter after another. That was part of his teaching style for, I came to understand, is most promising students.

He would make me present my findings in his office with nothing but chalk and a blackboard. I quickly learned that this was going to happen. The subsequent give and take from that practice were some of my best learning days of my life. I was learning that I could play in the Yale-level game (which it turned out was Nobel worthy), but I also learned that I was not always right. I learned about “laugh tests” as in, from Brainard, “that cannot possibly be true – consider this (made up) example”.

When each presentation was over and he was not convinced that I was right about a particular claim, I came to know that he was always right to be skeptical and that I had more work to do. I also knew why and made up possibilities were part of the process. I taught the concept of “laugh tests” for nearly 50 years.

That is to say, his ability to direct and dissect my dissertation is something that I carried with me throughout my academic career. Not just for my students. Middle of the night periods of staring at a dark ceiling upon which I could mentally draw graphs and write text became the norm. For years....

Why was this way of living productive? I would always remember what had happened in the dark, so it was in the short run. Did it turn out that these episodes were not healthy? Yes.

To support these mid-night episodes in the short to medium run, it turned out that my accidental multidisciplinary background at the University of Pennsylvania would support my interdisciplinary work in climate change with natural and physical scientists, as well as other social scientists. I could talk to them because I knew a little bit about lots of things. I could write with them because I knew some of their vocabulary and they would fix my mistakes. Ultimately, those eight years playing very competitive golf in a protected environment became the foundation of my professional life.

A few years after my last national amateur and also after spending a few years writing significant insights into the economics of decision-making under uncertainty (as indicated by where my papers were published), I found a lasting home at Wesleyan University. I was hot stuff at but time, but I wanted more (or less); and I was not sure if I was their ideal candidate.

Wesleyan was searching widely, but I had applied to one school – not because they were the only school looking for my demonstrated skills, but because they applied consistently to their liberal education philosophy of equally across disciplines for the student body and for the faculty. And also because I had met my wife in Connecticut.

As I am sure that they expected, I stopped publishing in economics journals late in the 1980's. I started to publish a lot in climate and science journals – sometimes big deals like *Nature* or *Science*. Sometime *Climatic Change* that was launched with some professional risk by a future friends and mentor – Steve Schneider. That was OK with my colleagues, even though I had come to them as an economic theorist. They were happy that I was making a contribution to the public welfare in journals that they could retrieve and read.

For me, their evaluation of my value to the University was the gift of a lifetime. The rest of this book covers the consequences of their decision.

I hereby thank them and the University for this freedom, but it was not unexpected. Wesleyan is, after all, the place where “academic freedom” was invented.

Later into my tenure at Wesleyan, I was invited to give a 12-minute talk to the Board of Trustees (the Chair was an attorney, so bill-able hours were

measured in tenths of an hour). He wanted me to speak to tenure decisions for junior faculty working inter-disciplinarily.

I had published 25 papers in the previous five years (none in economics, per se, but all have many citations – some as high as 12,500). I argued that a positive tenure decision on the basis of that record would have been appropriate at Wesleyan, but that it would have been impossible in a standard economics department at places like Yale or Michigan or Stanford.

Wesleyan did not agree to that standardized code. Anywhere else? I looked, and the answer from a limited sample was no – at least not for a typical top-tier Economics Department.

CHAPTER 2

PRICES VERSUS QUANTITIES UNDER UNCERTAINTY

The lede here is that cap-and-trade markets for allocated permits are always preferred to fixed standards for all sources of emissions of a pollutant. They may not, however, be preferred to a price (a tax) control, depending on the variability in total emissions and the resulting losses in expected benefits on the demand side of the product markets.

My PhD dissertation, *A comparison of prices controls and quantity controls under uncertainty*, is a microeconomic theoretic exploration of questions born from a seminal paper entitled “Prices vs. Quantities”, authored by Martin (Marty to his friends and enemies around he world) Weitzman in the *Review of Economic Studies* in 1974.¹

Marty’s paper was perhaps the first of many that showed us all his incredible skill in framing complicated questions as simple, analytically tractable propositions whose explorations and explanations would nonetheless illuminate the intricacies of the larger motivating context.

Here, he assumed a single firm facing a single market with quadratic benefit (profit) and cost functions. The firm knew its cost schedule very well, but demand was variable and not predictable from one time period to the next – sometimes it would be high, other times low, and occasionally average.

There were more subtleties than that behind his paper, of course, but I ran with the fundamentals - trying to understand the intuition behind the simple case before tackling more complicated possibilities of multiple firms.

Starting simply allowed me to understand that the important questions in the decision-making under uncertainty are “Who knows what? When do they know it? How do they respond?” This is where I came to understand that the answer to every economic question of any economic consequence

¹ <https://scholar.harvard.edu/weitzman/publications/prices-vs-quantities>

is “it depends”. It follows that the real question that we should all be asking is “on what?” Over the next fifty years, my students would hear that lesson over and over.

I would publish a number of papers on more complicated versions of this prices-versus-quantities comparison in big-deal economics journals after coming out of graduate school (numbers 1, 3, 4, 6 and 8 as well as the dissertation itself, #7; references and links below).

The equations that I worked through provided some insight into the “On what?” question. The equations said that:

- the significance of the choice depends upon the variance of total output under a price control (as opposed to strict quantity standard);
- the direction of the significance depends on the difference between the slopes of the marginal benefit and marginal cost curves; and
- the variance of total output under the price control depends on the slope of the marginal cost curves.

The intuition behind these results turned out to be fairly simple to explain for the single firm model. There were two cases that make this clear:

- Given a quantity control, a single firm would produce up to the specified quantity regardless of the market clearing price. The price would be high for high-demand periods, low for low-demand periods, and average for circumstances close to the mean. The benefits of quantity restrictions would stay the same, given that the specified fixed quantity would clear the market regardless of demand. As well, the single firm market would be unique and isolated by Weitzman’s assumptions, so there is no place for secondary changes in benefits.
- Allowing output to vary depending on demand conditions by setting a price control for which the *expected* output matched the quantity standard would allow the firm to increase its expected profits. Compared to the average, output would climb for high-demand and fall for low-demand – both to the benefit of the supplier. How do we know that will happen? Because the supplying firm would not change its output if it were not worthwhile to do so.

Unfortunately, variable output allowed by a price control decreases expected benefits for ordinary citizens to an extent determined by the curvature of the consumers' benefit curve. The reason is that increases in quantity above the average increase benefits society more slowly than reductions below the average cause harm.²

It follows, that we had discovered a tradeoff. Would you, if you were to move from a standard to a price control that would achieve the same outcome on average, achieve efficiency gains to the firm that would exceed the damage done to consumers? Maybe, but maybe not. And why not?

Here are the two cases so you can consider how applications of this intuition can inform action decisions for two pollution examples:

Case 1:

An emitting firm would always release up to the allowable quantity under the quantity control (and maybe more if the fine for violation were small).

Case 2:

Given a price control, the emitting firm would vary its emissions. It would emit more when demand for its product was high, and emit less if demand were low, and medium emissions when demand approximated the average.

We can now try out the is intuition for these two specific examples – still for a single firm and a single market.

First of all, for example, consider sulfur emissions. In this case, annual emissions matter and there exist existential thresholds. It follows that annual variability in increased emissions can do extraordinary harm. Damages could go up more quickly during periods of high product demand that generate high emissions, but they would fall more slowly when demand is lagging.

Flexibility in emissions allowed by a tax would, therefore, be potentially extremely expensive in terms of the economic accounting of environmental

² This is a reflection of diminishing marginal utility – a fundamental assumption in most of economics. A little more is better, but not so much if you are rich, and really a lot if you are poor.

damage, but this extra damage could be avoided by setting a quantity standard.

For carbon emissions, though, damages depend on temperature increases which themselves depend on *cumulative emissions*. It follows, therefore, that annual variability in emissions around a predictable annual average does not add to expected costs as long as cumulative totals over a specified, relatively long-term time horizon are constrained. Emissions may look large in any given year, but they would be smaller in other years.

It is here, based on straight up economics, that an emissions tax (this time on carbon) would be preferred, because the variability in emissions is essentially harmless over time.

Things get a little more complicated with multiple sources of pollution. The tradeoff still hinges on the variability of cumulative emissions, but now it is the sum of multiple firms' collective actions.

With a price control, they all face the same price for each unit of pollution emitted and they could bargain to make things better – for themselves and for society.

With firm specific quantity controls, though, total emissions would be fixed because all firms' emissions would be fixed. But would that be optimal

Within a cap-and-trade environment, firms could buy or sell permits from each other so that they could respond to high or low demand in their own markets as much as they want – that is, *they can maximize their profits subject to the constraint that their net total activity in the emissions market would cancel out – and therefore cause no additional harm*. In that way, lost expected benefits from pollution variation would be eliminated.

Simple application of this intuition confirms that a cap-and-trade regulation always dominates setting strict and firm specific standards for every emitter. Total emissions are fixed under both, but cap-and-trade regulation allows some flexibility across firms that makes them more profitable (otherwise, they would opt out of trading). The environment does not care where the pollution comes from, so the key here is that buying or selling permits will only occur if it is in two firms' best interest – meaning that net profits will increase.

Nonetheless, the Weitzman tradeoff still applies in the aggregate choice between a price (a tax) and a *total* quantity constraint with a permit market.