Title: Market Failures and the Design of New Climate Policy Instruments
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Summary
Recent legislation in the U.S. has provided the opportunity to inject enormous federal funding into policy instruments that have not been previously adopted at scale in U.S. climate policy. Moving beyond the combination of adoption subsidies, standards, and (albeit limited) attempts at carbon pricing that largely characterized climate policy over the last decade, the Infrastructure Investment and Jobs Act (IIJA) of 2021, CHIPS and Science Act of 2022, and Inflation Reduction Act (IRA) of 2022 have transformed not only the scale of U.S. climate activities but also the types of policies adopted. These laws have authorized significant funding for clean energy demonstration projects ($21 billion under IIJA), loan guarantees ($8.6 billion in appropriations, $290 billion in lending authority under IRA), a national green bank ($27 billion under IRA), and regional technology hubs ($11.5 billion under IIJA), among other programs.

One common characteristic of these newly scaled policy instruments is that they are motivated not only by the presence of un-priced carbon externalities driving a wedge between private and social costs of emissions, but also by a series of innovation market failures. As has been well documented in the economics literature, these additional innovation market failures exacerbate and interact with the carbon externality in complex ways (Jaffe, Newell, and Stavins, 2005). Firms may fail to fully appropriate the benefits of new knowledge creation, either in R&D, learning-by-using, or learning-by-doing, leading to under-provision of new technologies by the private market (Bollinger and Gillingham, 2012; Covert and Sweeney, 2022). Consumer inattention or failure to internalize positive spillovers from adoption may also slow the deployment of socially beneficial technologies (Allcott and Taubinsky, 2015). Information asymmetries between the developers of new technologies and those with access to investment capital, combined with an environment of regulatory uncertainty, may lead to financial market frictions that impede the creation of low-carbon products (Howell, 2017; Ewens, Nanda, and Rhodes-Kropf, 2018). Finally, the presence of network externalities or other complementary infrastructure investments may cause private firms to under-provide low-carbon products relative to a social planner who could simultaneously deploy, say, electric vehicles and charging stations or solar panels and grid-scale storage (Li, 2019; Butters, Dorsey, and Gowrisankaran, 2021).

While previous studies in the economics literature have examined various innovation market failures around low-carbon technologies, the economics profession has been slow to assess these new policy instruments in the context of *specific* market failures warranting *specific* types of policy intervention. Instead, the motivation for these policies is often vague, with economic theory providing little guidance for priorities in program development. Prior assessments of these policy instruments, when they have been adopted at a state level or in other sectors such as health care or defense, have provided valuable case studies or descriptive insights about past successes or failures.[1] However, there are further opportunities to formalize these insights through economic modeling and to connect program design decisions to the economic literature on innovation market failures.

The intended contribution of this paper is threefold. First, through a combination of literature review and simple analytical modeling, we seek to clarify the potential relationship between these

[1] See, for example, Nemet, Kraus, and Zipperer, 2016; Hart, 2017; and Khatcherian, 2022.

newer policy instruments and specific market failures affecting decarbonization efforts. As program leaders plan for policy implementation, it is important to clarify the market failures warranting policy intervention, so that policies may be designed as efficiently as possible. Second, we seek to identify potential tradeoffs between policy designs that target the relevant market failures, distributional goals, and political economy considerations, as relevant. These other policy goals may take the form of more equitable benefits sharing across U.S. communities or improvements to U.S. economic competitiveness or geopolitical position; in either case, clarifying potential tradeoffs between these considerations and direct targeting of market failures can help policymakers to make more informed decisions. Finally, we aim to use the lessons learned from the literature review and analytical modeling exercise to identify priority areas for carefully designed program evaluation. Given the paucity of rigorous empirical evidence on the impacts of these new policy instruments, even at smaller scales, it is likely that we will identify areas where the theory is ambiguous and further empirical analysis is needed. These areas would then be leading contenders for future policy experimentation aimed at generating knowledge about policy effectiveness that could then be incorporated in subsequent policy implementations.[2]

In keeping with longstanding NBER tradition, this paper will not make policy recommendations. Instead, the goal is to clarify links between the economic literature on innovation market failures and the large-scale use of these newer policy instruments, in a manner that is palatable for those charged with program administration.

An Example: Demonstration Projects

To illustrate many of the above ideas, we consider the economics of technology demonstration projects as an example. Technology demonstration projects, sometimes called first-of-a-kind projects, seek to bridge what is often labeled "the second valley of death" between product or technology prototypes and commercially bankable projects. In the last decade, the federal government funded a handful of demonstration projects in particular energy technology areas such as advanced nuclear reactors and carbon capture, utilization, and storage; states such as New York and California have also been active in funding clean energy demonstration projects. The IIJA significantly increased both the scale of federal funding for demonstration projects and the scope of energy technologies that will receive this funding, leading to the creation of a new Office of Clean Energy Demonstrations within the Department of Energy. This new office has a broad mandate to use demonstration projects to de-risk technology, unlock follow-on investment at scale, and work towards an equitable energy transition.[3]

The motivations for public funding of demonstration projects can generally be categorized as addressing one of several market failures. First, demonstration projects create a non-appropriability problem (Hart, 2017). Developing a new technology at scale and integrating the technology into existing systems often yield new knowledge whose benefits spillover beyond the entity funding the project. For example, project development at scale may require training contractors or regulators in the installation and use of the new technology, which may then reduce the start-up costs for all subsequent projects. Likewise, integrating a new technology with systems such as the electric

[2]This effort will be highly complementary to recent work on program evaluation for new federal climate policies (Aldy, 2022). Aldy identifies high-priority program characteristics for undertaking rigorous, causally identified program evaluation, such as programs with long duration, overlapping design across multiple programs, and programs with larger budget appropriations. Our work would identify areas where theoretical ambiguity around market failures and program design mean that empirical analysis is particularly important.

[3]See: `https://www.energy.gov/oced/office-clean-energy-demonstrations`.

grid or a large manufacturing facility may reveal new information about the product's commercial viability, which may benefit both the project developer and its competitors. Second, demonstration projects also suffer from imperfections in financial markets, such as investors' discount rates differing from those of a social planner. Further coordination frictions have also meant that institutional mechanisms for increasing efficiency in financial markets – such as portfolios of risky assets or relatively standardized venture capital contracts – have largely not developed for demonstration projects in the energy sector (Khatcherian, 2022).

This discussion of market failures and demonstration projects will be formalized and extended in the paper itself. Do existing reports on "lessons learned" suggest which types of new knowledge creation are likely to face the most substantial non-appropriability problem, leading to more sizeable underfunding of demonstration projects by the private sector? What are the range of solutions that contract theory has proposed for addressing asymmetrical information in new technology investment, recognizing that the specific solutions adopted in venture capital have largely not worked for demonstration projects? What are possible program evaluation strategies for disentangling the relative effectiveness of publicly-funded demonstration projects at combating these different market failures? The paper will seek to distill insights from economic theory to be useful for those charged with implementing demonstration projects, as well as the other climate policy instruments newly scaled in recent legislation.

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