Optimal Innovation Policy and the Reallocation of Public Funds: Evidence from China's Pharmaceutical Reforms

Panle Jia Barwick Ashley Swanson Hongyuan Xia Tianli Xia *

June 2026

1 Introduction

How should governments use limited public funds to promote socially valuable innovation? This question is especially important in pharmaceutical markets, where innovation is costly and uncertain, but successful products can generate large social benefits. Governments can shape firms' innovation incentives through a range of policy instruments, including R&D subsidies, insurance expansion, reimbursement rules, and price regulation (Bloom, Van Reenen, and Williams 2019; Garthwaite 2025). These instruments differ not only in how strongly they increase overall incentives to innovate, but also in how they shape the direction of innovation. By changing the relative rewards to different projects, public policy can influence whether firms pursue safer or riskier drugs, higher- or lower-value therapies, and drug types that generate different social returns (Acemoglu and Linn 2004; Budish, Roin, and Williams 2015; Finkelstein 2004).

This paper studies the optimal design and financing of public support for pharmaceutical innovation. We focus on two interrelated research questions. First, what form of public support best promotes high-value drug innovation when innovation risk and reward are

*Barwick: Department of Economics, UW-Madison, NBER, and CEPR, pbarwick@wisc.edu. Swanson: Department of Economics, UW-Madison and NBER, ashley.swanson@wisc.edu. H. Xia: Department of Economics, Cornell University, hx276@cornell.edu. T. Xia: Simon Business School, University of Rochester, tianli.xia@rochester.edu.

correlated? In particular, should governments rely more heavily on supply-side policies, such as R&D subsidies, or demand-side policies, such as insurance coverage and reimbursement support? Second, how should public funds be allocated across drug types so as to reduce misallocation and maximize social welfare?

Existing work has studied the effects of individual pharmaceutical policies on innovation, pricing, and access (Acemoglu and Linn 2004; Azoulay et al. 2019; Duggan and Scott Morton 2006; Gross and Sampat 2025). However, relatively little is known about how to rank alternative innovation policies from a welfare perspective when public funds are scarce and when policy instruments affect the composition, rather than only the amount, of innovation. This selection margin is central to the comparison between supply- and demand-side support. Supply-side subsidies reduce the cost of entering the innovation process and may therefore encourage marginal projects that would otherwise not be pursued. Demand-side subsidies, by increasing the return to successful innovation, may instead attract projects with larger potential benefits. The welfare ranking of these policies depends on how innovation risk is related to innovation value: if high-value projects are also systematically riskier, then policies that condition support on market success may have very different implications from policies that subsidize entry directly. Even less is known about how governments should finance such policies through the reallocation of existing healthcare spending.

We examine these questions in the context of China's recent pharmaceutical reforms. China provides a rich empirical setting because two major policy changes jointly reshaped the incentives facing drug developers and the allocation of public pharmaceutical spending (Barwick, Swanson, and Xia 2025). The National Reimbursement Drug List reforms expanded reimbursement for innovative drugs, increasing the demand-side returns to successful innovation. At the same time, the Volume-Based Procurement reform introduced competitive procurement for off-patent generics, sharply reducing public spending on drugs with widespread substitutes and freeing resources that could be redirected toward innovative medicines. Prior to the reforms studied here, roughly 80 to 90 percent of public pharmaceu-

tical expenditure went to off-patent generic drugs. Following the introduction of competitive auctions for generics, this share fell below 50 percent, freeing substantial public resources for innovative medicines. Together, these reforms generate variation in both innovation incentives and public fund allocation.

Using data on clinical trials, drug sales, and policy reforms, we estimate a structural model of pharmaceutical innovation. The model allows firms to choose whether to undertake drug development in response to expected costs, risks, and returns, and links these private decisions to social welfare. We use the estimated model to quantify the welfare effects of alternative policy instruments, measure the degree of public fund misallocation in pharmaceutical spending, and evaluate policy combinations that both promote high-value innovation and improve the financing of public healthcare expenditure.

Although the empirical analysis is based on the Chinese pharmaceutical market, the paper is designed as a broader policy-design study. The goal is not only to evaluate a particular institutional reform, but also to develop a framework for studying how governments should allocate public support across innovation policies when risks, rewards, and fiscal costs are jointly determined. The results speak to general debates about innovation incentives, public financing, and the efficient allocation of government spending across countries and sectors.

Related Literature This paper engages three distinct bodies of literature:

- Innovation policy: Much of the existing research focuses on direct supply-side interventions such as government subsidies and tax credits (Branstetter and Sakakibara (2002); Bronzini and Piselli (2016); Howell (2017); Dechezleprêtre et al. (2023); Melnik and Smyth (2024)). In the pharmaceutical sector specifically, Ward and Dranove (1995), Azoulay et al. (2019), and Gross and Sampat (2025) show that public funding, such as U.S. Committee on Medical Research contracts and NIH grants, can increase private-sector patenting and R&D investment, while Wallsten (2000) cautions that such grants may crowd out firm-financed research. A notable exception is Finkelstein

(2004), which finds that government vaccine recommendations, a demand-side intervention, have dynamic effects that stimulate R&D. We contribute to this literature by comparing supply-side and demand-side innovation policies within a structural welfare framework. This approach allows us to examine not only how different policies affect the level of pharmaceutical innovation, but also how they select different projects when innovation risk and reward are correlated.

- Misallocation: A large literature in macroeconomics and industrial organization shows that frictions in private markets can generate large aggregate losses by distorting the allocation of resources across firms and sectors (Bartelsman, Haltiwanger, and Scarpetta 2013; Hsieh and Klenow 2009; Midrigan and Xu 2014). We bring this allocative-efficiency perspective to the allocation of public pharmaceutical spending. While prior work has documented waste, leakage, and inefficiencies in government programs and public procurement (Olken 2007; Reinikka and Svensson 2004), much less is known about how public healthcare budgets are allocated across drug types with heterogeneous marginal social value and innovation incentives. This paper quantifies this form of public-spending misallocation and evaluates whether procurement reforms can improve welfare by reducing spending on products with low marginal social value and freeing resources for high-value pharmaceutical innovation.

- Public finance and program evaluation: Recent work in public finance emphasizes that government programs should be evaluated using their full net fiscal cost, rather than mechanical spending alone. This requires accounting for behavioral fiscal externalities, crowd-out, and substitution across related public and private programs (Finkelstein and Hendren 2020; Hendren and Sprung-Keyser 2020; Kline and Walters 2016). We apply this principle to healthcare policy by evaluating the NRDL and VBP reforms as a unified policy package. In our setting, the NRDL expands demand-side support for innovative drugs, while VBP reduces spending on off-patent generics and creates fiscal

space within the public insurance budget. Evaluating the two reforms jointly allows us to quantify their combined welfare effects and to show how procurement-driven reallocation changes both the fiscal cost and the welfare performance of demand-side innovation policy.

2 Institutional Background and Data

2.1 Two Pharmaceutical Reforms in China

China introduced two major healthcare reforms at roughly the same time: the National Reimbursement Drug List (NRDL) negotiation reform and Volume-Based Procurement (VBP). Together, these reforms reshaped the allocation of public drug spending by expanding reimbursement for innovative drugs while reducing public spending on mature generic drugs.

National Reimbursement Drug List. In response to growing public demand for broader access to innovative drugs, the National Healthcare Security Administration (NHSA) launched a landmark reform in 2016 that integrated innovative therapies into the national insurance catalog through centralized price negotiations. This reform marked a fundamental shift from a relatively rigid and budget-constrained reimbursement system toward a more dynamic model in which innovative drugs could obtain public reimbursement conditional on negotiated price concessions.

The negotiation process follows an annual cycle. Each spring, the NHSA defines an "eligible list" of drugs, focusing on innovative drugs that have obtained market approval within the last five years and address significant unmet clinical needs.[1] During the pre-negotiation stage, which can last for several months, firms with eligible drugs and the NHSA exchange information on costs, clinical value, and medical effectiveness. On the negotiation day, government representatives negotiate with each drug company separately. Successful negotiations

1. See: the 2024 Inclusion Criteria.

lead to inclusion in the NRDL, typically accompanied by average price reductions of 50-60% (Barwick, Swanson, and Xia 2025). If negotiations fail, the drug remains outside the national reimbursement catalog and continues to rely primarily on the private market, where sales volume is substantially lower. The reform has had a large impact on China's innovative drug market. By 2024, 699 drugs had been included in the NRDL, and cumulative spending on innovative drugs reached ě 460 billion ($67 billion) between 2016 and 2024, far exceeding the ě 66 billion ($10 billion) innovative drug market in 2015.[2]

Volume-Based Procurement. In parallel with the NRDL negotiation reform, China also implemented Volume-Based Procurement (VBP), a centralized competitive bidding system mainly targeting off-patent generic drugs. Under VBP, firms compete for guaranteed purchase volumes by offering lower prices, leading to substantial reductions in the reimbursed prices of mature drugs. While the NRDL expanded public reimbursement for innovative drugs, VBP reduced the share of public drug spending allocated to generics. In this sense, the two reforms were economically and institutionally complementary: VBP generated fiscal savings in the generic drug market, which helped create budgetary space for expanded public support of innovative drugs through the NRDL.

2.2 Cancer Drugs

We focus primarily on cancer (oncology) drugs for two reasons. First, cancer drugs are affected by both NRDL and VBP. It is the primary target of innovative drugs under NRDL, while the prices of chemotherapies are affected by VBP. This allows us to study both programs within a coherent product market. Second, oncology accounts for a large share of clinical trials, making it a desirable setting to study innovation policies.

2. Source: 2025 National Forum on Medical Insurance & Innovative Drug Development.

2.3 Data

The empirical analysis will draw on the following data sources:

Citeline TrialTrove Database. We utilize the Citeline TrialTrove database (2010–2024) to construct a comprehensive census of clinical trials initiated globally. TrialTrove aggregates data from official national registries (e.g., ClinicalTrials.gov in the U.S. and the ChinCTR in China) alongside public disclosures. For each trial, we observe the tested drug, sponsor type (private firm vs. public institution), therapeutic area, disease/indication, trial start date, completion status, trial phase, objective, methodology, duration, and trial population.

Citeline Pharmaprojects Database. Trials are linked to the Citeline Pharmaprojects database, which tracks key drug-development milestones, including patenting, out-licensing, and regulatory approvals (Cunningham, Ederer, and Ma 2021).

SinoHealth Drug Sales Data. We obtain granular pharmaceutical sales data from SinoHealth (2016–2024), a leading health-data provider in China (Xia 2024). Unlike other databases, SinoHealth provides superior coverage of both urban and rural hospital channels, through which nearly all innovative and generic drugs in China are dispensed.

Volume-Based Procurement Data. We collect VBP bidding outcomes and procurement prices for generic drugs from official government procurement records. These data allow us to identify drugs covered by VBP, winning firms, contracted purchase volumes, procurement prices, and the timing of each procurement round.

These data sources collectively allow us to estimate the structural parameters governing innovation incentives, characterize the pre- and post-reform allocation of public pharmaceutical spending, and simulate the welfare effects of alternative policy designs.

3 Structural Model

Demand Side Demand is similar to CHS, except that we need to accommodate quality as an explicit product characteristic (medical effectiveness). Because drug effectiveness is directly relevant to patient utility, demand, firm profit, and social welfare calculations, quality must enter the demand system. We can recover consumers' WTP for quality from drug fixed effects.

Supply Side We model pharmaceutical firms' R&D investment decisions as a function of expected returns, development costs, and clinical trial success probabilities. NRDL expands future expected returns for innovative drugs, while VBP works like a price control and reduces future returns for generic drugs (Ji and Rogers 2024).

The key structural parameters of interest are:

- The correlation between clinical trial success rates and drug effectiveness (quality), recoverable from clinical trial data.
- The marginal cost of conducting a clinical trial, recoverable from firms' propensity to initiate trials as a function of market size and expected returns.

The supply-side model is intentionally parsimonious without complicated dynamics (which is not necessary). A standard entry model with stochastic success is sufficient to generate the key qualitative and quantitative predictions about how R&D subsidies versus demand subsidies differentially attract high-value versus marginal innovators.

4 Policy Counterfactuals

With the structural model estimated, we simulate a range of policy counterfactuals, including: 1) R&D subsidies only; 2) demand-side coverage expansions; 3) both R&D subsidies and demand-side expansions; 4) varying the generosity and targeting of R&D subsidies and

demand-side coverage expansions, 5) alternative procurement regimes for generics, 6) joint optimization of both instruments (NRDL and VBP) subject to a government budget constraint that incorporates the marginal cost of public funds.

References

Acemoglu, Daron, and Joshua Linn. 2004. "Market size in innovation: theory and evidence from the pharmaceutical industry." *The Quarterly journal of economics* 119 (3): 1049–1090.

Azoulay, Pierre, Joshua S Graff Zivin, Danielle Li, and Bhaven N Sampat. 2019. "Public R&D investments and private-sector patenting: evidence from NIH funding rules." *The Review of economic studies* 86 (1): 117–152.

Bartelsman, Eric, John Haltiwanger, and Stefano Scarpetta. 2013. "Cross-country differences in productivity: The role of allocation and selection." *American economic review* 103 (1): 305–334.

Barwick, Panle Jia, Ashley T Swanson, and Tianli Xia. 2025. *A Double Dose of Reform: Insurance and Centralized Negotiation in Drug Markets.* Technical report. National Bureau of Economic Research.

Bloom, Nicholas, John Van Reenen, and Heidi Williams. 2019. "A Toolkit of Policies to Promote Innovation." *Journal of Economic Perspectives* 33 (3): 163–84.

Branstetter, Lee G, and Mariko Sakakibara. 2002. "When do research consortia work well and why? Evidence from Japanese panel data." *American Economic Review* 92 (1): 143–159.

Bronzini, Raffaello, and Paolo Piselli. 2016. "The impact of R&D subsidies on firm innovation." *Research Policy* 45 (2): 442–457.

Budish, Eric, Benjamin N Roin, and Heidi Williams. 2015. "Do firms underinvest in long-term research? Evidence from cancer clinical trials." *American Economic Review* 105 (7): 2044–2085.

Cunningham, Colleen, Florian Ederer, and Song Ma. 2021. "Killer acquisitions." *Journal of political economy* 129 (3): 649–702.

Dechezleprêtre, Antoine, Elias Einiö, Ralf Martin, Kieu-Trang Nguyen, and John Van Reenen. 2023. "Do tax incentives increase firm innovation? An RD design for R&D, patents, and spillovers." *American Economic Journal: Economic Policy* 15 (4): 486–521.

Duggan, Mark, and Fiona M Scott Morton. 2006. "The distortionary effects of government procurement: evidence from Medicaid prescription drug purchasing." *The Quarterly Journal of Economics* 121 (1): 1–30.

Finkelstein, Amy. 2004. "Static and Dynamic Effects of Health Policy: Evidence from the Vaccine Industry." *Quarterly Journal of Economics* 119 (2): 527–564.

Finkelstein, Amy, and Nathaniel Hendren. 2020. "Welfare analysis meets causal inference." *Journal of Economic Perspectives* 34 (4): 146–167.

Garthwaite, Craig. 2025. "Economic markets and pharmaceutical innovation." *Journal of Economic Perspectives* 39 (2): 3–26.

Gross, Daniel P, and Bhaven N Sampat. 2025. *The Therapeutic Consequences of the War: World War II and the 20th-Century Expansion of Biomedicine.* Technical report. National Bureau of Economic Research.

Hendren, Nathaniel, and Ben Sprung-Keyser. 2020. "A unified welfare analysis of government policies." *The Quarterly journal of economics* 135 (3): 1209–1318.

Howell, Sabrina T. 2017. "Financing innovation: Evidence from R&D grants." *American economic review* 107 (4): 1136–1164.

Hsieh, Chang-Tai, and Peter J Klenow. 2009. "Misallocation and manufacturing TFP in China and India." *The Quarterly journal of economics* 124 (4): 1403–1448.

Ji, Yunan, and Parker Rogers. 2024. *The Long-Run Impacts of Regulated Price Cuts: Evidence from Medicare.* Working Paper.

Kline, Patrick, and Christopher R Walters. 2016. "Evaluating public programs with close substitutes: The case of Head Start." *The Quarterly Journal of Economics* 131 (4): 1795–1848.

Melnik, Walter, and Andrew Smyth. 2024. "R&D tax credits and innovation." *Journal of Public Economics* 236:105157.

Midrigan, Virgiliu, and Daniel Yi Xu. 2014. "Finance and misallocation: Evidence from plant-level data." *American economic review* 104 (2): 422–458.

Olken, Benjamin A. 2007. "Monitoring corruption: evidence from a field experiment in Indonesia." *Journal of political Economy* 115 (2): 200–249.
Reinikka, Ritva, and Jakob Svensson. 2004. "Local capture: evidence from a central government transfer program in Uganda." *The quarterly journal of economics* 119 (2): 679–705.
Wallsten, Scott J. 2000. "The Effects of Government-Industry R&D Programs on Private R&D: The Case of the Small Business Innovation Research Program." *RAND Journal of Economics* 31 (1): 82–100.
Ward, Michael R, and David Dranove. 1995. "The vertical chain of research and development in the pharmaceutical industry." *Economic inquiry* 33 (1): 70–87.
Xia, Tianli. 2024. "Welfare Effects of Resale Price Maintenance: Evidence from the Chinese Pharmaceutical Industry." *Available at SSRN 5118723.*