Remarks to
G20: International Conference on Climate Change
Venice, Italy
July 11, 2021

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Let me start by conveying my thanks to the Bank of Italy and the G20 for sponsoring this important occasion to reflect on the state of climate change policy in our countries. We meet today in the midst of an alarming outbreak of climatic impacts in our countries –rising sea levels, giant wildfires, deadly heatwaves, and 1000-year floods. The central question is whether our political systems can catch up with the geophysical realities that threaten our lives and livelihoods.

No place on Earth could better serve as a venue for this discussion than Venice. People often associate Venice with climate change because of pictures of tourists wading through its fabled piazzas in *acqua alta*.

However, my appreciation of Venice comes because it lives under three unique flags. The first is the flag of Venice. Among its many remarkable features is that Venice has produced the longest-lived democracy of any major polity in the world. The democracy in Venice, until it was interrupted by Napoleon, survived 500 years. It is a reminder that humanity's objectives can best be served under the rule of law and democratic institutions.

Additionally, a second flag is the flag of Italy. The flag of Italy is important for many reasons, but I particularly want to celebrate Italy as the home of the first universities. While universities in the early days were rather parochial institutions, they gradually evolved into institutions of independent thinking, of social and natural sciences, of humanistic thinking, of rational discourse. We could not have this discussion today – filled with measurement, analysis, statistical reasoning, and modeling –

without the deep knowledge about natural and social science that is the product of the world's great universities.

The final flag in Venice is that of the European Union. The EU is unique as the major multinational government in the world today. It is a "club of nations," where the activities that spill over borders, such as transnational emissions or displaced migrants, can be regulated by the center. This kind of club will be necessary if we are to make significant progress in slowing greenhouse-gas emissions in the years to come.

Democracy, science, and multinational agreements – all three are the inspiration for the policies and thinking we need to deal with climate change.

Failure of policy

Moving from the institutional background to our topic today, this talk will cover four issues. The first one concerns the impact of climate change policy to date. The basic conclusion is that we have seen no major change in the trajectory of CO_2 emissions over the last three decades.

Figure 1 shows the trend of decarbonization from 1990 to 2019. The figure shows the trend in the carbon intensity, which is CO_2 emissions divided by global real GDP. The figure shows a straight red line, which is the trend, declining at 1.8 percent per year. Additionally, the graph shows the dotted blue line, which is the actual trend in carbon intensity.[ii]

The key takeaway from Figure 1 is that there has been no change in the trend of decarbonization over the last three decades. So even with all the international agreements, the Framework Convention of 1994, the Kyoto Protocol of 1997, the Copenhagen Accord of 2005, and the Paris Accord of 2015, along with twenty-five conferences of the parties – through all these, the rate of decarbonization remains unchanged. This graph is the central one to examine if you want to know the effectiveness of current climate policies.[iii]

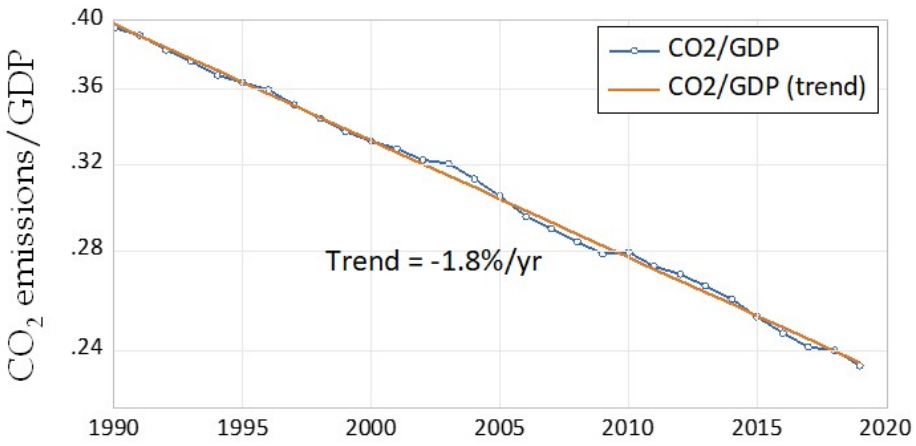


Figure 1. Trend in decarbonization, 1990 – 2019
The carbon intensity of global production has declined continuously at 1.8% per year since 1990, with no apparent impact of climate policies. Data exclude China. Straight line is the trend, while line with circles is actual.

You might ask, why is that? There are three reasons, which will be explored in the rest of this talk. To begin with, the price of CO_2 emissions in the world are essentially zero. So, there is no real market incentive to decarbonize. Secondly, our economies suffer from inadequate investment in low-carbon technologies because of the structure of innovation incentives, or what is known as the knowledge externality. Finally, the entire structure of policy is hampered by the syndrome of free riding. Countries are free-riding on the actions of others, and that tendency undermines strong climate agreements.

This overview figure about no progress leads naturally to the following discussion about low prices on greenhouse-gas emissions, weak incentives for low-carbon technologies, and the syndrome of free-riding. Given these three facts, it cannot be a surprise that the world has made so little progress to slow climate change.

Paris Accord and the 2 °C target

Looking forward, what path for emissions is necessary to attain the international objective of limiting temperature increase to 2 °C? Figure 2 shows three scenarios. The top line shows emissions under current policies. Emissions in 2019 were around 54 billion tons of CO_2 equivalent per year, including non-CO_2 gases. With the low level of current policies at both the national and international levels, emissions are projected to grow about one percent per year over the next five decades – up, not down.

The bottom line in Figure 2 shows a representative path that will meet the international 2 °C target. Note that it turns down sharply immediately. Whereas current policies will show a rise of emissions of almost 25% by 2030, the 2 °C path requires a decline of 30% in emissions by 2030 and reaching zero emissions shortly after 2050. (All figures are relative to 2015.)

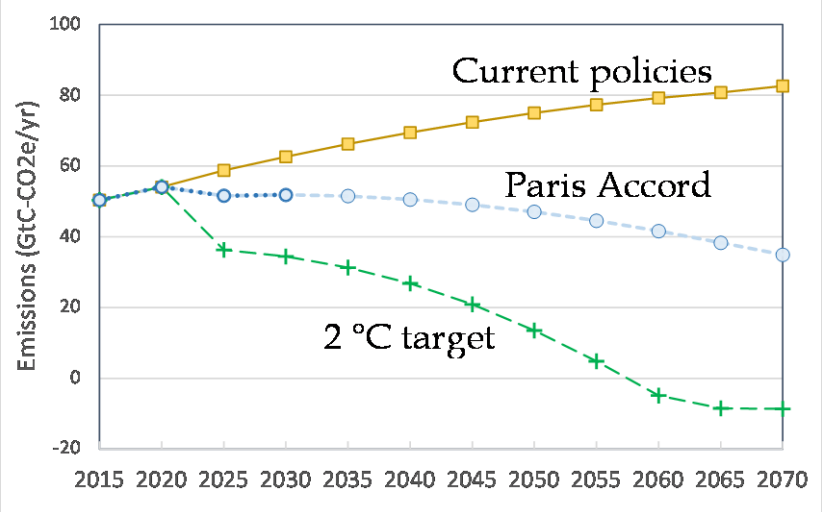


Figure 2. CO_2 emissions under three scenarios, 2015- 2070

Top line is the trend with current minimal policies. Middle line is the projection with Paris commitments to 2030 and then progressively deepened after that time. Bottom line is the emission reductions necessary to limit global temperature increase to 2 °C.

The middle line in Figure 2 shows the emissions under the Paris Accord. The estimates for 2030 are actual national commitments under the Accord, while those after 2030 are projections of a continued tightening at the same rate as during the 2015 – 2030 period. The emissions trajectory under the Paris Accord is virtually flat, rising 3% from 2015 to 2030 and then declining slightly after that. Moreover, these projections assume that Paris commitments are actually honored.

The main point is that meeting the 2 °C target would require an immediate and very sharp drop in emissions. Even if countries meet the Paris accord, they will be only a fraction of the way to meeting our international objective of limiting temperature increase to 2 °C.

We should recognize that countries have moved beyond Paris in their domestic commitments. Many countries are committed to attaining zero net emissions by mid-century or shortly thereafter. However, these are soft commitments, with no international agreement, and lacking the actual policy mechanisms to implement them.

In reality, there is a vast chasm between aspirations and policies. In the next sections, I discuss some of the policies that can bridge the chasm.

The landscape of carbon pricing

An aggressive policy to slow global warming has three key components that are necessary for meeting our objectives: universal and harmonized carbon pricing, strong support for low-carbon technologies and a new approach to international agreements.

We can begin with carbon pricing. It has been a key feature of policy proposals for many years that high prices on CO_2 emissions are a necessary ingredient in climate policy. This means that emissions of CO_2 and other major greenhouse gases must have an economic penalty attached to them. So, for example, when a power plant burns a ton of coal, and the government has levied $50 per ton of carbon prices, this will add approximately $120 per ton to the price of coal. Other sectors will have a smaller impact. It will add about $230 to the cost of driving a gasoline-

powered car but only $1 to the cost of financial services. Moreover, the price should be rising over time to allow the economy to adjust and to gradually tighten the screws of reductions.

A second point, which is less obvious, is that the level of the carbon price needs to be harmonized to meet the objectives. This means harmonized (that is, equalized) across countries and sectors. It won't do to have some sectors, say motor fuels, with astronomical carbon prices, while other sectors such as steel or aluminum production have low carbon prices. Harmonization allows the world to attain its objectives at minimum cost. Calculations suggest that putting the burden of reductions on half the countries or half the sectors will raise the cost by at least a factor of two.

How high a carbon price is necessary? Economic estimates that include only measured damages suggest a price of around $50 per ton in 2020, rising about 3% per year. However, this will not attain the objective of a 2 °C target or the target of zero net emissions by 2050.

For the more ambitious target of net zero emissions by 2050, estimates vary widely because it is so ambitious. A recent analysis finds a near-term carbon price of around $\$500/tCO_2$ in 2030, rising to around $\$1000/tCO_2$ by 2050. But the estimates vary by a factor of 10.

What is the reality here? The fact is that carbon prices, emission prices, and the regimes under which they operate are highly fragmented. If you look at the calculations of the actual carbon price that have been prepared by the World Bank, the average carbon price in 2019 was about $\$2/t\ CO_2$. It is not even in the same universe as what is needed for international objectives. The low carbon prices are one reason why policies have been so ineffective, as shown in Figure 1.

The next picture in Figure 3 shows what I call the carbon price landscape, coming from the impressive World Bank Report, showing the actual regimes and prices in different regions. The horizontal axis shows the share of emissions that are covered by the regime. The vertical axis shows the carbon price of the regime.

The large green bubble in the lower middle is the European Trading System (ETS). This is the largest system and is also a multinational trading

scheme. Even the ETS, as impressive as it is, has two flaws. The first is that the price is relatively low. It has been as low as \$5/t CO_2 and as high as \$50/t CO_2. In the period covered by the World Bank report, it was a little under \$20/t CO_2. More important is that the ETS covers only a fraction of the EU economy – slightly under half. At the far right are regions with a very high coverage rate and a very low tax. These include the Quebec cap and trade and the California cap and trade. Off the chart to the top are Sweden and Switzerland, with very high prices but very low coverage.

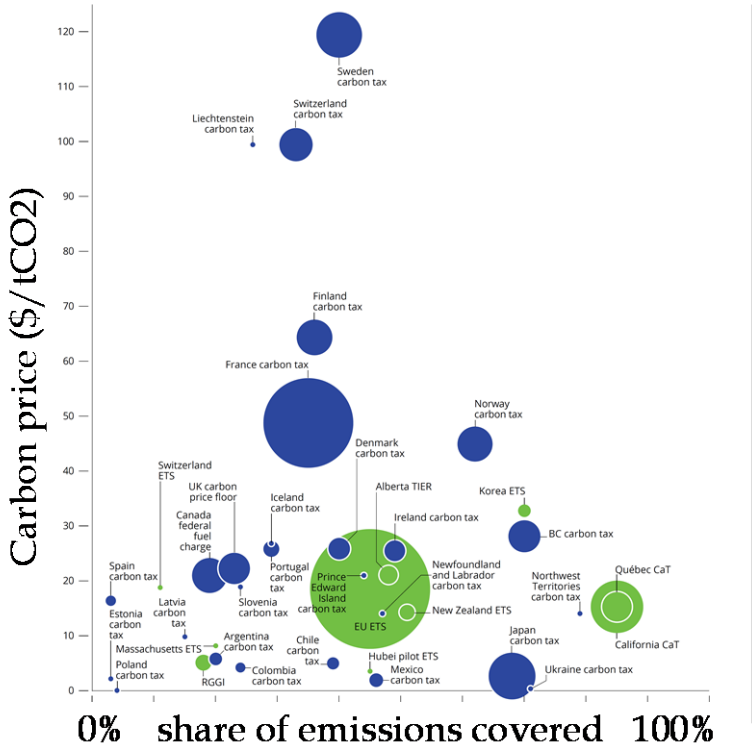


Figure 3. The carbon price landscape, 2019

The figure shows the various carbon pricing plans in different regions. Green are cap-and-trade, while blue are carbon taxes. Note that 80% of global emissions are uncovered and are therefore at the (\$0, 0%) origin. Source: World Bank.

Figure 4 then shows the policy necessary to meet international targets. The large dot there superimposes what is needed to meet international objectives on the actual landscape. Suppose the requirement is \$100/t CO_2 and 100% coverage. The point here is that high and harmonized carbon prices are key to climate change policy, but carbon prices today are very low and very fragmented.

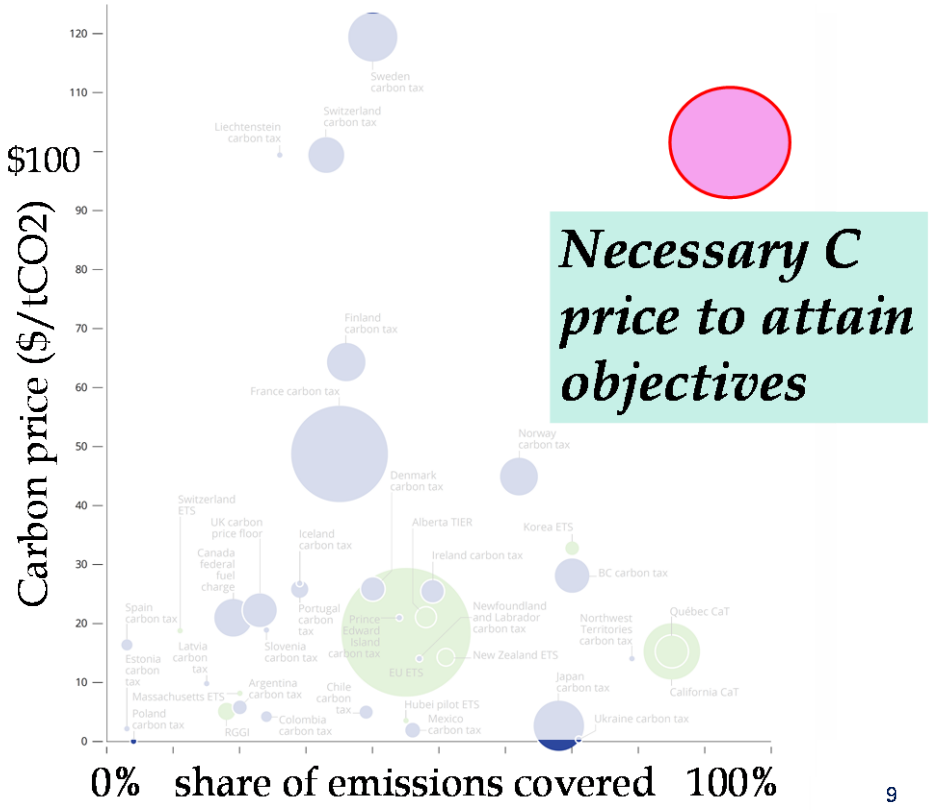


Figure 4. Actual and ideal carbon price landscape

This figure adds a hypothetical regime at the upper right with \$100 per ton CO_2 covering 100% of sectors. This policy is the minimum that what would be needed to achieve international objectives.

Support for low-carbon technologies

A second critical area for policy is enhanced support for low-carbon technologies. This area is less emphasized, perhaps because people have

focused on carbon prices. But developing radically new technologies is central to meeting our objectives. Just as countries used enhanced incentives to develop COVID-19 vaccines in record time, we need to use all our ingenuity to accelerate low-carbon technologies.

The key reason for the need is that a low- or zero-carbon global economy will need to replace large parts of our energy infrastructure and/or develop brand-new carbon removal technologies. Fossil fuels accounted for 84% of the world's primary energy consumption in 2019. A rough guess is that it will take in the order of $100 - $300 trillion of new capital to reduce this to zero net emissions over the next four decades. And much of that new capital will be technologies that are largely unproven or immature today.

From an economic point of view, research and development (R&D) suffers from a severe externality in the same way that climate does. The public returns on green innovation are much larger than the private returns on green innovation. Indeed, there is a double externality for low-carbon R&D because low prices on emissions reinforce the normal gap between the public and private returns to innovation. In other words, green inventors get only a small fraction of the returns to their innovations, and this is exacerbated because the reduced emissions are underpriced in the marketplace.

A good example of the double externality is carbon capture and sequestration (CCS). Economic returns to the research and commercialization of CCS spill over to other firms and future users. However, in addition, the captured carbon is worthless in most countries because carbon emissions are drastically underpriced, which makes investments in CCS commercially unviable in the market and therefore in corporate boardrooms.

The same logic holds for advanced nuclear power and the hydrogen economy, which have no advantages over fossil fuels because of low carbon prices. Hydrogen will never be the wave of the future when carbon prices are $2/t CO_2.

It is critical to emphasize that the need is for the support of *research and development*, not production. We need to develop new low-carbon technologies and energy sources, which is much more important than subsidizing the current generation of low-carbon equipment in cars, houses, and industry.

The policy recommendations here are two: First, it is critical to have high carbon prices to provide a market for low-carbon technologies. In addition to that, we need enhanced incentives at the level of our government's fiscal subsidies and intellectual property rules for low-carbon technologies.

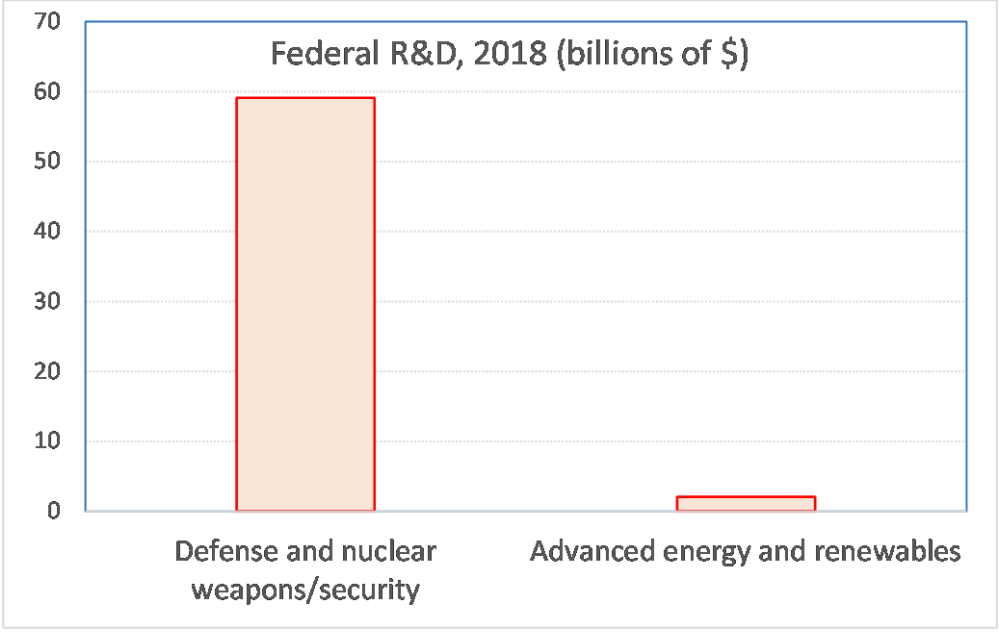


Figure 5. US Federally Supported Research and Development, 2019

US federal priorities are largely tilted to supporting military research, with only a few crumbs left over for low-carbon technologies.

Here is one example of misplaced priorities in our governmental research budgets. Let's look at what the US government spends on military research compared to spending on renewable energy, shown in Figure 5. R&D on military systems – new aircraft, drones, AI, robots, nuclear weapons, and security. The most recent data indicated federal spending of

$60 billion dollars on federal research and development; by contrast, advanced energy and renewables received R&D funding of only $2 billion. While there may be political logic here, there is no societal logic to this imbalance given the climate threats the globe faces over the coming years.

Thus, the second major priority – surely a happier prospect than carbon pricing – is to have a major enhancement of governmental support for low-carbon technologies.

The syndrome of free-riding

Why have landmark agreements such as the Kyoto Protocol and the Paris Accord failed to make a dent on emissions trends? The reason is *free-riding*, which is the tendency for countries to put their national interests over global interests. When a country says not only "America First" but "Only America Counts," that displays the syndrome. Nationalist policies that maximize the interests of a single country at the expense of other countries – beggar-thy-neighbor policies – are a poor way to resolve global problems. Non-cooperative nationalist policies in the area of tariffs, ocean fisheries, war, and climate change lead to outcomes where most or sometimes all nations are worse off.

It is painful to acknowledge, but free-riding lies at the heart of the ineffectiveness of our international climate agreements. We must acknowledge that our international climate policy is at a dead end.

The fatal flaw in the 25 Conferences of the Parties (COPs) is that they are based on the principle of unanimity and have produced voluntary agreements. Indeed, all of our climate agreements dating back to the Framework Convention through the Kyoto protocol through the Paris Accord are voluntary. Countries may agree to take steps, but there are no penalties if they withdraw or fail to keep their commitments. Under the Kyoto protocol, when the US withdrew, there were no penalties. When Canada withdrew, there were no penalties. In every agreement to date, there are no penalties for non-participation, and there are no penalties for breaking promises.

You might ask, what is wrong with that? A voluntary treaty in climate change will result in very little emissions reductions – that is the lesson of history and economic theory and is validated by the climate agreements as shown in Figure 1.

For you Finance Ministers, the problem of voluntary cooperation will sound familiar. It is similar to the race to the bottom in global corporate taxation. Free-riding has substantially reduced corporate taxation; free-riding in climate basically ensures that countries will get stuck at the bottom. We see declining corporation taxes and minimal carbon prices.

One proposal to combat free-riding in climate treaties is what I have called a "climate club" to overcome free-riding. Scholars who study effective international agreements find they need sticks as well as carrots – that is, they need penalties for non-participants and rule-breakers. The trade treaties and the World Trade Organization epitomize an effective approach. They require countries to make costly commitments that are in the collective interest, but they also penalize countries who do not keep their commitments.

This would be a model for an effective climate agreement. Here is an example that has been studied and modeled at Yale and other universities. You might start with a target carbon price. Countries would be obligated to impose minimum domestic carbon prices, say $50 per ton CO_2 rising over time. The mechanism for effecting this would be decided by the country – it could be a cap-and-trade mechanism or a carbon tax. Moreover, countries would keep the revenues for their own purposes.

The new feature is that there is a penalty on non-participants and countries who fail to meet their obligations. In our analysis, we have used a uniform penalty tariff, which is much simpler to administer than a countervailing duty.

The modeling we've done at Yale suggests that a $50 per ton carbon price plus a uniform tariff penalty of 3 to 5% would be sufficient to induce strong participation in a climate club. We find that it would become a successful club if at the outset it contained key club regions such as the EU, the United States, Japan, and China

Summary

I will summarize with the four key points. First, there has been little progress in slowing global warming. Even with all the domestic and international activities, the rate of global decarbonization is unchanged over the last three decades. We need to implement a swift and sharp downturn in emissions to meet our objectives.

Second, a central goal of policy is high and harmonized carbon prices. Carbon prices should start at about $50 per ton CO_2 and rise sharply after that. They need to be harmonized across countries and across sectors. Actual carbon prices are virtually zero today.

The third point, which has been neglected, is the importance of low-carbon technologies. Our countries are drastically underinvesting in fundamental research and development in the energy systems for a low- or zero-carbon economy. This must be remedied through high emissions prices and strong support by governments.

Finally, effective international policies require some kind of club structure – a structure where steep abatement is induced with both carrots and sticks. In a climate club, countries would participate because it is in their interest, not because they are cajoled or coerced to participate.

A club structure with high carbon prices and strong support for low-carbon technologies – these are the keys to meeting our ambitious objectives.

Thank you very much for inviting me to speak to this distinguished body.

Endnotes

[i] These written remarks augment the talk given to the plenary session at the G20 conference on July 11, 2021.

[ii] Carbon intensity here is calculated excluding China because China's numbers are so anomalous that they tend to distort the aggregate data. The numbers including China are only slightly different. I go through 2019 because the pandemic has disrupted economies too much to provide useful guidance after that.

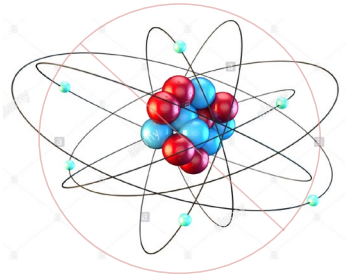
[iii] Data for Figure 1 are from EDGAR and the IMF. The series show there excludes China. Figure 2 is from the author based on historical data, the DICE model, and estimates from various sources on the national commitments under the Paris Accord. Results on the carbon price associated with the 2 °C target are from the DICE model and Keywan Riahi et al., "Long-term economic benefits of 1 stabilizing warming without overshoot 2 – the ENGAGE model intercomparison," in pre-print, 2021. Figure 3 is from Celine Ramstein et al., *State and trends of carbon pricing 2019,* The World Bank, 2019. Data in Figure 5 is from US Federal Budget, Analytical Perspectives, FY2020, "Research and Development." Estimates of need for new capital are from the International Energy Agency (IEA) and the Organization for Economic Cooperation and Development (OECD).

National and International Policies for Slowing Global Warming

William Nordhaus
Sterling Professor of Economics
Yale University

July 11, 2021
Venice, Italy

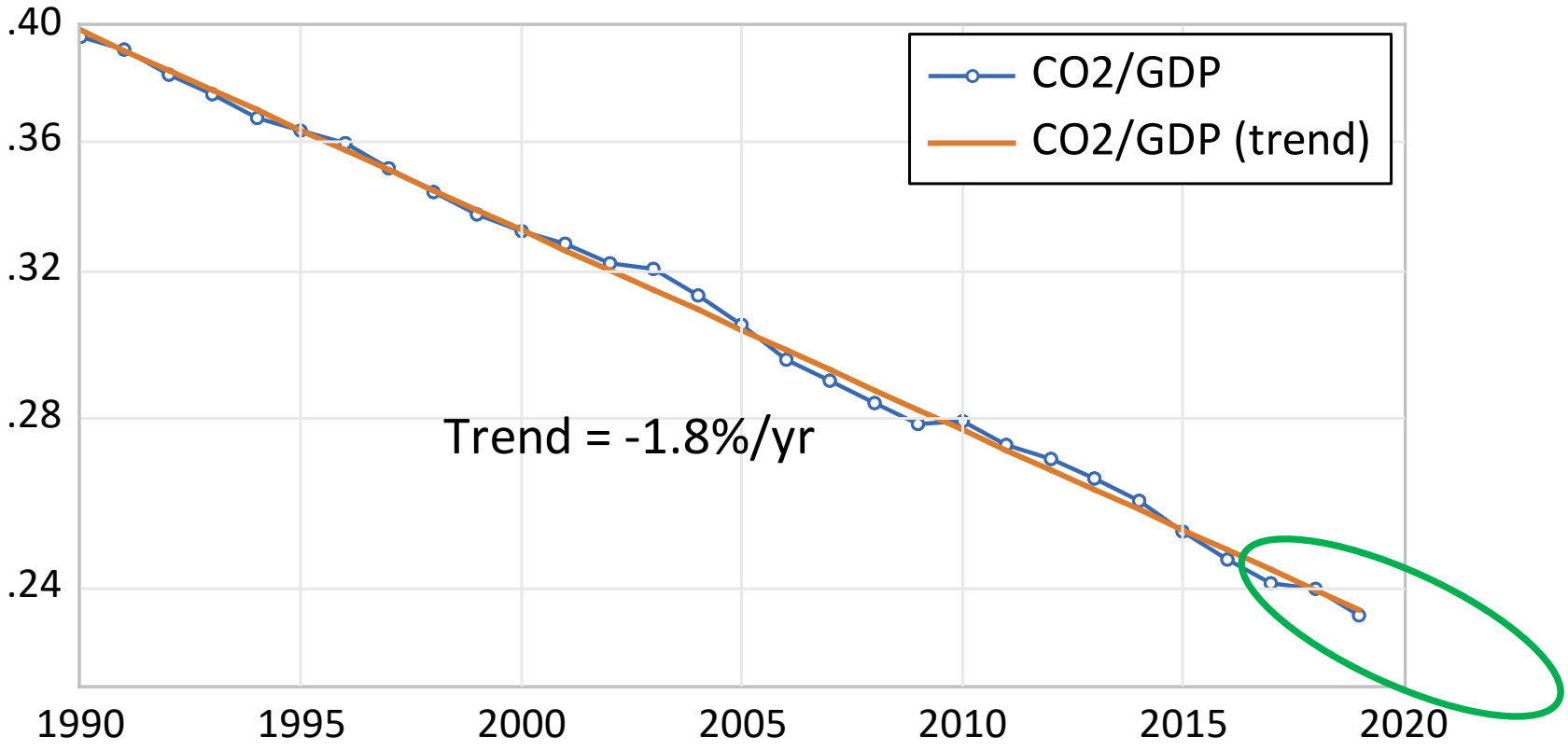
G20 Venice Climate Summit



Four key issues for today

1. No improvement in decarbonization
2. Carbon prices are much too low
3. Inadequate investment in low-carbon technologies
4. Free riding undermines climate agreements

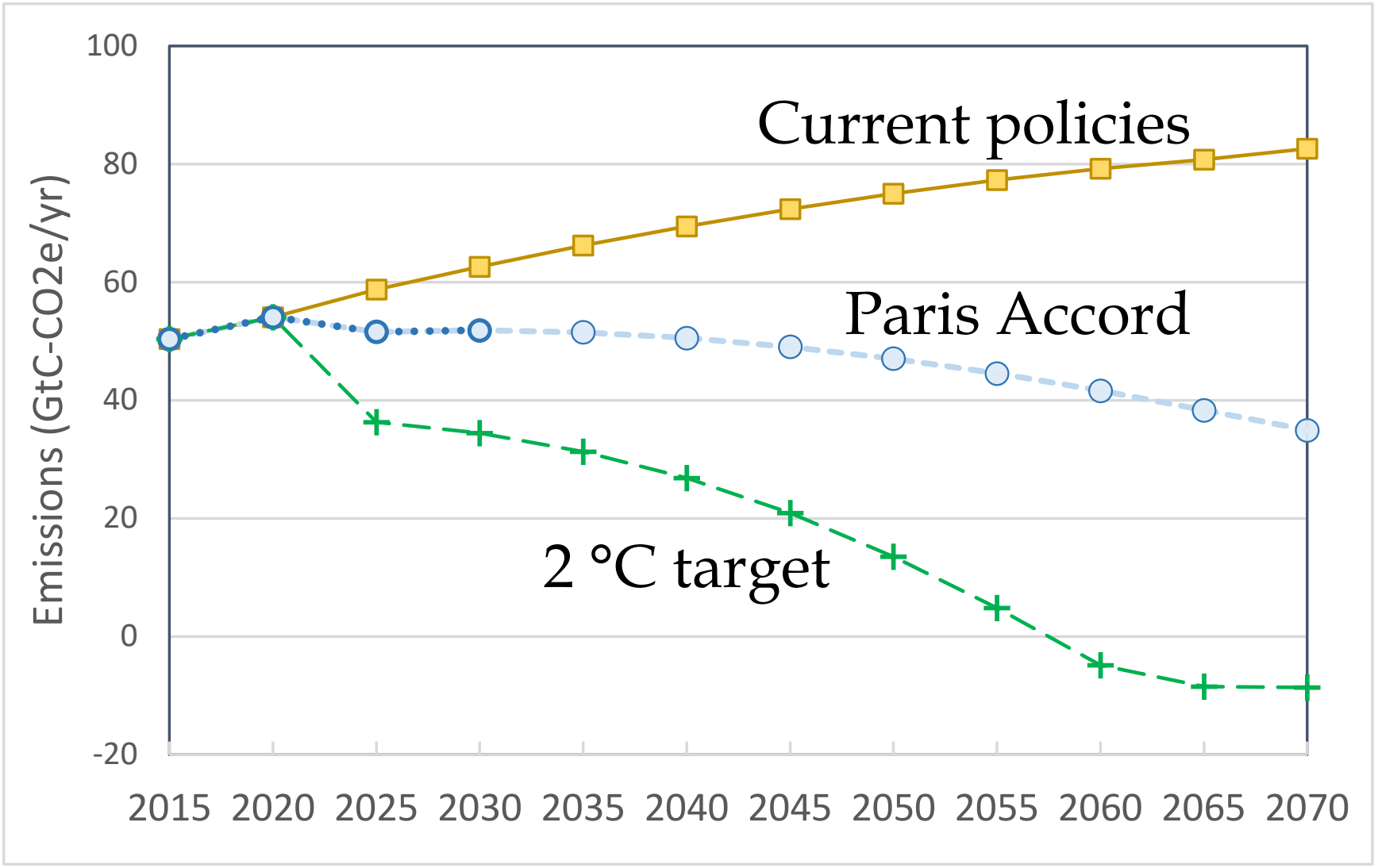
1. No improvement in decarbonization



Decarbonization = rate of change of the CO2/GDP ratio.
Data exclude China.

Policies are inadequate for international objectives

Emissions: Aspirations v Reality



2. Carbon prices are much too low

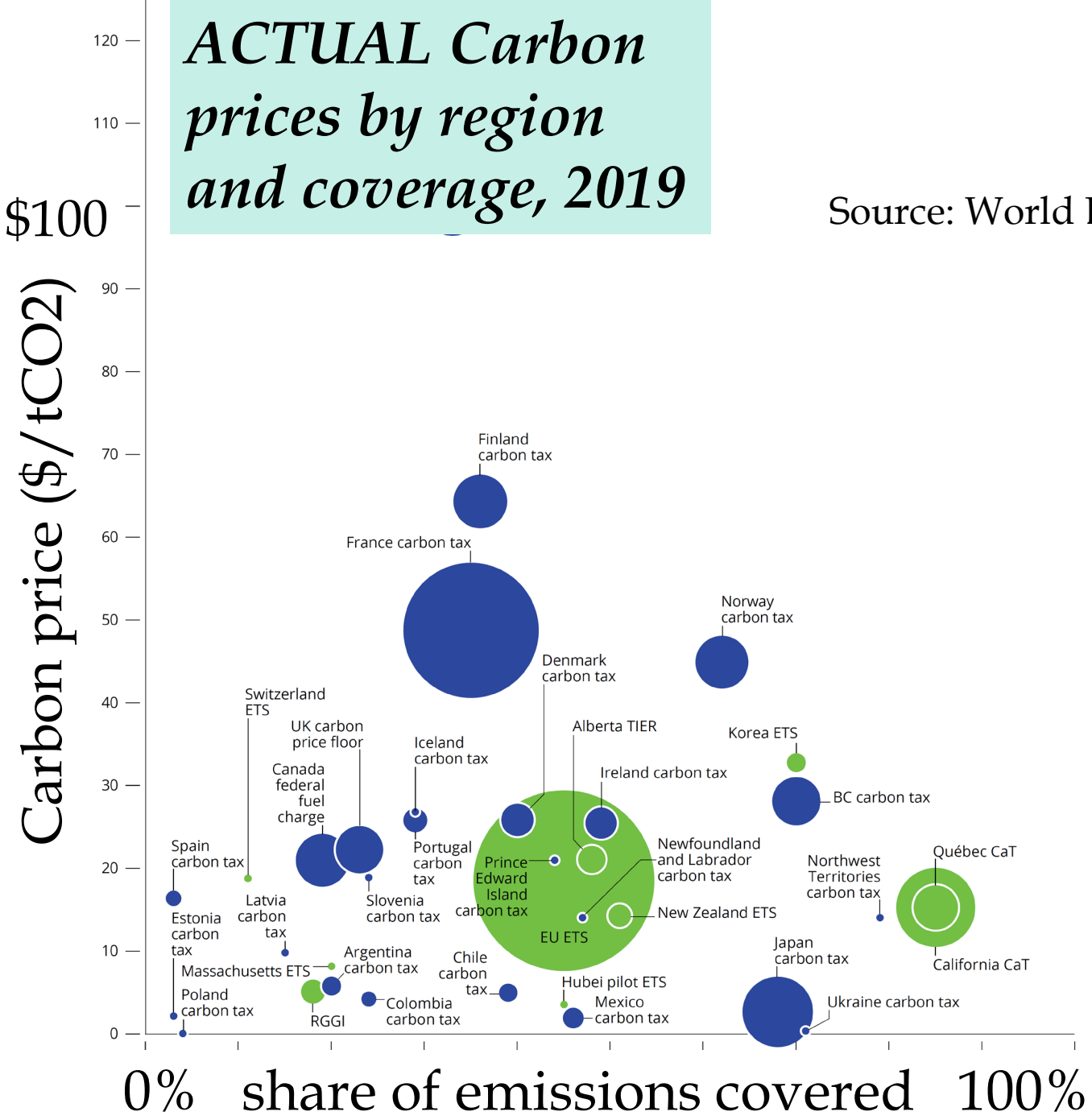
- High price on CO_2 emissions is the key to sharp emissions reductions.
- Level of price should be **harmonized** to meet climate target

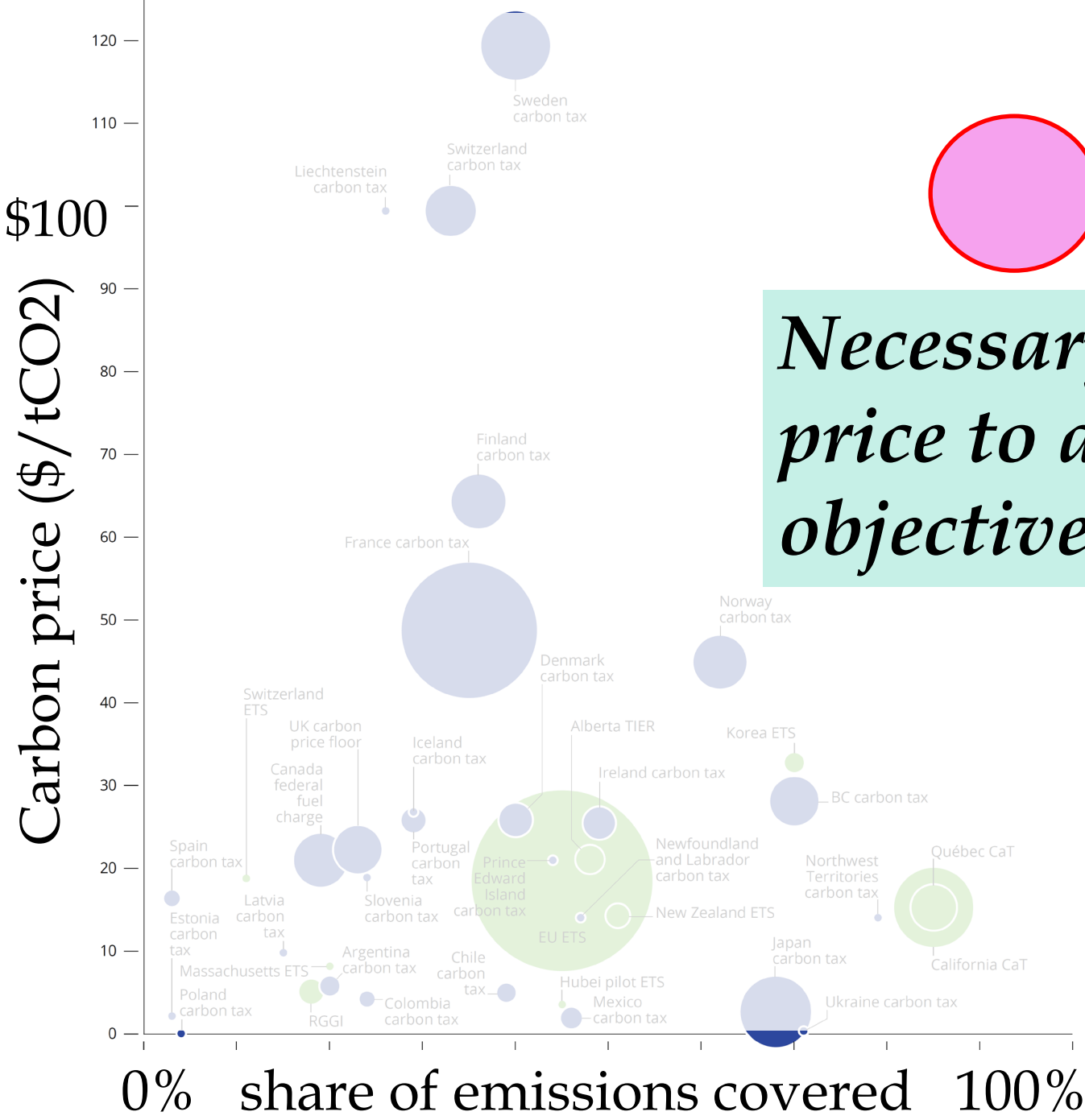
But …

- Prices and regimes highly fragmented.
- Current policy would require $50 - $150/tCO2
- Average carbon price in 2019 = $2/tCO2

ACTUAL Carbon prices by region and coverage, 2019

Source: World Bank





Necessary C price to attain objectives

3. Inadequate investment in low-carbon technologies

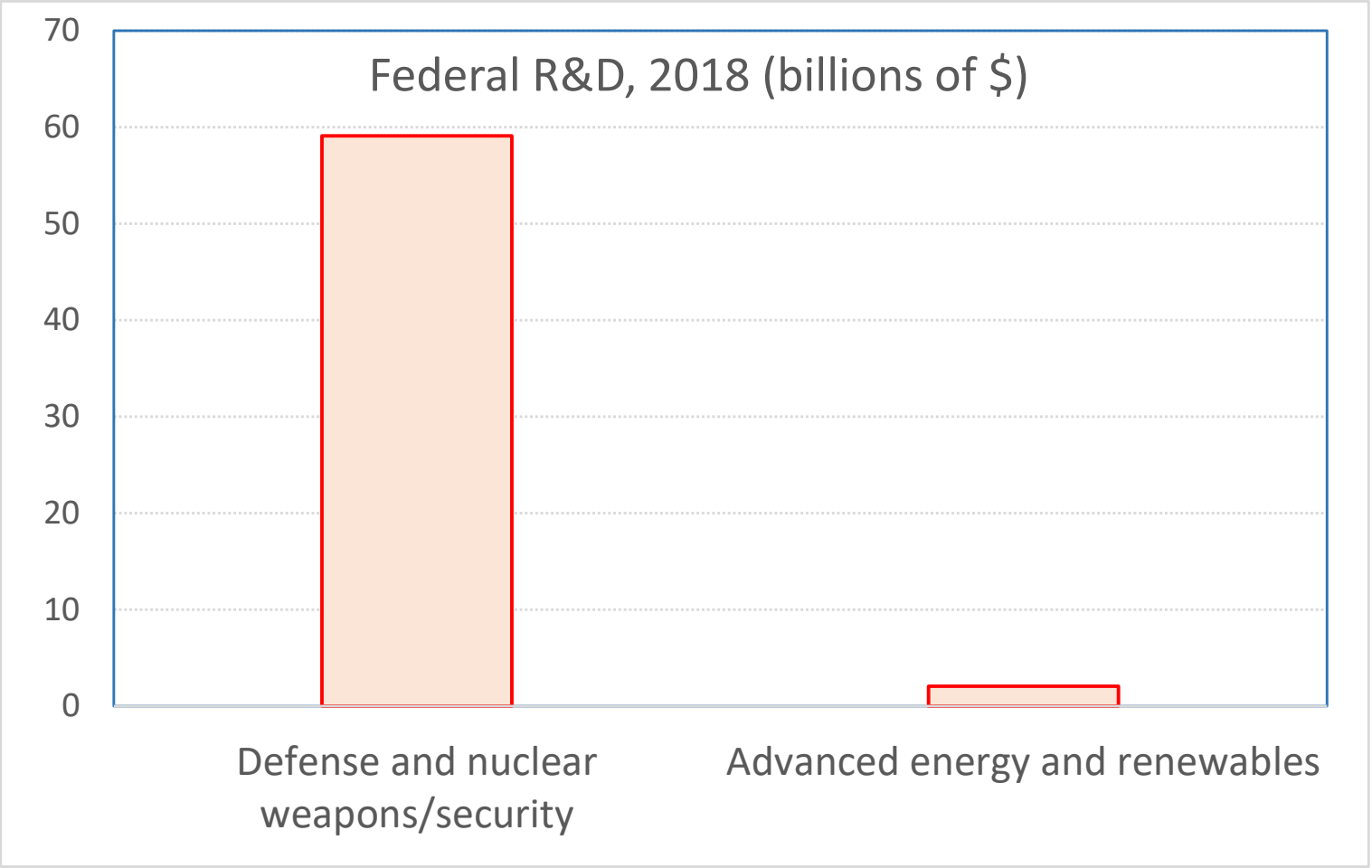
- Public return on innovation many times larger than private returns
- But even worse: there is ***double externality*** for low-carbon innovations:
  - normal innovation externality
  - climate impacts externality because C price too low

Policies requires

- fix climate externality through C pricing
- special incentives for low-C technologies

Note major imbalance between military and green R&D in the US (next slide)

Misplaced priorities in US federal R&D



Source: National Science Foundation

4. Free Riding Undermines Climate Agreements

- International climate policy is at a dead end.

… because international climate change policy is hampered by ***free riding :***

  - All agreements are voluntary.
  - Therefore, no penalties for non-participation

- Evidence is the failure to reduce emissions.
- Similar to race to the bottom in global corporate taxation.

A "Climate Club" to Overcome Free-Riding

- Effective international agreements require incentives: climate club with carrots and sticks.
- A **climate club** involves a regime with two features:
  - Target carbon price, perhaps $50 per ton CO_2
  - Penalty tariff on non-participants, say 3% penalty tariff
- Modeling suggests this would be much more effective than voluntary approach.

Summary

- Little progress on slowing warming.
- Central goal is high and harmonized carbon prices.
- Low-carbon technologies are critical but suffer from underinvestment.
- Effective international policies require climate club structure with carrots and sticks.