A Double Dose of Reform: Insurance and Centralized Negotiation in Drug Markets

Panle Jia Barwick Ashley Swanson Tianli Xia *

March 21, 2025

PRELIMINARY: PLEASE DO NOT POST, CITE, OR DISTRIBUTE

Abstract

Making expensive, innovative drugs affordable and accessible is a pressing global challenge. In this paper, we explore the welfare and equity effects of a recent policy reform in China that coupled centralized drug price negotiation with expanded insurance coverage. Successful negotiations were followed by 48% decreases in retail prices, 80% reductions in out-of-pocket prices, and 350% increases in utilization. Focusing on cancer drugs, we estimate a flexible demand and supply model that features heterogeneous households, bargaining with potential breakdowns, and a government objective function that depends on consumer surplus and insurance expenditure. Our analyses deliver several findings. First, insurance coverage combined with central negotiation incentivizes drug producers to reduce drug prices, which increases consumer surplus gains by 77% relative to scenarios where drugs are covered without negotiation. Second, a more standard market access negotiation expands access to more marginal drugs, but reduces utilization of high quality, inframarginal drugs. Third, centralized bargaining is far more beneficial to patients in low- to moderate-income provinces compared to decentralized negotiation. Fourth, paradoxically, a regressive schedule with lower co-insurance rates for high-income households increases drug access for all consumers through increased bargaining leverage. In ongoing work, we present evidence on mechanisms that leverage the best aspects of each of these policy alternatives.

*Barwick: Department of Economics, UW-Madison, NBER, and CEPR, pbarwick@wisc.edu. Swanson: Department of Economics, UW-Madison and NBER, ashley.swanson@wisc.edu. Xia: Simon Business School, University of Rochester, tianli.xia@rochester.edu. We thank Matt Backus, Liran Einav, Matt Grennan, Amanda Starc, Bob Town, and seminar and conference participants at Cornell, Rochester, Stanford, and UCLA for their helpful comments. Jiyu Xia provided excellent research assistance. We are grateful to SinoHealth for generously providing the data.

1 Introduction

Innovative drugs have the potential to generate large social value, but creating efficient mechanisms to pay for them is a challenging economic problem. Take, for example, Verzenio, a breast cancer therapy approved by the U.S. Food and Drug Administration (FDA) in 2017. While it was shown to improve 5-year survival rates by 12%, its price is prohibitively high: $180,000 per year in the U.S. and an initial price of ¥60,000 ($8,570) per year in China. Such exorbitant prices place life-saving treatments out of reach for the majority of self-paying patients. Prescription drug insurance increases access to these drugs for a wider population, but comes with substantial costs. For instance, the Medicare Part D program for the elderly in the U.S. spends 61% of its budget on the top 100 highest-priced drugs (CMS, 2024).

In this paper, we examine the economic and policy implications of China's ongoing National Reimbursement Drug List (NRDL) Reform, which began in 2016.[1] Prior to the reform, the NRDL — the national drug formulary that determines drug coverage under China's universal health insurance — provided no coverage for innovative drugs. Patients were required to pay the full cost of these expensive medications out of pocket, in many cases leading to financial hardship or foregoing treatment altogether.[2] The NRDL Reform expands universal insurance coverage to include an increasing number of innovative drugs, provided that their manufacturers negotiate price reductions with China's National Healthcare Security Administration (NHSA). Once a drug is added to the NRDL, patients can access the drug at a fraction of the negotiated price, with the government paying the balance. In our motivating example of Verzenio, inclusion in the NRDL in 2021 reduced the retail price from ¥60,000 to ¥20,000 and the average out-of-pocket (OOP) price from ¥60,000 to ¥7,400.

We use the variation generated by the NRDL Reform in China to investigate the nuanced welfare implications of observed and counterfactual drug market reforms. For motivation, note two striking features of the environment. First, 25% of negotiations fail, and higher-quality drugs are more often successfully negotiated. Second, insurance generosity varies widely. The patient's share of the drug cost (the coinsurance rate) ranges from 20% in higher-income provinces to 45% in lower-income provinces due to provincial subsidies. We incorporate these features into a deep investigation of how key policy choices — regarding negotiating parties'

[1] The program is also referred to as the "National Health Insurance Negotiation," the "Reimbursement-Linked Drug Price Negotiation," and "China's National Negotiation of Drug Prices" (Zhou et al., 2024; Lu and Zhang, 2023).

[2] These challenges were poignantly illustrated in the 2018 film *Dying to Survive*, which is based on the true story of a leukemia patient who resorted to smuggling cancer medicine from India. The film had China's fourth-biggest theatrical opening weekend ever.

outside options, centralization, and insurance generosity — impact bilateral gains from trade. The gains from trade in turn determine the extensive margin of which drugs are covered, and the intensive margin of negotiated price levels. As usual, all policy choices entail tradeoffs.

The NRDL Reform in China offers a valuable context for analyzing potential policy instruments aimed at controlling the rising costs of pharmaceuticals. In contrast to the U.S., where drug prices are determined by both administrative and negotiated pricing regimes across a range of public and private payers, China's healthcare system is predominantly public. This simplifies the modeling necessary to evaluate the effectiveness of the insurance expansion. The reform's staggered implementation across products, combined with variation in coinsurance rates across provinces, provides ample panel variation in prices and coverage for our research design. Finally, in contrast to many settings where only successful negotiation outcomes are observed, we observe rich market outcomes for both successful and failed negotiations, providing a novel opportunity to infer government preferences.

We analyze a unique dataset with comprehensive coverage of drug sales across China from 2017 to 2023. The primary data source is SinoHealth, a publicly listed health consulting firm.[3] We supplement the SinoHealth data with additional datasets that detail negotiation outcomes for all participating drugs, approved usage of each drug for different indications, clinical evidence concerning improved survival times, and provincial demographic information.

We present to our knowledge the first comprehensive evidence on the price and quantity effects of China's NRDL Reform. To do so, we analyze the changes in prices and quantities dispensed after a drug's inclusion in the NRDL, relative to other drugs not yet covered by the NRDL. The documented effects were tremendous. The program expanded coverage of 487 innovative drugs to over a billion people during our study period. The negotiations resulted in a 48% reduction in retail prices and an 80% reduction in patients' out-of-pocket prices on average. These sharp price drops drove large increases in the utilization of innovative drugs: the average successful negotiation was followed by a quantity increase of 350%. These findings contribute to a broad literature examining the effects of prescription drug insurance coverage and generosity on utilization and prices (see, e.g., Abaluck et al. (2018); Dalton et al. (2019); Duggan and Scott Morton (2010); Einav et al. (2015)). We also contribute to a relatively nascent literature on China's recent drug market reforms (Cao et al., 2022; Fang et al., 2021).

To unpack the economic mechanisms underlying these results, we build a structural framework consisting of a demand model that features random preferences and differences in affordability across income groups, and a supply side where the government and pharmaceutical

[3]SinoHealth's data are widely utilized by major international and domestic pharmaceutical companies, including Pfizer, Roche, Bayer, AstraZeneca, GlaxoSmithKline, Merck, and Eli Lilly, among others.

firms negotiate prices to split surplus. The supply side features centralized bargaining with heterogeneous households, bargaining breakdowns, and a government objective function that depends on patient welfare and government expenditure. We estimate several key parameters: income-varying price elasticities of demand, firms' marginal costs of producing and distributing innovative drugs, a bargaining parameter that determines the surplus split between firms and the government, and the relative weights the government places on patient surplus vs. government expenditures. Our model shares features with structural work on drug markets (Atal et al., 2022; Branstetter et al., 2016; Cao and Chatterjee, 2022; Chaudhuri et al., 2006; Xia, 2024) and with the recent empirical literature on bargaining in health care markets more broadly (e.g., Gowrisankaran et al. (2015); Grennan (2013); Ho and Lee (2017); see Grennan and Swanson (2022) for a review).

One innovation of our model is its ability to infer the central government's weight on government expenditures relative to patient surplus, which can be interpreted as the shadow cost of the government's budget constraint. As this weight increases, the set of feasible negotiated prices narrows; eventually, the negotiation fails as including a drug in the NRDL formulary at a price acceptable to the drug company would be too costly for the government.[4] We recover the distribution of this shadow cost using a novel maximum likelihood specification estimated on both successful and failed negotiations. In addition to allowing for bargaining parameters across negotiating pairs to depend on drug characteristics such as foreign/domestic status, we allow the shadow cost of the government's budget constraint to depend upon drug quality (medical benefits). In doing so, we extend prior work that models bargaining ability as a function of firm organizational characteristics (Grennan, 2014; Lewis and Pflum, 2015).

The structural analysis focuses on two classes of innovative cancer drugs: monoclonal antibodies and protein kinase inhibitors. Of the 70 such drugs invited for negotiation, 57 were successful. These ultimately accounted for two-thirds of revenues for negotiated drugs in the NRDL program. Consistent with prior work on global drug markets (e.g., Dubois et al. (2022)), price elasticities are low, around -1.6 for the median patient and -1.96 for patients at the 25^{th} income percentile. The government assigns equal weight to consumer surplus and government expenditures for the median drug, and lower weights on expenditures for drugs with larger survival improvements in clinical trials. Finally, firms have an average bargaining

[4] An alternative explanation for the bargaining failures observed in our setting would be incomplete information. See Ausubel et al. (2002) for a review. A unique feature of our environment casts doubt on the theory that incomplete information is the key driver of bargaining failures. Specifically, we observe multiple years of market outcomes for most drugs in our sample. Therefore, both the government and drug manufacturers would have a strong signal of both demand and costs prior to negotiation. Moreover, during the pre-negotiation stage, information is exchanged frequently between the parties.

parameter of 0.68, suggesting that firms have considerable bargaining power.

The model estimates allow us to evaluate the effectiveness of the NRDL Reform, as well as counterfactual policies. The NRDL Reform as implemented combines insurance and negotiation. Insurance expansion alone would reduce price sensitivity, leading to lower OOP prices but higher retail prices; see Cutler and Reber (1998), Jaffe and Shepard (2020), and Liu and Jin (2015).[5] Price negotiation alone would have no impact, as firms would receive no gain from trade from participating in the negotiation relative to firms' outside option of setting profit-maximizing prices on the private market. The combined reform allows the government to discipline prices, while patients benefit from greater drug access. NRDL Reform increases the market share of innovative drugs among all cancer drugs by 18 ppt (1100% relative to baseline), which exceeds the gains achieved by insurance alone (4 ppt, or 290%) and negotiation alone (0 ppt). At the same time, it reduces OOP costs by 89%, and the improved access to innovative drugs increases average survival by four months per cancer patient. Social surplus increases by ¥8,280 per cancer patient, compared to only ¥5,720 with insurance alone and ¥0 with negotiation alone.

We next turn to a series of exercises that shed further light on how policy choices impact economic outcomes and welfare in this setting. We simulate counterfactual equilibria under a range of alternative scenarios, allowing both formularies and negotiated prices to adjust.

First, we focus on the role of outside options. We strengthen the government's leverage by modeling a more typical "market access" negotiation, with and without insurance expansion. Here, the government's threat point is the exclusion of the drug from the Chinese market entirely. This counterfactual increases the gains from trade to both firms and the government, implying all drugs will be successfully negotiated but with ambiguous effects on welfare. This analysis contributes to recent work on bargaining with exclusion and alternative formulary structures (Ho and Lee, 2019, 2024). If firms must negotiate with the government to access the market, even without insurance expansion, retail prices would decrease by 53% at zero cost to the government and the innovative drugs' market share would increase by 2.45 ppt. Moreover, we continue to find that insurance expansion reinforces negotiation. Market access negotiation *plus* insurance expansion reduces retail prices by 62% and OOP prices by 87%, expanding the negotiated drugs' share of the cancer drug market by 20 ppt. In comparison with the NRDL Reform, a "Market-access negotiation with insurance" results in coverage of more drugs, but higher negotiated prices for inframarginal, higher quality drugs. Ultimately, social welfare is higher under the market access negotiation, but altering negotiating parties'

[5]This is consistent with classic models of moral hazard, but the fact that many patients could simply not afford innovative drugs prior to the reform suggests drug access plays an important role (Nyman, 1999).

threat point generates a tradeoff between extensive and intensive margin effects.

Next, we examine the role of centralization in the NRDL Reform. There is wide variation in income and price sensitivity across provinces, implying that centralized negotiation may create winners and losers relative to a decentralized province-by-province negotiation. To investigate this, we contrast the effects of centralized national bargaining with those of a counterfactual in which each province negotiates its own prices. This analysis sheds light on recent policy debates and academic research regarding central procurement; see, e.g., Dubois et al. (2021), Dubois and Sæthre (2020), Dubois et al. (2022), Ho and Pakes (2024), and Maini and Pammolli (2023). The key driving feature of this comparison is that gains from trade are lower for both firms and the government in low-income vs. high-income provinces. As a result, the effects of centralization vary significantly across regions: while most provinces benefit from more successful negotiations and lower prices than those under provincial-level negotiations, the highest-income provinces tend to benefit from decentralization.

The last set of counterfactual analyses examines the efficiency and equity implications of income-based coinsurance schedules. Public insurance programs often include subsidies tied directly to income, rather than geography. For example, the U.S. Medicaid, Medicare, and health insurance exchange programs determine subsidy eligibility as a function of income and other factors. Our analyses of coinsurance design contribute to the literatures on subsidies for privately-supplied products, see, e.g., Polyakova and Ryan (2022) and Finkelstein et al. (2019), and on optimal coinsurance given the tradeoff between moral hazard and risk protection (Cutler and Zeckhauser, 2000; Einav et al., 2018; Gowrisankaran et al., 2015).

We explore two-tier structures with different coinsurance rates for households above and below median income. To evaluate the equity implications of more and less progressive schedules, we follow the public finance literature (e.g., Saez (2002)) and reweight households' consumer surplus by $income^{-\nu}$. When $\nu = 0$, the measure reflects utilitarian preferences, while higher ν indicates a stronger emphasis on equity. We document a few notable results. First, higher coinsurance decreases firm gains from trade, but has an ambiguous effect on the government's gains from trade. For the coinsurance schedules we consider, lower coinsurance rates lead to more bargaining failures, which hurt both low- and high-income patients. At the extreme, offering a 20% coinsurance rate to all patients would reduce the fraction of successful negotiations to 50% due to the increase in government expenditures. Second, lower coinsurance for high-income households expands demand and increases firms' willingness to grant price discounts in exchange for inclusion in the national formulary. Third, utilitarian social surplus is maximized with a moderately regressive insurance schedule, as demand expansion from

high-income households offers the government greater bargaining leverage. However, a higher preference for equity yields a flat, high coinsurance schedule as the optimum.

The rest of the paper proceeds as follows. Section 2 provides institutional background and describes the data. Section 3 presents the model and Section 4 discusses estimation results. Section 5 conducts counterfactual analyses to shed light on policy designs. Section 6 concludes. The appendices contain more details and additional analyses.

2 Institutional Background and Data

2.1 Institutional Features: CHS and the NRDL Reform

The Chinese healthcare system, known as CHS, provides nearly universal coverage to over 95% of Chinese citizens, making it the largest healthcare insurance program in the world (Yu, 2015). It was created in 1999 and has gone through several changes over the years. Today, it consists of two major health insurance plans: the urban employee basic medical insurance plan (UEBMI) for individuals working in (and retirees of) state-owned enterprises and some private-sector businesses, and the urban and rural resident basic medical insurance plan (URRBMI) for other residents. The premium for these insurance plans was set at ¥1080 in 2023, with individuals and employers paying ¥380 and the government contributing subsidies of ¥700. There is a small commercial market for complementary insurance, accounting for less than 7% of total expenditure (National Health Commission of the PRC, 2023). Given CHS's widespread insurance coverage, we do not model insurance participation decisions and assume all households are enrolled.

A key component of China's health insurance program is its prescription drug coverage, which constitutes 40% of total CHS spending.[6,7] Historically, CHS's National Reimbursement Drug List excluded innovative drugs due to budget considerations.[8] In recent years, CHS faced criticism due to its lack of coverage for innovative drugs, which resulted in limited access to effective treatments and high out-of-pocket prices.

In response to public pressure, the CHS launched a drug reform in 2016 that is ongoing

[6]Source: China Health Statistical Yearbook 2020, https://pmc.ncbi.nlm.nih.gov/articles/PMC9335887/. Besides prescription drugs, China's health insurance program also covers inpatient care, emergency care, preventive care such as vaccines, and maternity benefits.

[7]China had various price caps and price regulations on pharmaceutical drugs during the 1980s-2000s. In 2015, China removed most price regulations, and only retained price controls for anesthetics. See https://www.gov.cn/gongbao/content/2015/content_2901387.htm.

[8]For a list of drugs covered by the NRDL in 2017, see: https://www.gov.cn/xinwen/2017-02/23/5170392/files/60c89aae96da450e9efb6175ed8dafe4.pdf.

today (Macabeo et al., 2023). Each year, the NHSA comes up with an "eligible list" of drugs and invites drug producers to participate in negotiation. Firms and the NHSA exchange information on drugs and government preferences during the pre-negotiation stage, which can last for up to a month. On the day of the negotiation, government representatives negotiate with delegates from each drug company simultaneously and independently. Table 1 summarizes the seven rounds of negotiation from 2016 to 2022, which had an average success rate of 76%. Negotiations occur annually, and the number of negotiated drugs has rapidly increased since the initial pilot years.

Table 1: Summary of Each Round of Negotiation 2016-2022

Round	2016	2017	2018	2019	2020	2021	2022	All
# Negotiated Products	5	44	18	150	162	117	147	643
# Successful Negotiations	3	36	17	97	119	94	121	487

Data source: NHSA website. Overall success rate: 75.7%.

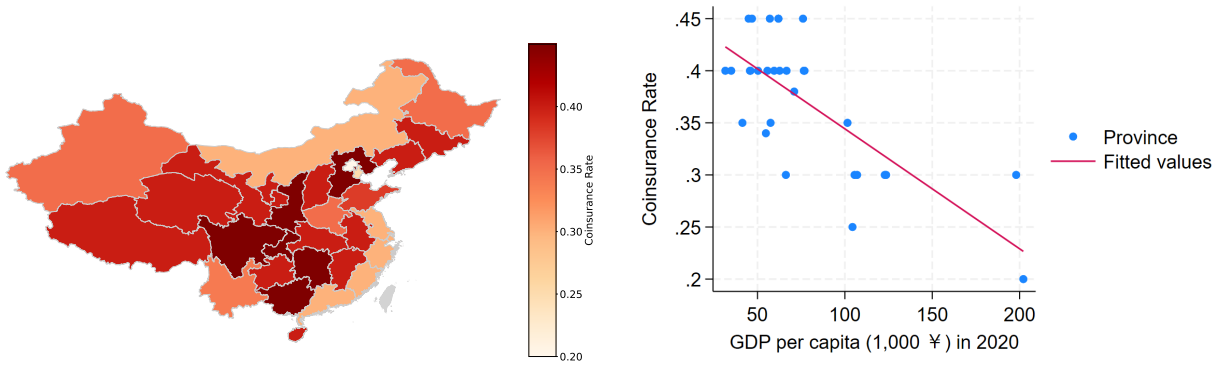
There are three notable features of this negotiation process. First, both parties possess a lot of information about supply and demand. Most eligible drugs were already sold in the private market prior to negotiation. Moreover, during the pre-negotiation stage, information is exchanged frequently between the parties. As a result, the government likely has a good understanding of the firm's production costs and the drug firms likely know the government's preferences. Second, the government prioritizes both social benefits and also government expenditures. It hires two groups of experts for each negotiation: pharmacoeconomic experts who calculate potential patient benefits, and finance experts who assess the drug's affordability for the health insurance fund. Lastly, negotiations for each drug are conducted independently. Each government team negotiates with a specific drug company's representative in a separate room, with no communication across teams. Thus, each negotiation is an independent event, with no strategic interaction across negotiations.

If the negotiation is successful, the drug will be included in the NRDL, typically within a quarter. Once a drug is in the NRDL, patients can access it by paying a reduced fraction (a "coinsurance rate") of the retail price. While coverage decisions are made centrally, coinsurance rates are determined at the province level, resulting in significant variation across provinces. The two major insurance plans, UEBMI and URRBMI, cover the same sets of drugs but have different coinsurance rates. URRBMI, covering more than 70% of the population, offers on average 5ppt higher coinsurance rates.[9] Within each province and plan type, coinsurance

[9]For a summary of the two alternative types of insurance, see https://www.nhsa.gov.cn/art/2023/7/10/art_7_10995.html.

rates are uniform for all covered drugs. We use URRBMI's coinsurance rate for the baseline analysis and incorporate UEBMI's coinsurance rate in a robustness analysis. The left panel of Figure 1 presents a map of the URRBMI coinsurance rates across provinces; the right panel presents a scatterplot of the coinsurance rates vs. provincial income. Patients in wealthier provinces like Beijing and Shanghai pay 20-30% of the retail price, whereas those in poorer regions like Gansu pay up to 45%.

Figure 1: Coinsurance Rate Design



(a) Coinsurance Rates across Provinces (b) Coinsurance Rates and GDP per Capita

Note: Figure (a) presents provincial coinsurance rates for innovative drugs. Figure (b) presents the relationship between coinsurance and GDP per capita across provinces.

2.2 Data and Sample Description

Our primary dataset contains comprehensive coverage of drug sales in China from 2017 to 2023, sourced from SinoHealth. SinoHealth is the only health consulting firm that is publicly listed in China. It supplies data to all major international pharmaceutical companies, including Pfizer, Roche, Bayer, AZ, GSK, Merck, Eli Lilly, etc. Its price and sales data closely match the information posted on NHSA's website and published in China's Statistic Yearbooks. SinoHealth provides better coverage than IQVIA, another commonly used database on pharmaceuticals, particularly in rural China. We focus on hospital sales because nearly all innovative drugs are dispensed through hospitals. The hospital sales dataset is at the province-quarter level and includes total drug sales, quantities dispensed (standardized to years' supply), and retail prices at the SKU level. We merge the SinoHealth data with CHS data on negotiation outcomes, including drug eligibility for negotiation, negotiation success, and negotiated prices.

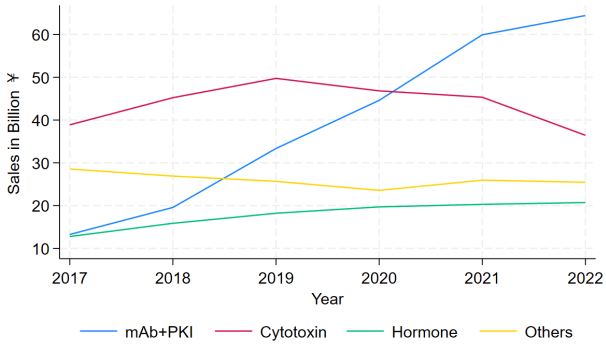
Innovative drugs that are eligible for NRDL negotiations include drugs that treat cancer, hypertension, and diabetes, as well as orphan drugs. We focus on cancer drugs in our structural analyses for two main reasons. First, this market is significant from both health and economic perspectives. In 2020, China had 4.6 million cancer cases and 3 million cancer-related deaths, accounting for 24% of global cancer incidence and 30% of global cancer mortality. China's pharmaceutical market for cancer drugs is growing rapidly, with total sales reaching ¥140 billion (around 0.1% of China's GDP) in 2022. Second, cancer drugs are the most critical category in NRDL negotiations, with cancer drugs accounting for more than 60% of revenues among all successfully negotiated drugs.

We have constructed several ancillary datasets concerning cancer drug markets. First, we obtained brand-year-level indications from the Handbook of Innovative Cancer Drugs, which details the approved usage of each cancer drug for different indications by China's National Medical Products Administration, the analog of the U.S. FDA. Second, we collected clinical evidence for all innovative cancer drugs from Phase III clinical trials on ClinicalTrials.gov. Phase III studies are large-scale, double-blind, randomized control trials comparing the safety and efficacy of interventions relative to control therapies; they are typically a prerequisite for FDA approval, as is registration on ClinicalTrials.gov. We use the clinical trial results to measure the quality of each drug. Our preferred measure is overall survival (additional months lived) relative to the standard treatment for the relevant disease. When this measure is missing (less than 30% of cases), we use alternative measures such as overall survival *rates* and progression-free survival. Third, we collected province-level demographics from each province's Statistics Yearbook, along with cancer incidence data from the annual reports published by the National Cancer Center.

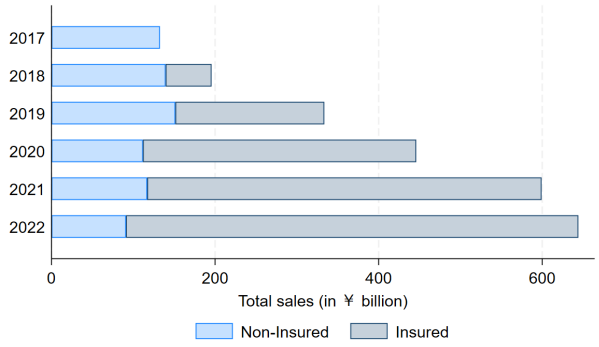
There are four major types of cancer drugs on the market: monoclonal antibodies (mAbs), protein kinase inhibitors (PKIs), cytotoxins (traditional chemotherapy), and hormone drugs. Innovative cancer drugs are either mAbs or PKIs and are the primary target of the NRDL Reform. Cytotoxins can be effective in killing cancer cells but typically have more severe side effects. Hormone drugs are useful for treating certain types of cancers. In addition to these four major types, there are ancillary drugs used for cancer treatments, including traditional Chinese medicine-based products. As of 2023, there had been 97 negotiations of innovative cancer drugs, with 57 successes.

Figure 2 presents key data patterns regarding the cancer drug market. First, the NRDL Reform led to substantial market expansion for innovative cancer drugs (mAb and PKI). Sales skyrocketed from ¥13 billion in 2017 to ¥64 billion in 2022 (panel a). At the same time, sales

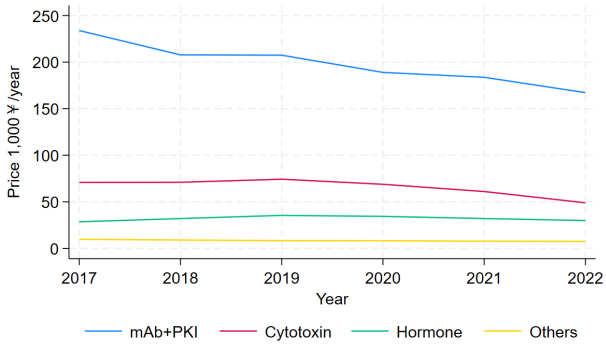
Figure 2: Overview of the Cancer Drug market



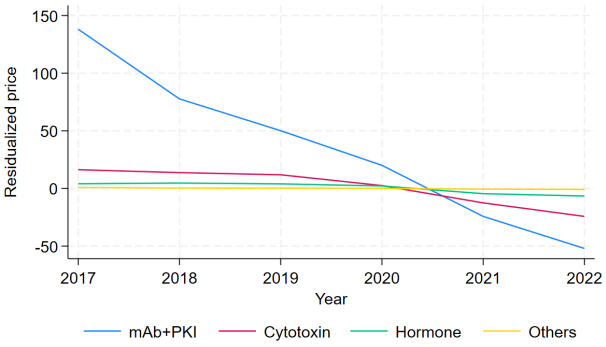
(a) Market Sales by Cancer Drug Category



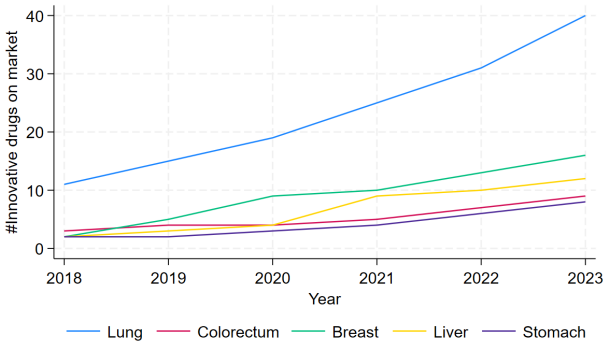
(b) Sales for Non/Insured Innovative Cancer Drugs



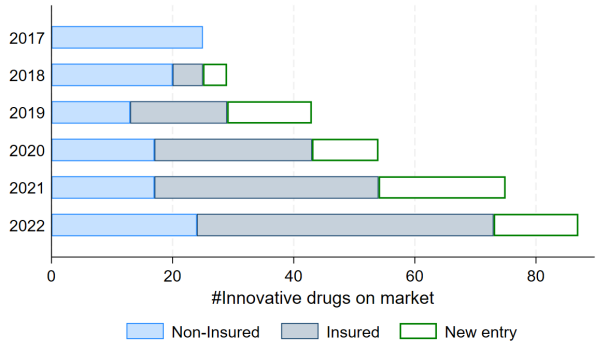
(c) Retail Price (raw)



(d) Residualized Retail Price



(e) Num. of Drugs for Major Indications



(f) Num. of Innovative Cancer Drugs in Market

Note: Figure (a) plots the sales of cancer drugs for each major category by year. Figure (b) decomposes sales of the mAb and PKI categories – the innovative cancer drugs – into insured sales and non-insured sales. Figure (c) plots raw prices by category. Figure (d) plots residualized prices by category, after controlling for drug and time fixed effects. Figure (e) reports the number of drugs that treat each of the top cancer indications. Figure (f) reports the number of drugs in the market in each year, with incumbents denoted by the blue and grey solid bars and new entries denoted by the green-bordered bars.

of traditional chemotherapy drugs declined, suggesting that there was some switching from cytotoxins to innovative treatments. Panel (b) decomposes the sales of innovative cancer drugs into insured and non-insured products. In 2017, the innovative cancer drug market was entirely uninsured and patients had to pay the full retail price to receive treatment. In 2022, five years after the first round of negotiations, more than 80% of innovative cancer drug sales were for insured (successfully negotiated) products. Meanwhile, the average retail price of innovative cancer drugs declined substantially (panel c), from roughly ¥per year in 2017 to ¥per year in 2022. This pattern is even more pronounced for residualized prices, after partialing out brand fixed effects to account for price changes driven by product entry and exit (panel d).[10]

This period also saw significant market entry and a growing variety of innovative cancer drugs. Panel (e) shows that the number of innovative drugs available surged for the most common types of cancer between 2017 and 2022, and panel (f) demonstrates that the number of innovative cancer drugs available in China nearly tripled over that period. Many of these new entrants to the Chinese market were already available in developed countries, suggesting that the insurance expansion may have increased the anticipated profitability of the Chinese market and thereby made it more attractive for multinational drug companies.[11]

2.3 Descriptive Patterns

In this Section, we present event study evidence on what happens to prices and quantities after drugs are included in NRDL, across all innovative drugs and for cancer drugs specifically.

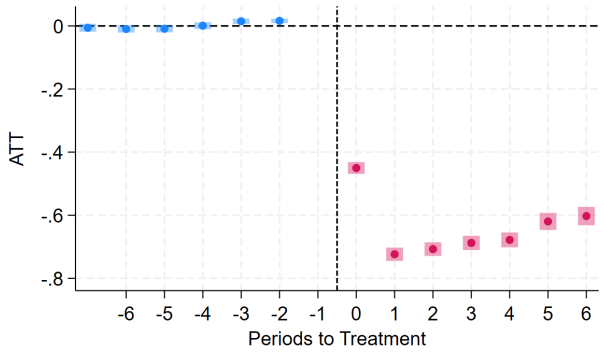
Prices and Quantities Panels (a) and (b) of Figure 3 compare outcomes for successfully negotiated innovative drugs with those of a never-treated group (defined as drugs that appeared on the "eligible list" but were never successfully negotiated). We use the method in Callaway and Sant'Anna (2021), which implements difference-in-differences regressions allowing for variation in treatment timing and heterogeneous treatment effects. The program led to a 48% reduction in retail price and a 350% increase in quantity.[12] The price response is immediate — retail prices adjust to the negotiated price within one quarter, while the

[10]There is a modest decline in prices for cytotoxin drugs, likely due to the 2019-20 introduction of a procurement auction program targeting generic drugs (Cao et al., 2022).

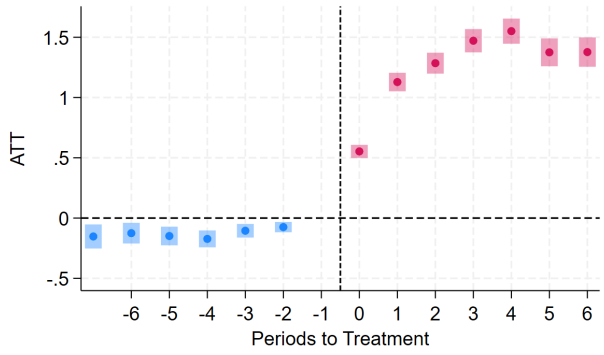
[11]The ratio of new cancer drug indication approvals in China relative to the U.S. was 0.24 between 2001-2016 and more than doubled to 0.5 during 2017-2020.

[12]A few innovative drug companies offer a "Patient Assistance Program" that provides discounts off the retail price to patients. We have adjusted the retail prices to reflect these discounts.

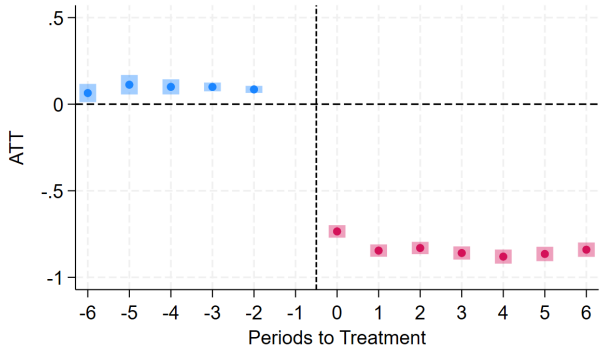
Figure 3: Effects of the NRDL Reform on Price and Quantity



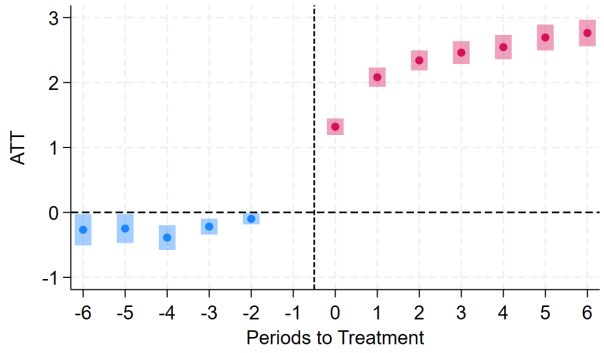
(a) Retail Price: All Categories



(b) Quantity: All Categories



(c) Retail Price: Cancer Drugs



(d) Quantity: Cancer Drugs

Note: This figure reports the effects of the NRDL Reform on the retail prices and quantities of successfully negotiated drugs. The horizontal axis denotes quarters relative to the negotiation period. The vertical axis reports estimated dynamic treatment effects using Callaway and Sant'Anna (2021)'s CSDID method.

quantity response takes slightly longer to fully materialize. There are no visible pre-trends in prices, indicating that firms did not strategically manipulate retail prices in anticipation of the negotiation. Appendix Figure A2 shows that price and quantity treatment effects were large and significant for drugs in all negotiation cohorts, but there is some variation in magnitudes across cohorts due to composition.[13] This supports our use of Callaway and Sant'Anna (2021)'s method. However, we have also estimated the treatment effect of successful negotiation using a more standard Two-Way Fixed Effects (TWFE) regression, leveraging the staggered timing of negotiation across drugs for identification. As shown in Appendix Figure A3, the results are similar to those in Figure 3.

[13]Price reductions and quantity expansions were more substantial in 2019 and 2022, when a larger proportion of the successfully negotiated drugs were innovative cancer therapies.

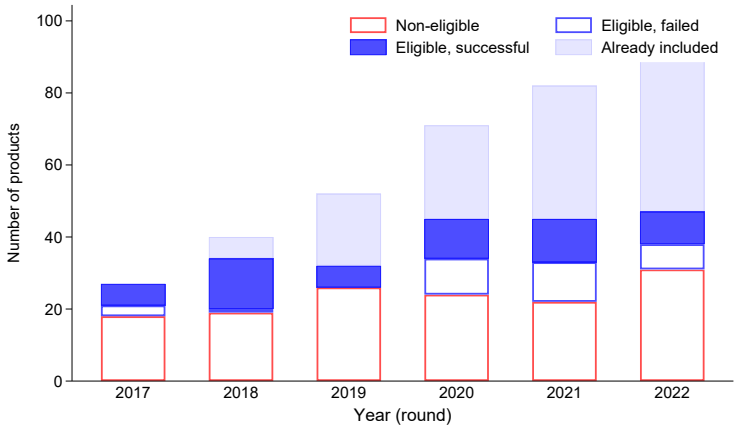
Panels (c) and (d) of Figure 3 present the event study estimates of the treatment effects for successfully negotiated *cancer* drugs. The control group consists of innovative cancer drugs that are eligible for negotiation but have either not yet been included or have never been included in the formulary. Given the greater potential for spillovers (business stealing) across drugs within a single class, these estimates are likely to underestimate the price response and overestimate the quantity response. The results are more pronounced than the patterns observed for all innovative drugs: we estimate a 57% reduction in retail prices and a dramatic 930% jump in quantity.

Negotiation Successes and Failures Next, we present descriptive evidence on negotiation successes and failures, as motivation for our structural model. Figure 4 presents the annual distribution of cancer drugs from 2017 to 2022, categorizing them into those ineligible for NRDL negotiation, those successfully negotiated, those that failed negotiation, and those already included in the NRDL. On average, around half of all cancer drugs were eligible for negotiation. By 2022, a total of 97 negotiations had taken place for cancer drugs, with 57 resulting in successful agreements. Notably, there were more successful negotiations in the early rounds, while later rounds saw an increase in negotiation failures.[14]

To examine the determinants of negotiation outcomes, we regress negotiation success on drug characteristics and report the results in Table 2. Several key patterns emerge. First, expected improvements in patient survival play a significant role — each additional month of survival benefit increases a drug's likelihood of NRDL inclusion by 1.5 to 2.4 percentage points. Second, negotiations are significantly more likely to succeed if the drug is newer. Third, higher lagged sales are positively correlated with negotiation success, suggesting that market demand influences outcomes. Taken together, the drugs most likely to be included on the NRDL are newer and better (or perceived by the market to be better).

[14] A negotiation fails when the drug is brought to the negotiation table but the two parties fail to reach an admissible price.

Figure 4: Summary of Negotiations with Cancer Drugs



Note: This figure presents the negotiation status of innovative cancer drugs. The top, light blue solid bar denotes drugs that were already included on the NRDL that year. The next, dark blue solid bar denotes drugs that were successfully negotiated that year. In combination, the solid bars denote all drugs insured by CHS that year. The next, hollow blue bar denotes failed negotiations, and the bottom, hollow red bar denotes drugs that were not negotiated. In combination, the empty bars denote the drugs on the market, but excluded from the NRDL that year.

Table 2: Regressions on Bargaining Outcome

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ survival (month)	0.024***						0.015*
	(0.008)						(0.008)
$\mathbb{1}$(1st negot. of an indication)		0.225*					0.106
		(0.117)					(0.106)
log(mortality)			-0.000				-0.008
			(0.013)				(0.011)
International firm				0.008			-0.087
				(0.098)			(0.084)
#Year since entry					-0.057		-0.108***
					(0.046)		(0.041)
log(sales$_{-1}$)						0.087***	0.088***
						(0.015)	(0.016)
Constant	0.407***	0.471***	0.531***	0.523***	0.620***	0.527***	0.750***
	(0.062)	(0.054)	(0.158)	(0.076)	(0.088)	(0.042)	(0.161)
R^2	0.075	0.034	0.000	0.000	0.014	0.245	0.336
Independent Variable Mean	4.94	0.21	11.65	0.60	1.62	-0.00	

Note: This table presents OLS regression results, regressing an indicator for negotiation success on various product features. 58 of the 97 total negotiations resulted in success. Δ survival (months) denotes the estimated improvement in overall survival from the drug, compared to standard therapy, based on Phase III clinical trials. $\mathbb{1}$(First negot. of an indication) takes the value of 1 if the drug is the sole insured drug for any indication; log(mortality) denotes the log(mortality) of approved indications for the drug. International firm is an indicator for firms based outside China. Years since entry denotes how long the drug had been sold on the Chinese market as of the negotiation round. log(sales$_{-1}$) denotes the log sales of the drug in the quarter before the negotiation.

3 Model

We now present a model of China's cancer drug market that formulates how key market primitives, such as demand, cost, the government budget constraint, and bargaining power jointly determine policy effectiveness. The model also serves two primary counterfactual objectives. First, it allows us to disentangle the impact of the NDRL reform into effects driven by insurance expansion vs. those driven by centralized negotiation. Second, it facilitates simulations of market outcomes under alternative insurance designs and negotiation protocols.

3.1 Model of Patient Demand

Patient i's utility from taking drug j in market m (province-quarter) is assumed to take the following form:

$$u_{ijm} = \alpha_{im} \times \log(OOP_{jm}) + \mathbf{X}_{ijm}\delta + \xi_{jm} + \epsilon_{ijm}, \tag{1}$$

where OOP_{jm} is the out-of-pocket price for drug j in market m, defined as

$$OOP_{jm} = p_{jm} \times (\mathbb{1}(\text{insured})_{jm} \times \text{Coins rate}_m + \mathbb{1}(\text{not insured})_{jm}).$$

A "drug" is a brand-molecule combination. The inside good includes branded innovative drugs, where each brand corresponds to a unique molecule.[15] There may in general be multiple producers of non-innovative cancer molecules. The total market size is the imputed population of cancer patients from China's cancer registry, at the province-year level. The outside option is a composite good that may include Chinese medicine, non-drug treatment, or no treatment.

Our preferred specification allows patient i's price sensitivity to depend on income: $\alpha_{im} = \alpha_0 + \alpha_1 \times \log(\text{income})_{im}$, where the empirical distribution of $\text{income}_{im} \sim logN(\mu_m, \sigma_m)$ in each province is observed in the Census data. In alternative specifications, we introduce a random coefficient term in price sensitivity: $\alpha_{im} = \alpha_0 + \alpha_1 \times \log(\text{income})_{im} + \alpha_2 \times \nu_i$, where ν_i follows a standard normal distribution. All specifications control for $\mathbf{X}_{ijm}$, which consists of drug and province-by-quarter fixed effects, dummy variables for the seven major cancer body system indications (an important set of cancer drug attributes), and a total count of other minor cancer indications for each drug in each year.

The sets of instruments we use are as follows: (1) a negotiation dummy (=1 if the drug is included in the NRDL in that quarter), which exogenously shifts the retail and out-of-

[15] None of the innovative drugs have exact generic substitutes, and biosimilars have not yet been eligible for negotiation.

pocket prices; (2) a negotiation dummy interacted with province-level median income, which allows differential responses to the price shock created by the NRDL Reform among high-income patients; (3) a negotiation dummy interacted with the 25th, 50th, and 75th percentiles of province-year income, to provide flexibility relative to (2); and (4) the number of direct rival products within the same drug class-province-year, aiming to capture the effect of local competition on prices. The "drug class" is the 5th-level Anatomical Therapeutic Chemical classification (ATC5), which groups pharmacological products according to their chemical substance.

3.2 Bargaining Model

We posit that the negotiation process between the government and pharmaceutical companies is best described by a complete information multi-lateral Nash-in-Nash framework. Following the empirical bargaining literature for health care and other vertical markets, we assume that bargaining outcomes are binding in all contingencies, and the failure of one negotiation does not influence the outcomes of others (Crawford et al., 2018; Gowrisankaran et al., 2015; Grennan, 2013; Ho and Lee, 2017; Horn and Wolinsky, 1988). These assumptions are supported by the institutional features of the NRDL Reform, wherein each group of experts is delegated by the government to negotiate over a specific drug with the pharmaceutical company that holds its patent (see Section 2.1).

Firm Profit Pharmaceutical companies participate in NRDL negotiations to maximize their profits in the Chinese market. While profits associated with a successful negotiation are standard, the threat points – firms' profits when negotiations fail – are different in our setting than in most empirical studies of health care bargaining. Typically, negotiation breakdowns would result in the product being excluded from consumers' choice sets. However, in our context, a failed negotiation means the drug is excluded from the NRDL formulary but remains available in the retail market. The key difference is the coinsurance amount: without NRDL inclusion, patients bear 100% of the retail price, compared to the 20%-45% coinsurance if the drug were included. As a result, firms' deviation payoff in the event of a negotiation failure is the maximum achievable profit via Bertrand-Nash pricing, given the formulary status and prices of other products in the market.

For simplicity, we assume single-product firms in the following discussion, though our estimator accommodates multi-product firms. With a slight abuse of notation, we use j to denote the firm producing the drug. Let $\mathcal{G}$ denote all drugs included in the NRDL formulary

and m denote a market (province-quarter). Under a successful negotiation, firm j's profit at the negotiated price p_j (uniform nationally) and given the formulary $\mathcal{G}$ is:

$$\pi_j(p_j; \mathbf{p}_{-j}, \mathcal{G}) = \sum_m (p_j - mc_{jm})\, q_{jm}\,(p_j; \mathbf{p}_{-j}, \mathcal{G})\,.$$

Firm j's payoff from a failed negotiation is the maximal profit achieved from selling the drug without insurance in each retail market a la Bertrand-Nash:

$$\pi_j^{dev}(\mathbf{p}_j^{BN}; \mathbf{p}_{-j}, \mathcal{G}) = \max_{\tilde{\mathbf{p}}_j} \sum_m (\tilde{p}_{jm} - mc_{jm})\, q_{jm}(\tilde{p}_{jm}; \mathbf{p}_{-j}, \mathcal{G}/\{j\})$$

Crucially, firm j sets different prices across provinces under negotiation failure. Its gain from a successful negotiation at the price p_j and network $\mathcal{G}$ is defined as: $\Delta\pi_j(p_j; \mathbf{p_{-j}}, \mathcal{G}) \equiv \pi_j(p_j; \mathbf{p}_{-j}, \mathcal{G}) - \pi_j^{dev}(\mathbf{p}_j^{BN}; \mathbf{p}_{-j}, \mathcal{G})$.

Government Incentives The central government cares about patient welfare but faces constraints on drug insurance spending. We consider several welfare metrics, including the standard measure of consumer surplus, but also more equitable measures, such as an inverse-income weighted consumer surplus measure drawn from the public finance literature (Hendren, 2020; Saez, 2002). The discussions below focus on consumer surplus, though the analyses are similar with other welfare metrics. Let V denote the government objective function, where β captures the government's relative weight on insurance program expenditures:

$$V(\mathbf{p}, \mathcal{G}) = CS(\mathbf{p}, \mathcal{G}) - \beta TC(\mathbf{p}, \mathcal{G}),$$

The change in consumer surplus from adding drug j to the NRDL formulary is the aggregate monetized increase in patient utility compared to no insurance coverage for drug j:

$$\Delta CS(p_j; \mathbf{p_{-j}}, \mathcal{G}) = \sum_m \mathrm{MS}_m \cdot \int_i \int_{p_j}^{p_{jm}^{BN}} \underbrace{\frac{1}{\alpha_i/p}}_{\substack{\$ \text{ per} \\ \text{util}}} \cdot \underbrace{\frac{\partial \widetilde{EU}_{im}(p; \mathbf{p_{-j}}, \mathcal{G})}{\partial p}}_{\substack{\text{change in utils for} \\ \text{a local price change}}} dp \cdot dF(i|m),$$

where MS_m is the market size (number of patients diagnosed with cancer) in province m and $\widetilde{EU}_{im} = \mathbb{E} \max_j u_{ijm}$ denotes the ex-ante utility of patient i in market m given their choice set. Patient utility u_{ijm} is defined in Equation (1). Government spending, TC, consists of

insurance program expenditures on all drugs covered by the NRDL formulary:

$$TC(\mathbf{p}, \mathcal{G}) = \sum_j \sum_m \mathbb{1}(j \in \mathcal{G}) \, (1 - \text{Coins}_m) \, p_j q_{jm}.$$

The government's gain from covering drug j at the negotiated price p_j is $\Delta V(p_j; \mathbf{p_{-j}}, \mathcal{G}) = \Delta CS(p_j; \mathbf{p_{-j}}, \mathcal{G}) - \beta \Delta TC(p_j; \mathbf{p_{-j}}, \mathcal{G})$.[16]

Equity Considerations The specification of the government's objective function above assumes that the government has a utilitarian preference and cares about consumer surplus. As a robustness check, we consider alternative specifications that allow for equity considerations following the public finance literature (Saez, 2002):

$$V(\mathbf{p}, \mathcal{G}) = \frac{1}{H} \int_i \text{income}_i^{-\nu} CS_i(\mathbf{p}, \mathcal{G}) di - \beta TC(\mathbf{p}, \mathcal{G}) \tag{2}$$

where ν is a scalar that represents the government's preference for redistribution considerations, with higher ν indicating a stronger preference for equity. The normalization constant $H = \int_i \text{income}_i^{-\nu} di$ is the sum of inverse income across all individuals. We examine three different cases: $\nu = 0$ (corresponding to the utilitarian preference above), $\nu = 1$, and $\nu = 2$.

Negotiation A negotiation succeeds if the government and drug company find an *admissible* price such that gains from trade are positive for both parties. In this model, the central government's relative weight β on total expenditure, which we assume is a random variable from a given distribution $\beta \sim F_\beta$, serves several purposes. First, it is a parsimonious way to reflect the government's priorities on patient welfare vs. fiscal constraints. Second, the parameter helps rationalize negotiation failures observed in our data. As β increases, the government's focus on minimizing expenditure intensifies, exerting downward pressure on the drug prices deemed acceptable. If these prices fall below a threshold where the gains from trade for pharmaceutical companies turn negative, negotiations may fail, with drug companies withdrawing from the bargaining table. Third, the assumption that β is a random variable helps explain the variability in bargaining outcomes among drugs with similar consumer surplus gains. The fact that drugs with similar patient surplus gains sometimes, but not always, make into the NRDL suggests that different government representatives may apply different weights during

[16] In principle, both firms and the government care about the discounted sum of future payoffs. We assume that the parties hold passive beliefs about future negotiation outcomes, so the expected gains from successful negotiations are the same in each future period. Therefore, the static payoff approximates the discounted sum of future payoffs. Modeling potential dynamic incentives is beyond the scope of this paper.

their negotiations with pharmaceutical firms.

The magnitude of β determines the range of admissible prices that yield positive gains from trade for both negotiating parties. Let $\mathcal{P}_j$ represent the admissible set for drug j:

$$\mathcal{P}_j \equiv \{p_j : \Delta V_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right) \geq 0 \text{ and } \Delta \pi_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right) \geq 0\}.$$

If β is sufficiently high, such that no mutually agreeable price exists with positive gains for both sides, then the admissible set is empty, $\mathcal{P} = \varnothing$, and the negotiation fails.

For successful negotiations, the post-negotiation price maximizes the Nash product of gains from trade for both parties. The price discount relative to the retail price is determined by firm j's bargaining power τ_j:

$$p_j = \arg\max_{p_j} \left(\Delta \pi_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right)\right)^{\tau_j} \left(\Delta V\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right)\right)^{1-\tau_j},$$

which implies the following first-order condition for successfully negotiated prices:

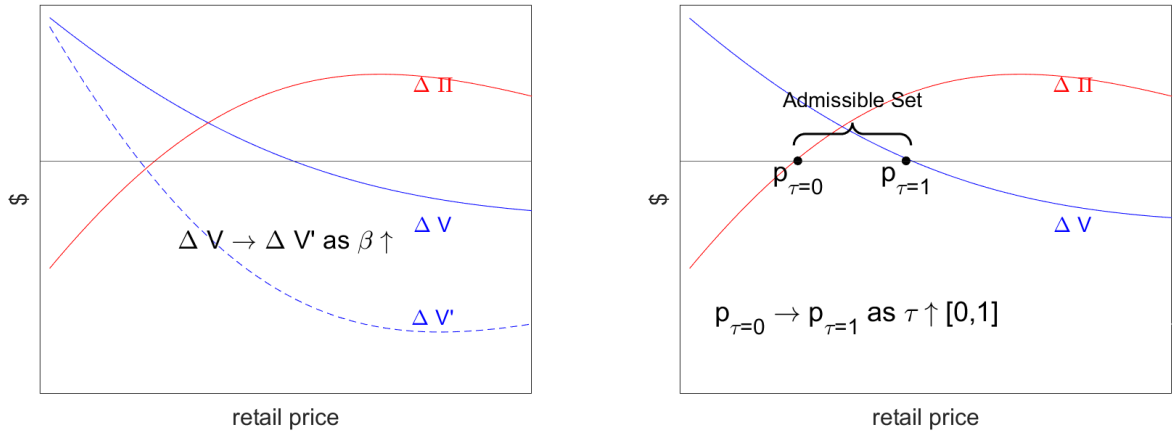
$$\sum_m \underbrace{(p_j - mc_{jm})}_{\text{retail margin}} \frac{\partial q_{jm}}{\partial OOP_{jm}} = -\sum_m \underbrace{\frac{q_{jm}}{\text{Coins}_m}}_{\text{expansion effect}} + \underbrace{\left(\frac{1-\tau_j}{\tau_j} \times \frac{\Delta \pi_j}{\Delta V_j} \frac{dV_j}{dp_j} \frac{1}{\text{Coins}_m}\right)}_{\text{bargaining effect}}, \ \forall j \in \mathcal{G}. \quad (3)$$

To illustrate how the government's preference β and a drug company's bargaining power τ affect negotiation outcomes, Figure 5 plots each party's gains from trade against the negotiated price. The price range where both curves are positive is the admissible set: the zone of possible agreement. Ceteris paribus, as β increases, the government's gains from trade shift downward, narrowing or even eliminating the admissible set; conversely, lower β values expand it (Panel (a)). The bargaining parameter determines the negotiated price within the admissible region. If the pharmaceutical company holds all bargaining power, the negotiated price will align with the upper bound of the admissible set. If the government wields more bargaining power, the final price will be closer to the lower bound (Panel (b)). In essence, whether negotiations succeed pins down the upper bound of β, whereas the location of the negotiated price within the admissible set together with parametric assumptions jointly identifies τ and β.

3.3 Estimation

Estimation proceeds through the following steps. Step one: recover demand parameters in Equation (1).

Figure 5: An Illustration of Model Predicted Bargaining Outcomes



(a) Identification of β

(b) Identification of τ

Note: This figure illustrates the roles of β and τ in determining the bargaining outcomes using a simulated example. Panel (a) plots the government gains from trade with two different β values: the dashed blue line represents a low β (ΔV), and the solid blue line represents a high β ($\Delta V'$). Panel (b) plots changes in the negotiated price as the firm's bargaining power τ increases.

Step two: for each successfully negotiated drug, we recover their marginal costs in each province using demand parameter estimates and the observed prices and market shares during the quarter before the negotiation, assuming Bertrand-Nash competition among all firm-market pairs.[17] We assume that marginal costs for drugs under negotiation remain unchanged from their pre-negotiation levels. In addition, both the government and firms use demand conditions from one quarter prior to the negotiation to evaluate gains from successful negotiations in future periods. Note that we can separately identify marginal costs and bargaining parameters because we observe market outcomes in pre-negotiation periods.

Step three: assume the government's relative weight on insurance spending $\exp(\beta)$ follows a log-exponential distribution (or β follows T1EV distribution): $\exp(\beta) \sim Exp(X_{\beta j}; \theta_\beta)$. We allow θ_β to be a function of drug attributes $X_{\beta j}$ such as clinical effectiveness. The pharmaceutical company's bargaining power depends on its firm attributes (such as nationality): $\tau_j = f(X_{\tau j}; \theta_\tau)$.

Step four: construct the sample log-likelihood function for parameters $\theta = \{\theta_\beta, \theta_\tau\}$, using the observed negotiation outcomes $\{\mathcal{G}_j \in \{0, 1\}, \forall j\}$ and negotiated prices $\{p_j\}$ for all success-

[17] We back out the marginal costs of other drugs using observed prices and market shares in the same quarter. The marginal cost estimates for non-negotiated drugs change from period to period, though the differences are modest as drug prices change infrequently. Results are similar if we restrict marginal costs to be constant over the entire pre-negotiation period.

ful cases $\mathcal{G}_j = 1$. A negotiation fails if the government's gains from trade are zero or negative at the lowest price acceptable to the drug company, denoted by p_j^l. By definition, p_j^l satisfies

$$\Delta\pi_j(p_j^l; \mathbf{p}_{-j}, \mathcal{G}) \equiv \pi_j(p_j^l; \mathbf{p}_{-j}, \mathcal{G}) - \pi_j^{dev}(p_j^{BN}; \mathbf{p}_{-j}, \mathcal{G}) = 0,$$

meaning the firms' gains from trade are exactly 0. We then define $\underline{\beta_j}$ as the β value at which the government's gains from trade become zero at price p_j^l:

$$\underline{\beta_j} = \frac{\Delta CS_j(p_j^l; \mathbf{p_{-j}}, \mathcal{G})}{\Delta TC_j(p_j^l; \mathbf{p_{-j}}, \mathcal{G}),} \tag{4}$$

Any β above $\underline{\beta_j}$ results in the government's gains turning negative at p_j^l, leading to bargaining failure. Intuitively, this condition implies that the government is unwilling to include the drug in the formulary, even at the firm's lowest profitable price. The likelihood of observing a negotiation failure for drug j is $Pr_j(\beta > \underline{\beta_j}) = 1 - F_\beta(\underline{\beta_j}; \theta_\beta)$.

For successful negotiations ($\mathcal{G}_j = 1$), β satisfies the interior condition: β_j and observed negotiated price p_j must satisfy Equation (3), the bargaining FOC. The equation is invertible with respect to β_j, leading to a closed-form solution of β as a function of negotiated price and bargaining parameter:

$$\beta_j(p_j, \tau_j) = \frac{-\vartheta\Delta CS_j + \Delta\pi_j \frac{\partial CS_j}{\partial p_j}}{\vartheta\Delta TC_j - \Delta\pi_j \frac{\partial TC_j}{\partial p_j}},$$

where $\vartheta = -\frac{\tau_j}{1-\tau_j}\frac{\partial \pi_j}{\partial p_j}$. Given the distribution assumption of β, the likelihood for observing p_j is $Pr_j(\beta = \beta_j) = \frac{\partial \beta_j}{\partial p_j} f_\beta(\beta_j(p_j; \tau_j); \theta_\beta)$.

Step five: the joint log-likelihood function is:

$$log\mathcal{L}(\theta) = \sum_j \underbrace{\mathbb{1}(\mathcal{G}_j = 1) log\left(Pr_j(\beta = \beta_j)\right)}_{\text{successful negotiations}} + \underbrace{\mathbb{1}(\mathcal{G}_j = 0) log\left(Pr_j(\beta > \underline{\beta_j})\right)}_{\text{failed negotiations}}.$$

We estimate the supply-side parameters via maximum likelihood.

Table 3: Demand Estimates

	OLS	IV	IV+RC		
	(1)	(2)	(3)	(4)	(5)
log(OOP)	-0.716	-1.211	-10.542	-9.783	-9.482
	(0.009)	(0.022)	(0.654)	(0.640)	(0.711)
log(OOP) × log(income)			0.865	0.795	0.692
			(0.060)	(0.059)	(0.059)
log(OOP) × ν_r					0.605
					(0.236)
Indication					
Lung cancer	0.531	0.264	0.224	0.227	0.159
	(0.056)	(0.058)	(0.063)	(0.062)	(0.063)
Breast cancer	-0.001	-0.016	-0.034	-0.033	0.012
	(0.112)	(0.114)	(0.107)	(0.106)	(0.109)
Colon cancer	0.626	0.663	0.767	0.759	0.602
	(0.088)	(0.089)	(0.084)	(0.084)	(0.089)
Stomach cancer	0.630	0.557	0.617	0.613	0.453
	(0.090)	(0.091)	(0.077)	(0.076)	(0.089)
#Indication	0.161	0.118	0.073	0.077	0.080
	(0.012)	(0.012)	(0.013)	(0.012)	(0.012)
Observations	112019	112019	112019	112019	112019
P75 elasticity	-0.72	-1.21	-1.30	-1.28	-1.89
Median elasticity	-0.72	-1.21	-1.60	-1.56	-2.35
P25 elasticity	-0.72	-1.21	-1.96	-1.89	-2.85
Product FE	Yes	Yes	Yes	Yes	Yes
Province*Time FE	Yes	Yes	Yes	Yes	Yes

Note: The table shows the demand estimates. Column (2) instrument: negotiation dummy. Column (3) instruments: negotiation dummy, alone and interacted with province-year median income. Column (4) instruments: negotiation dummy, alone and interacted with 25th, 50th, and 75th percentiles of province-year income. Column (5) instruments: negotiation dummy, alone and interacted with province-year median income, plus the count of rival products within the same ATC5-province-year. The median elasticity reported in this table is the median individual-level elasticity ($\frac{ds_{ij}/s_{ij}}{dp_j/p_j}$) across products.

4 Results

4.1 Demand Estimates

Table 3 reports demand estimates. Column (1) presents OLS estimates, while Column (2) instruments prices using the negotiation dummy. Columns (3) and (4) allow price sensitivity to vary with income. Column (3) uses the negotiation dummy and its interaction with province-year median income as instruments. Column (4) uses the negotiation dummy and its interaction with the 25th, 50th, and 75th percentiles of province-year income as instruments. Column (5) adds a random coefficient on price and additionally uses the number of direct rival products within the same ATC5-province-year as an instrument.

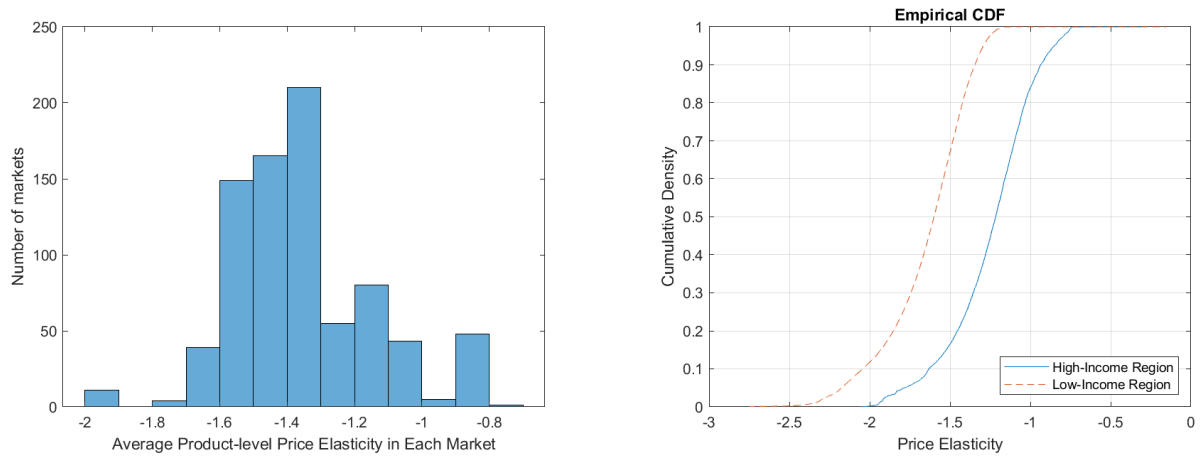
Instrumenting for the out-of-pocket price OOP has the anticipated effect of increasing the estimated price elasticity. Products with large positive demand shocks tend to have both higher prices and higher demand, biasing the price coefficient downward. In Column (2) that instrument for prices, the median own-price elasticity of demand is -1.2, in line with recent studies on global drug markets (Dubois et al., 2022). Across Columns (3) to (5), the interaction between income and price is both statistically significant and economically significant, indicating that higher-income individuals are less price-sensitive. In our preferred specification Column (3), the median own-price elasticity is -1.6, with an inter-quartile range of [-1.96, -1.3]. The differences in price sensitivity between wealthy and less wealthy households underscore the importance of distributional considerations, especially since the highest-income provinces in our setting also have the lowest coinsurance rates. The results in Column (4) with more instruments closely match those in Column (3). The random coefficient specification in Column (5) yields parameter estimates similar to those in Column (3), but the median own-price elasticity rises to -2.35, implying lower profit margins than those suggested by industry reports, also failing to rationalize the big observed retail price reduction in the negotiation.[18] Hence, we use Column (4) as our preferred specification.

Figure 6a shows a histogram of the implied average product-level own-price elasticities across provinces, based on the demand estimates from Column (3) of Table 3. Figure 6b plots the cumulative distribution function of the estimated price elasticity for provinces with above-median incomes (blue line) and below-median incomes (dashed red line). The distribution for high-income provinces shifts considerably to the right relative to that of low-income provinces, although there is still significant heterogeneity in both income and price sensitivity within each

[18]The elasticity at -2.35 would imply that 75% successfully negotiated drugs have negative profits post-negotiation.

group.

Figure 6: Estimated Income Elasticity across Different Income Levels



(a) Histogram of Price Elasticity

(b) CDF of Price Elasticity

Note: Figure (a) plots the model implied average product-level own-price elasticities across different markets and Figure (b) plots the model-implied own-price elasticities across patients, both according to the specification in Column (3) of Table 3. The solid line denotes patients in high-income provinces (Beijing, Shanghai, Guangdong, Tianjin, Zhejiang, Jiangsu, Fujian), and the dashed line denotes patients in low-income provinces.

4.2 Supply Estimates

Table 4 presents the estimates for β, the government's weight on drug insurance spending, and τ, firms' bargaining power parameter. The first specification only estimates the average of the β distribution, while the second specification allows the average to depend on the life-years saved per course of treatment as estimated from published phase III clinical trials. In addition, the second specification allows domestic and foreign firms to have different bargaining power.

Focusing first on the government's weight on drug spending (i.e., the budget constraint), the θ parameters for the log-exponential distribution imply that β =0.78 for the average drug and β =1 for the median drug. In addition, β is lower for drugs with greater overall survival benefits. That is, for the median drug, the government weighs drug spending and consumer surplus equally, but the budget constraint is relaxed for higher-quality drugs. This finding implies that the government prioritizes the inclusion of high-quality drugs in the NRDL formulary.

The bottom panel of the table indicates that the average bargaining power of firms, τ, is roughly 0.68, with the difference in bargaining power between foreign multinationals and domestic firms being small and imprecisely measured. At $\tau = 0.68$, firms hold more bargaining

Table 4: Supply-side Estimation

	Baseline (1)		More Covariates (2)	
Variable	Coef.	S.E.	Coef.	S.E.
Gvt. Budget Constraint				
θ_β^0	4.27	0.48	4.91	0.93
θ_β^1 (Δ survival)			-0.10	0.05
Firm Bargaining Power				
θ_τ	0.68	0.00		
θ_τ^0 (Foreign)			0.68	0.02
θ_τ^1 (Domestic)			0.65	0.00

Note: This table presents the supply side estimates. The estimation sample includes 97 negotiations with cancer drugs in 2016-2022. β is assumed to follow a log-exponential distribution with inverse scale parameter determined by θ_β. τ is assumed to be a deterministic function of θ_τ.

power than the government, but the negotiated prices would still be substantially lower than the equilibrium prices in the private market (where prices are set via Bertrand-Nash, which is equivalent to firms having all the bargaining power).

As a robustness check, we estimate the supply-side parameters assuming the government cares about equity considerations (Equation (2)). The estimates θ_τ are robust across ν's, but $\nu = 0$ delivers the best in-sample fit as measured by the likelihood. We use $\nu = 0$ as our preferred specification in the remainder of the draft and report welfare results with $\nu = 1$ and $\nu = 2$ in the appendix. We next conduct a policy evaluation of the NRDL reform.

4.3 Evaluation of the NRDL Reform

The NRDL reform consists of two policy instruments: a) insurance expansion, which adds previously uninsured innovative drugs to the NRDL formulary, and b) central negotiation, where the government and pharmaceutical firms bargain to determine a mutually agreeable price. We first decompose the effects of the NRDL reform on price, quantity, and welfare into impacts driven by insurance expansion and those by central negotiation. We then explore how these welfare implications vary across provinces and income groups.

During our study period (2017–2023), 57 drugs were included in the NRDL formulary. The analyses here focus on these drugs with successful negotiation outcomes. We revisit the 13 drugs that failed NRDL negotiations and the issue of bargaining failure in Section 5, where

we examine alternative policy designs. We conduct simulations using the second quarter of 2023 as our reference period, holding patient income, preference, and production costs at their 2023(Q2) levels. In each counterfactual simulation, we predict negotiated prices for these 57 drugs, solve for the equilibrium prices for drugs excluded from the formulary and sold in the retail market, and recalculate the equilibrium quantities for all cancer drugs.

We consider four scenarios. In the **Baseline** scenario, we assume that the NRDL Reform did not exist. There was no insurance expansion, and all 57 successfully negotiated drugs would be sold exclusively in the private market. This scenario mirrors the pre-reform conditions (before 2017) but accounts for new drugs that entered the Chinese market between 2017 and 2023. In the **Negotiation-only** counterfactual, the government negotiates drug prices with pharmaceutical firms, but it does not offer insurance coverage for successfully negotiated drugs. Firms retain the option to sell in the private market when negotiations fail. In the **Expansion-only** scenario, the government includes the 57 successfully negotiated cancer drugs in the NRDL formulary, allowing patients to pay only their out-of-pocket portion at province-specific coinsurance rates. However, no central negotiation occurs, and pharmaceutical firms continue to set prices a la Bertrand-Nash. Finally, we consider the case of **Negotiation plus Expansion**, which represents the full NRDL reform as observed in the data but assumes that all negotiations occurred in the 2nd quarter of 2023.

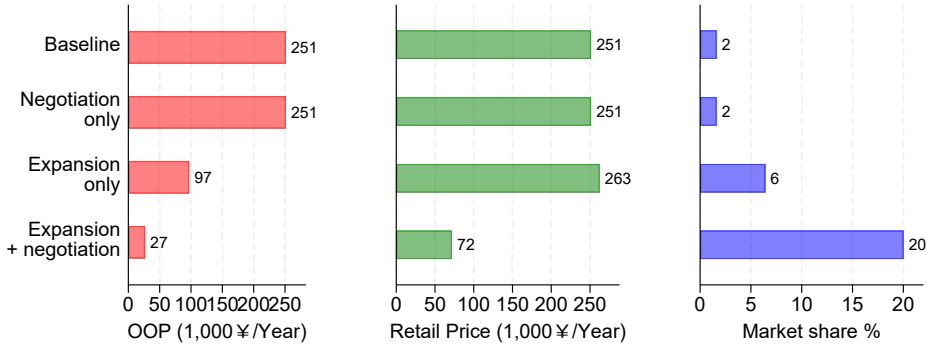
Changes in Prices and Quantity The top row of Figure 7(a) reports baseline price and quantity estimates.[19] Absent the NRDL Reform, both OOP and the retail price for an annual dosage would average about ¥251,000 per year (equivalent to $35,900), with the focal innovative drugs capturing only 2% of the cancer drug market.

Results for the "Negotiation only" scenario in the second row of Figure 7(a) are identical to the Baseline. Without insurance expansion, the government has no leverage to incentivize firms to participate in negotiations. Without the prospect of market expansion, firms prefer to sell drugs in the private market at profit-maximizing prices rather than accepting negotiated terms.

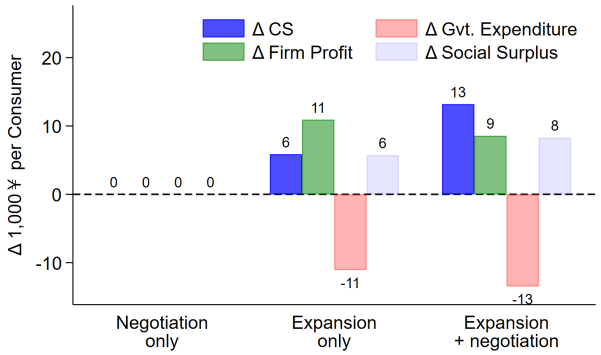
The third row of Figure 7(a) presents results for the "Expansion only" scenario. Here, insurance coverage is extended to all 57 drugs, but no price negotiation takes place. Insurance lowers patients' out-of-pocket costs, increases demand, and allows firms to raise their optimal retail prices. Specifically, for every ¥100 increase in the retail price, patients pay only ¥20–¥45 after insurance. This leads to a 4% increase in the average retail price to ¥262,000, while

[19] See Appendix Table A4 for numbers.

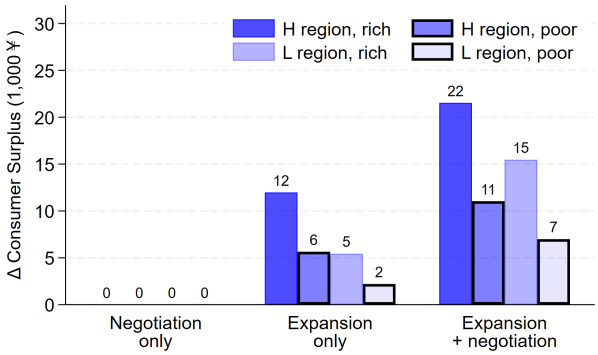
Figure 7: NRDL Reform—Decomposition Results



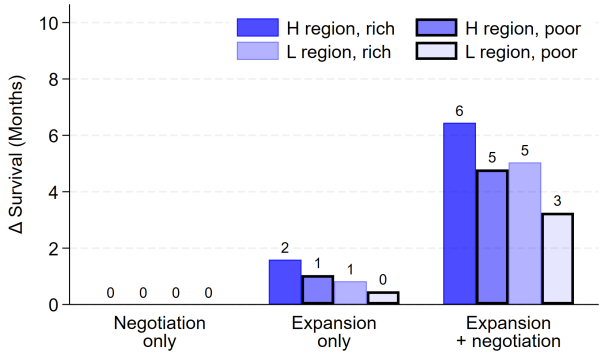
(a) Price and Market Share



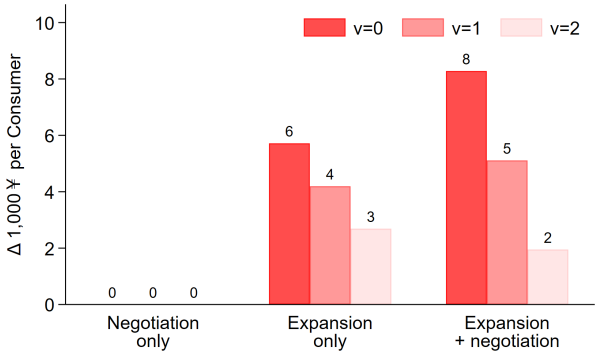
(b) Welfare Breakdown



(c) Δ Consumer Surplus (WTP) across Income Groups



(d) Δ Survival across Income Groups



(e) Alternative Social Surplus Measures

Note: This figure summarizes counterfactual outcomes for 57 cancer drugs that were successfully negotiated as of 2023. In panel (a), we compare four scenarios. "Baseline" denotes Bertrand-Nash pricing without insurance coverage. "Negotiation only" assumes that the government negotiates with firms to cut prices but does not offer insurance coverage. "Expansion only" assumes that the government offers insurance coverage but does not negotiate prices with firms. "Expansion+negotiation" denotes the NRDL scenario, where the government offers insurance coverage and negotiates prices. Panels (b)-(e) compare outcomes in each scenario to the "Baseline" scenario.

patients' OOP spending decreases to ¥97,000 per year (a 61% reduction). Demand surges; the focal innovative drugs' market share increases from 2% to 6% (a 200% expansion).

The fourth row of Figure 7(a) illustrates the combined effect of the full NRDL Reform, with both insurance expansion and central negotiation. Unlike the Expansion only scenario, the combined reform significantly lowers both both OOP *and* retail prices. Specifically, OOP spending per annual dose drops by ¥225,000 (an 89% reduction), and the average retail price decreases by ¥182,000 (a 72% reduction). These price reductions drive a 1,133% increase in market share, with the focal innovative drugs capturing 20% of the cancer drug market, a result comparable to the 903% quantity expansion documented in the descriptive analyses in Section 2.3.

Overall, these simulation results indicate that the combined effects of insurance expansion and price negotiation are greater than the sum of their individual effects, suggesting complementarity between negotiation and insurance expansion.

Welfare Figure 7(b) illustrates the welfare effects relative to the Baseline. Each group of four bars represents changes in consumer surplus (CS), firm profit (PS), government spending (GS), and total surplus (CS + PS − GS). To emphasize that higher government spending reduces total surplus, we plot government expenditures as negative values, with bars extending downward on the y-axis.

As expected, the "Negotiation only" scenario has no welfare impacts relative to the Baseline. In contrast, "Expansion only" increases consumer surplus by ¥6,000 per patient per year and firm profit by ¥11,000 per patient per year, but at the cost of an ¥11,000 per patient per year increase in government spending. The "Expansion plus Negotiation" reform raises consumer surplus by ¥13,000 per patient-year, more than doubling the gains from "Expansion only" due to the sharp reduction in patients' OOP costs. Notably, the increase in consumer surplus matches the rise in government expenditure, suggesting that the combined reform more effectively achieves the government's goal of improving patient welfare while maintaining fiscal control. Firm profit increases by ¥9,000 per patient per year under the combined reform, slightly lower than in the "Expansion only" scenario.

These results highlight that negotiation alone has no effect on welfare, while insurance expansion benefits patients but entails relatively large government spending. In the combined reform, negotiation and insurance expansion work as complements: insurance expansion ensures broader patient access to drugs, while negotiation shifts part of the financial burden from the government to pharmaceutical firms (through lower drug prices), benefiting both the government and patients. Overall, total surplus is highest under the combined reform,

increasing by ¥8,000 per patient per year relative to the Baseline, compared to only ¥6,000 under "Expansion-Only".

An alternative approach to evaluating welfare gains is through health outcomes. Based on clinical evidence from medical literature, enhanced access to innovative cancer drugs under the combined NRDL reform extends overall survival by 4.85 months per patient, a *1,372%* increase relative to the Baseline. This effect is more than five times greater than the survival benefit of insurance expansion alone, which increases survival by 0.92 months (259% of the Baseline, which is 0.35 months). Note the contrast with Figure 7(b): while gains in CS under the combined NRDL reform are twice those in the "Expansion-only" scenario, the survival benefits are fivefold higher. This discrepancy arises because poorer patients contribute less to CS due to their lower willingness to pay, even though they experience substantial health benefits.

Equity Considerations The aggregate welfare effects presented above mask substantial heterogeneity across patients, both by province and income level. To capture these distributional differences, we classify provinces into wealthy and less wealthy regions based on median provincial income. Within each province, we further categorize patients into high-income and low-income groups using each provincial median income as the threshold. This results in four distinct groups: high- and low-income patients in wealthy provinces and high- and low-income patients in less wealthy provinces.

These distributional effects are illustrated in Figure 7(c). Wealthier regions tend to offer more generous (lower) coinsurance rates; hence a given reduction in retail drug prices leads to a larger decrease in OOP expenses for patients in these areas. In addition, high-income households are less price-sensitive and more likely to purchase innovative drugs. As a result, wealthy individuals in high-income (low-coinsurance) regions experience the largest dollarized welfare gains under both the "Expansion only" and "Expansion + Negotiation" policies, at ¥12,000 and ¥22,000, respectively. In contrast, the welfare gains for poor patients in low-income provinces are significantly lower, at ¥2,000 and ¥7,000, respectively.

A similar, though less extreme, pattern emerges when we measure patient benefits using increases in months survived, as shown in Figure 7(d). While wealthy households in high-income provinces still benefit the most, the disparities in survival gains are much smaller than those in CS gains. This is because survival is a quantity-based measure and is therefore less sensitive to the differences in price sensitivity across income groups. Echoing the discussions above, all income groups experience four to fivefold increases in survival benefits under the combined reform relative to the "Expansion-only" scenario.

Turning to social surplus, Figure 7(e) shows that both the "Expansion only" and "Expansion plus Negotiation" policies lead to increases in social surplus compared to the Baseline/Negotiation Only scenario. However, both scenarios are regressive, as wealthier patients benefit more than poorer ones in terms of both CS and survival improvements. The relative ranking of these two policies depends on the government's preference for equity. As the government's weight on equity increases (ν increases from 0 to 1 or 2), the social surplus gains associated with each policy decline. This is because both policies entail greater government subsidies for high-income patients than for low-income patients, and a stronger preference for equity penalizes such transfers.

If the government is utilitarian ($\nu = 0$) or has a moderate preference for equity ($\nu = 1$), the efficiency considerations (gains in CS) dominate, making the combined reform the preferred policy. However, if the government has a stronger preference for equity ($\nu = 2$), then the flatter gradient in consumer surplus under "Expansion only," seen in Figure 7(c), becomes more desirable than the steep gradient under "Expansion plus Negotiation." With a sufficiently strong preference for equity, "Expansion only" is preferred over "Expansion plus Negotiation."

5 Counterfactual Policy Simulations

In this section, we compare the observed NRDL reform with several alternative policy designs to evaluate how policy choices impact the firms' and governments' gains from trade and, ultimately, the welfare effects of drug market reforms. Section 5.1 examines market access negotiation, Section 5.2 compares centralized negotiation (as in NRDL reform) with decentralized negotiation, and Section 5.3 investigates optimal coinsurance designs.

We discuss both extensive and intensive margin effects for all alternative policy designs. On the extensive margin, different policy frameworks alter the range of prices that are mutually acceptable to firms and the government, thereby influencing the number of successful negotiations relative to the NRDL reform. On the intensive margin, policy variations affect the government's and firms' surplus, which in turn changes negotiated prices, realized quantities, and welfare conditional on negotiation success.

Our simulations consider all 70 drugs in the 2023Q2 market, including the 13 that failed NRDL negotiations. Since we do not observe the negotiated prices for these drugs, we cannot recover their $\boldsymbol{\beta}$ values. However, we observe the lower-bound thresholds, $\underline{\boldsymbol{\beta}}$'s as defined in Equation (4). At these thresholds, the government's gains from trade are zero at the price that makes the drug company's gains from trade also exactly zero. That is, a slight reduction

in β would have resulted in negotiation success. In the counterfactual simulations presented in the main text, we set $\boldsymbol{\beta} = \underline{\boldsymbol{\beta}}$ for these 13 drugs. In Appendix Section D, we report results under an alternative extreme assumption that these 13 negotiations would always fail (effectively setting $\boldsymbol{\beta} = \boldsymbol{\infty}$).[20]

Since the success or failure of one drug's negotiation can influence the gains from trade in other negotiations, there might be concerns of multiple equilibria in counterfactual simulations. We detail our algorithm for addressing these concerns in Appendix B.1.[21]

5.1 Market Access Negotiation

In Section 4.3, we noted that negotiation for NRDL formulary inclusion alone has no effect unless paired with insurance expansion. In this section, we strengthen the government's leverage by modeling a "market access" negotiation, where formulary inclusion is bundled with a drug's entry into the Chinese market. Under this policy, a failed negotiation results in the drug being entirely excluded from the Chinese market. This market-exclusion threat point is commonly used in empirical health economics studies, e.g., Dubois et al. (2022); Gowrisankaran et al. (2015); Grennan (2013); Ho and Lee (2017). We analyze two scenarios: market access negotiation without insurance expansion (MA-N) and with insurance expansion (MA-I). Additionally, we use the abbreviation FA-N for formulary access negotiation without insurance and FA-I for formulary access negotiation with insurance (i.e., the NRDL reform).

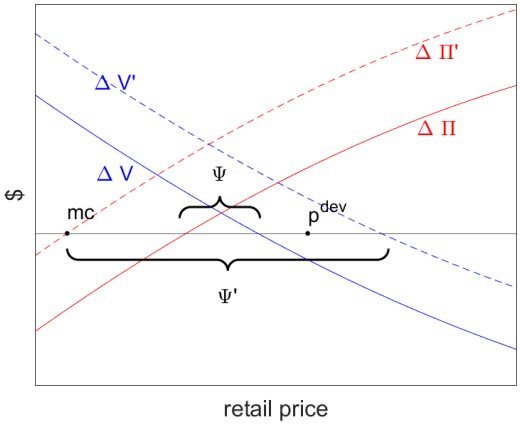
Consider first the MA-N scenario, where government expenditure is always zero regardless of the negotiation outcome, and the government's sole objective is to maximize consumer surplus. Unlike the ineffective "Negotiation alone" case in Section 4.3, the equilibrium price in the event of bargaining failure is higher: it is the virtual price p^{virtual}, at which demand is zero and firms earn zero profit. In contrast, under FA-N, the disagreement price is p^{BN} ($< p^{\text{virtual}}$). The harsher disagreement payoff under MA-N increases the gains from trade for both the government and firms. This, in turn, expands the range of admissible prices, which is any price between the marginal costs of producing innovative drugs and patients' willingness to pay. Consequently, negotiations always succeed, and the government *does* have leverage in this setting, as shown below.

Now consider MA-I. This policy differs from FA-I (the NRDL Reform) in several key ways.

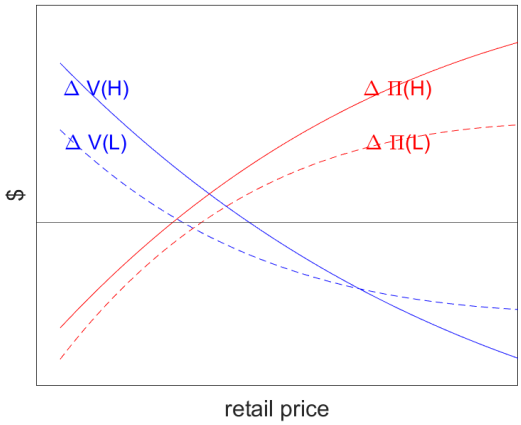
[20] Since β represents the shadow value of a dollar of government spending (i.e., social surplus generated if funds were allocated elsewhere), it is unlikely to be infinite. The results reported here and in the Appendix thus provide two meaningful bounds.

[21] In our setting, we do not find evidence of multiple equilibria, likely because these cancer drugs are sufficiently differentiated and target distinct indications.

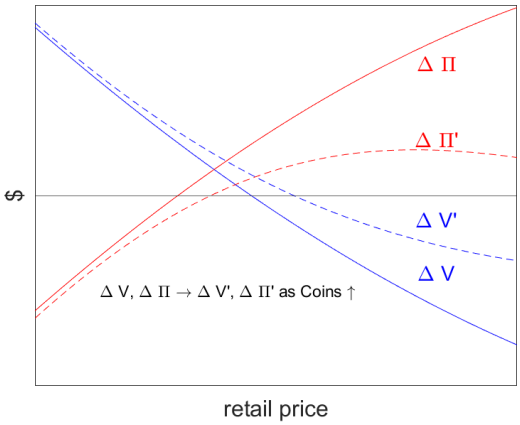
Figure 8: Effects of Policy on Gains from Trade



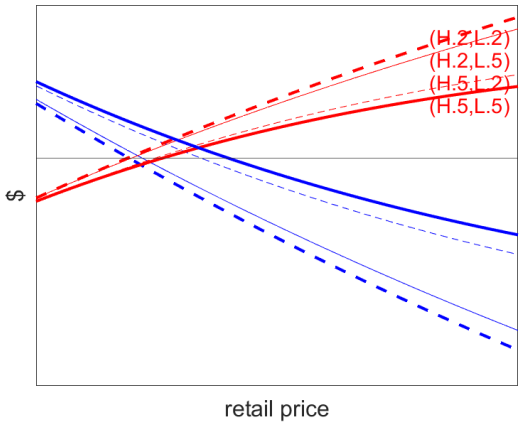
(a) Comparison with Market Access as Threat Point



(b) The Effect of Income



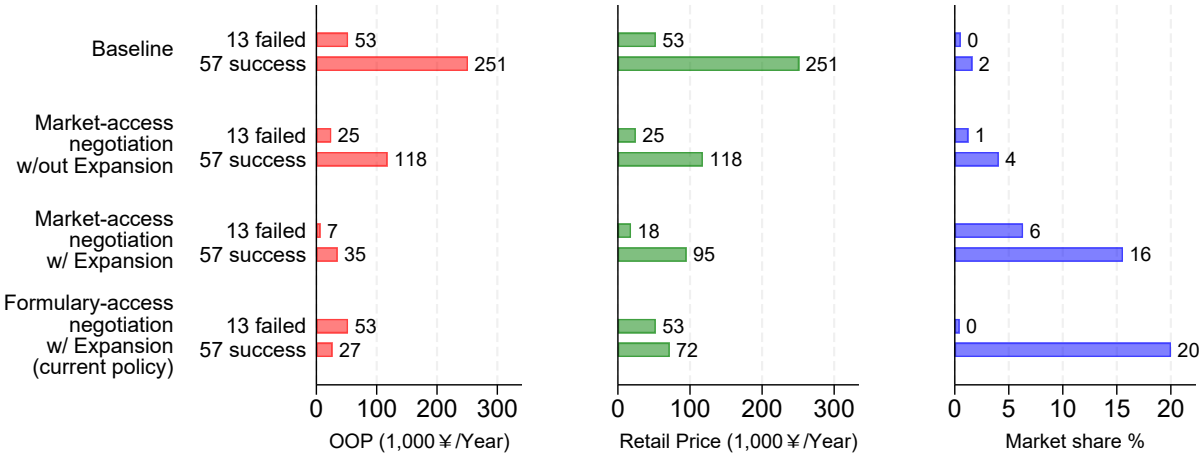
(c) The Effect of Coinsurance



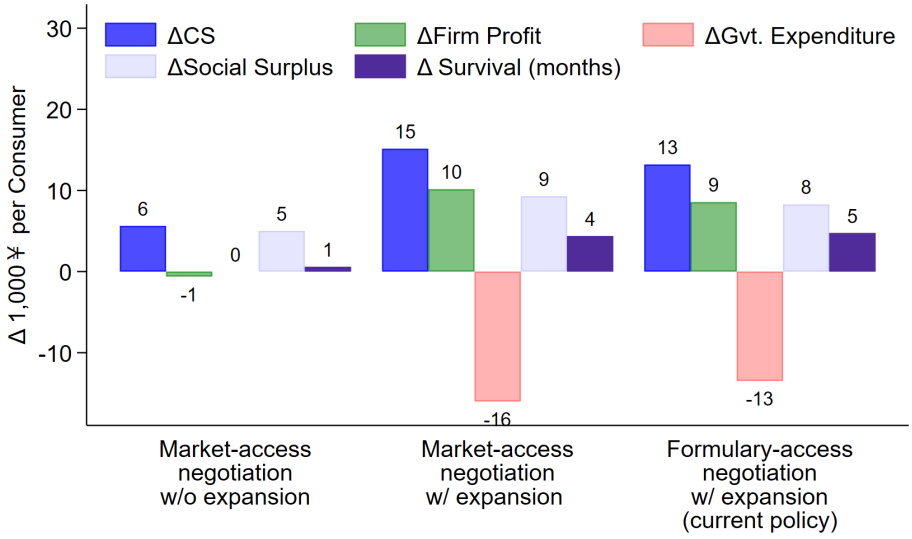
(d) The Effect of Income-specific Coinsurance

Note: This figure illustrates the effects of policy on the firm's and government's gains from trade. The firm's gains from trade are shown in red and labeled $\Delta\Pi$; the government's gains from trade are shown in blue and labeled ΔV. Panel (a) compares gains from trade for the observed NRDL combination of insurance expansion plus formulary access negotiation ($\Delta\Pi, \Delta V$, range of admissible prices Ψ), vs. the counterfactual combination of insurance expansion plus market access negotiation ($\Delta\Pi', \Delta V'$, range of admissible prices Ψ'). Panel (b) compares gains from trade in a high-income province ($\Delta\Pi(H), \Delta V(H)$) vs. a low-income province ($\Delta\Pi(L), \Delta V(L)$). Panel (c) compares gains from trade for an insurance expansion with low coinsurance rates ($\Delta\Pi, \Delta V$) vs. high coinsurance rates ($\Delta\Pi', \Delta V'$). Panel (d) compares gains from trade for different income-based coinsurance *schedules* ($Coins_H, Coins_L$), where $Coins_H$ is the coinsurance rate for high-income patients and $Coins_L$ is the coinsurance rate for low-income patients: the thick dashed lines correspond to $(0.2, 0.2)$, the thin solid lines correspond to $(0.2, 0.5)$, the thin dashed lines correspond to $(0.5, 0.2)$, and the thick solid lines correspond to $(0.5, 0.5)$.

Figure 9: Counterfactual Results: Alternative Bargaining Formats ($\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$)



(a) Price and Market Share



(b) Welfare Breakdown

Note: Alternative negotiation scenarios allow negotiation for 70 innovative cancer drugs and assume $\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$ for drugs that failed the NRDL negotiations. In panel (a), we compare four scenarios. "Baseline" denotes Bertrand-Nash pricing without insurance coverage. "Market access negotiation" assumes that, in the event of bargaining failure, the government excludes the drug from the market. Bargaining power is fixed at the estimated values. "Expansion + Market access negotiation" further provides insurance coverage at observed provincial coinsurance rates if the negotiation is successful. "Expansion + Formulary access negotiation" is the NRDL Reform. Results are presented separately for the 57 drugs that succeeded in the NRDL Reform, and for the 13 that failed. Panel (b) compares welfare outcomes in each scenario to the "Baseline" scenario.

Similar to the discussion above, the equilibrium price in the event of bargaining failure under MA-I is the virtual price p^{virtual}, whereas under FA-I, it is p^{BN} ($< p^{\text{virtual}}$). The more severe disagreement payoff expands the set of admissible prices. Firms are willing to accept any price above marginal cost, while the government is willing to pay any price where consumer surplus exceeds government expenditure (weighted by β). Thus, switching from FA-I to MA-I increases the likelihood of successful agreements.[22] Figure 8(a) illustrates how the gains from trade for both the government (solid blue line) and the drug company (solid red line) shift upward under MA-I compared to the NRDL reform. That said, the effect on negotiated prices is ambiguous. If patients have a high WTP for an innovative drug (i.e., ΔCS is high), the government's bargaining position weakens under MA-I, as denying market entry would significantly harm consumer surplus. In such cases, negotiated prices under MA-I may be higher than those under FA-I.

Price Reduction and Market Expansion Figure 9(a) compares simulated OOPs, retail prices, and quantities under four scenarios (FA-N is discussed in Section 4.3): 1) the Baseline Bertrand-Nash (no negotiation or insurance expansion), 2) MA-N, 3) MA-I, and 4) FA-I (i.e., the existing NRDL Reform). Appendix Table A5 provides further details. Since the 13 drugs that failed NRDL negotiations had significantly lower market shares and pre-negotiation retail prices than the 57 successfully included drugs, we categorize them as 'failed drugs' and the latter as 'successful drugs' and report the counterfactual results separately for each group.

Compared to the baseline, both MA-N and MA-I ensure successful negotiations for all drugs, driving significant market expansion on both the extensive and intensive margins. Under MA-N, the government achieves substantial price reductions by leveraging the threat of market exclusion, even without insurance expansion. The average negotiated price drops to 53% of baseline levels for both 'failed drugs' and 'successful drugs'. The OOP prices remain the same as negotiated prices. Market shares increase by 0.7 ppt (120% sales growth) for the 13 failed drugs and by 2.4 ppt (150% sales increase) for the 57 successful drugs.

With insurance expansion (MA-I), negotiated prices decline even further, leading to major reductions in OOP prices. For failed drugs, retail prices decrease by ¥35,000 (66%), OOP prices drop by ¥46,000 (87%), and market share expands by 5.7 ppt (1,000% increase in sales). For successful drugs, retail prices fall by ¥156,000 (62%), OOP prices decline by ¥216,000 (86%), and market shares grow by 13.9 ppt (870% increase in sales).

While MA-I achieves significant price reductions for both failed drugs and successful drugs,

[22] negotiation may still fail under MA-I if the coinsurance rate is low (leading to high government spending) and the opportunity cost of government funds, β, exceeds 1, as shown in Section 5.3.

the reductions for successful drugs are slightly smaller than those under NRDL reform. As a result, market expansion for successful drugs is also smaller (13.9 ppt vs. 18.3 ppt; 870% vs. 1,140% increase in sales). Intuitively, the more severe threat point in MA-I disproportionately impacts the government's gains from trade: losses in consumer surplus are large relative to losses in firm profit for the 57 successful drugs. This weakens the government's bargaining position, resulting in higher equilibrium prices.

Welfare Implications and Gains in Survival Months Figure 9(b) illustrates changes in consumer surplus, firm profit, government expenditure, and social surplus (in ¥000s per cancer patient) along with gains in survival months for the three policy designs relative to the baseline. There are several differences between MA-I and FA-I (NRDL reform). MA-I generates higher consumer surplus, firm profits, and overall social surplus, but it also increases government expenditure. These results are perhaps not surprising as more drugs (70 vs. 57) are included in the formulary. In contrast, the NRDL reform (FA-I) achieves greater gains in average survival months. This arises because it delivers lower prices for successful drugs, while failed drugs receive no price reduction, leading to higher utilization of higher-quality drugs and lower consumption of marginal ones. However, it is worth noting that the medical benefits under FA-I are specific to our setting and can be reversed if the failed drugs were more effective in extending survival.

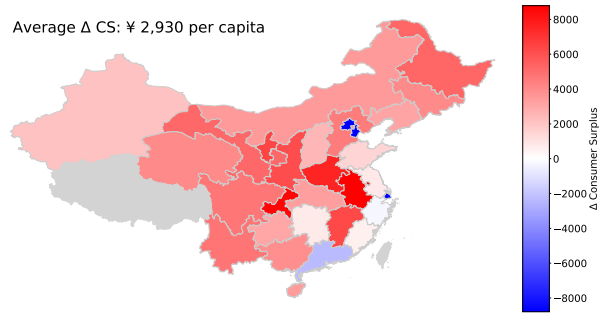
This analysis highlights three key takeaways. First, in the absence of insurance expansion, market access negotiation is (infinitely) more effective than formulary access negotiation. Second, insurance expansion amplifies the effects of negotiation, making the two policy tools highly complementary.[23] Third, MA-I delivers greater overall welfare gains (higher consumer, firm, and social surplus), whereas FA-I provides stronger medical benefits (though the survival-month advantage under FA-I could reverse were the failed drugs more effective).

5.2 Centralized vs. Decentralized Negotiation

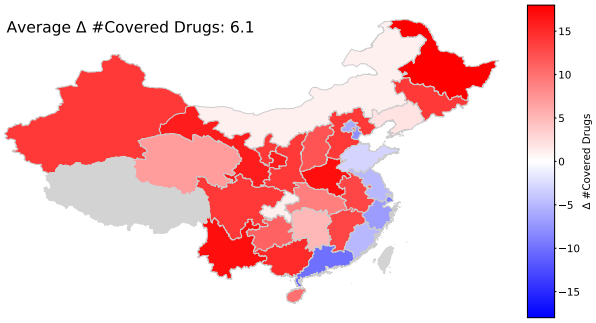
The findings in Section 4.3 on the distributional effects of the NRDL Reform motivate two sets of counterfactual analyses that explicitly investigate geographic variations and the program's regressivity. This section focuses on the former and contrasts centralized national bargaining (the status quo) with a counterfactual scenario where each province negotiates its own prices. This analysis sheds light on recent policy debates and academic discussions regarding the costs

[23]Section 4.3 documents the complementarity between formulary access negotiation and insurance expansion. The complementarity between market access negotiation and insurance expansion can be observed by comparing results in Figures 7(a) and 9(a).

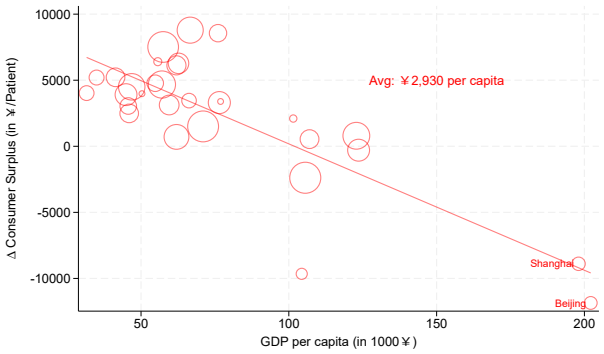
Figure 10: Effects of Centralized vs. Decentralized Negotiations



(a) Δ CS (¥/Patient)



(b) Δ Number of Covered Drugs



(c) Δ CS vs. Income



(d) Δ Number of Covered Drugs vs. Income

Note: Figures (a)-(b) show the geographic distributions of the change in consumer surplus and the number of covered drugs, comparing centralized negotiation paired with insurance expansion to decentralized negotiation paired with insurance expansion. Figures (c) and (d) present bubble plots of the same outcomes, with income on the x-axis. Each bubble indicates one province; bubble size scales with the province population. All the results are based on simulations that set $\boldsymbol{\beta} = \underline{\boldsymbol{\beta}}$ for failed negotiations.

and benefits of central procurement; see, e.g., Dubois et al. (2021), Dubois and Sæthre (2020), Dubois et al. (2022), and Maini and Pammolli (2023).

In the decentralized negotiation setting, each provincial government independently manages its formulary and negotiates drug prices, with the exclusion from the provincial formulary serving as the threat point rather than exclusion from the national list. To ensure comparability, we assume a uniform local coinsurance rate across provinces for decentralized negotiation, set at the national average of 0.37, and apply the same rate for centralized negotiation. Fixing coinsurance rates across provinces allows us to isolate the distributional effects of centralized negotiation from those arising from variations in coinsurance rates, which are examined separately in Section 5.3.

Negotiation Success, Price, and Quantity There are important intensive and extensive margin effects. On the extensive margin, centralized bargaining would result in 6.1 (11%) more negotiation successes in the average province, relative to decentralized bargaining. Focusing on the 57 drugs in the current formulary, average retail prices would be 34% lower, and the innovative drug market share would be 4.5 ppt higher under centralized negotiation relative to decentralized negotiation. These effects reinforce one another, and the net result is that aggregate social (consumer) surplus is ¥110, or 2% (¥2,930, or 32%) higher under centralization. See Appendix Table A6 for more details.

Welfare Effects of Centralization by Province Figure 10 shows the distributional impacts of centralization across provinces. Centralization increases the leverage of poor provinces at the expense of rich provinces. Figure 10(a) and 10(b) plot the change in consumer surplus and number of drugs covered in the formulary when we switch from decentralized to centralized negotiation. Centralized negotiation benefits patients in most regions by both metrics, especially regions in the center and west of China with lower income. To put a finer point on this, Figure 10(c) shows that there is a fairly steep income gradient in the consumer surplus effects of centralization, while Figure 10(d) shows a similar income gradient in drug coverage. The provinces that have lower consumer surplus under centralization are typically the same provinces that have fewer covered drugs under centralization, as shown in Figure 10(b). For example, Beijing and Shanghai would cover 6 to 9 fewer drugs under centralization.

What makes centralized negotiation different? Theoretically, if all provinces were homogeneous, then decentralized negotiation would lead to the same price and quantity outcomes. However, because of regional heterogeneity in willingness-to-pay, decentralization leads to many negotiation failures in lower-income provinces. Intuitively, $\Delta\pi$ is always higher in high-

income provinces than low-income provinces. Moreover, in the neighborhood of prices that are agreeable to firms, ΔV is also higher in high-income provinces, as the market expansion effects of formulary inclusion are large relative to government's expenditures.[24] This is illustrated in Figure 8(b). As a result, decentralization results in fewer negotiation successes in low-income provinces and more negotiation successes in high-income provinces.

5.3 Efficiency vs. Equity in Coinsurance Design

Section 2.1 shows that China's existing provincial coinsurance schedule is regressive (Figure 1). This section explores the welfare implications of alternative income-based coinsurance schedules. For simplicity, we consider a two-tier structure where households with income above and below the national median face different coinsurance rates. We simulate equilibrium prices, quantities, and surplus while varying coinsurance rates for high- and low-income patients between 20% and 50%, a range consistent with observed data. To incorporate equity preferences in the social planner's objective, we weigh consumer surplus by $income^{-\nu}$ as discussed in Section 3.2. The case of $\nu = 0$ corresponds to a utilitarian social planner, while higher values of ν reflect stronger preferences for equity and redistribution.

The impact of higher coinsurance rates on negotiation outcomes is theoretically ambiguous. Higher coinsurance unambiguously reduces firms' gains from trade by raising patients' OOP costs and depressing demand. The effect on the government's gains from trade is more nuanced. High coinsurance rates decrease government expenditure but also consumer surplus and expected survival. Figure 8(c) illustrates a case where the government's gains from trade are higher under a higher coinsurance rate.[25] In such scenarios, higher coinsurance has an ambiguous effect on the likelihood of negotiation success, but tends to increase retail prices and OOPs for successfully negotiated drugs. Intuitively, conditional on negotiation success, higher coinsurance rates decrease firms' gains from trade, thereby increasing their bargaining leverage and making them tough bargainers.

Importantly, the magnitude and direction of these effects depend on *who* is affected by coinsurance increases. Figure 8(d) extends the example from Figure 8(c), comparing gains from trade under four income-based coinsurance schedules, where high- and low-income patients face either 20% or 50% coinsurance. Increasing coinsurance rates for high-income patients has

[24] Though this is no longer the case at higher prices, where the greater demand in high-income provinces becomes prohibitively expensive.

[25] For a given negotiated price and with a higher coinsurance rate, the government's gains from trade are always higher when $\beta \geq 1$. However, if $\beta < 1$, the impact on ΔV can be positive or negative. See Appendix B.3 for details.

a much larger impact on gains from trade than increasing it for low-income patients. In this parameterization, the most generous schedule (0.2, 0.2) leads to negotiation failure. All other schedules expand the set of admissible prices, benefiting patients on the extensive margin of drug access but harming patients on the intensive margin with higher negotiated prices. The most important takeaway is that the effects of coinsurance schedules are complex, with trade-offs between negotiation success, pricing, and accessibility.

Negotiation Failure The effects of alternative coinsurance schedules across all 70 eligible drugs are presented in Figure 11.[26] Figure 11(a) confirms that low coinsurance rates increase negotiation failure, particularly when they apply to high-income patients. For example, when coinsurance equals 20% across all patients, half of all negotiations fail.

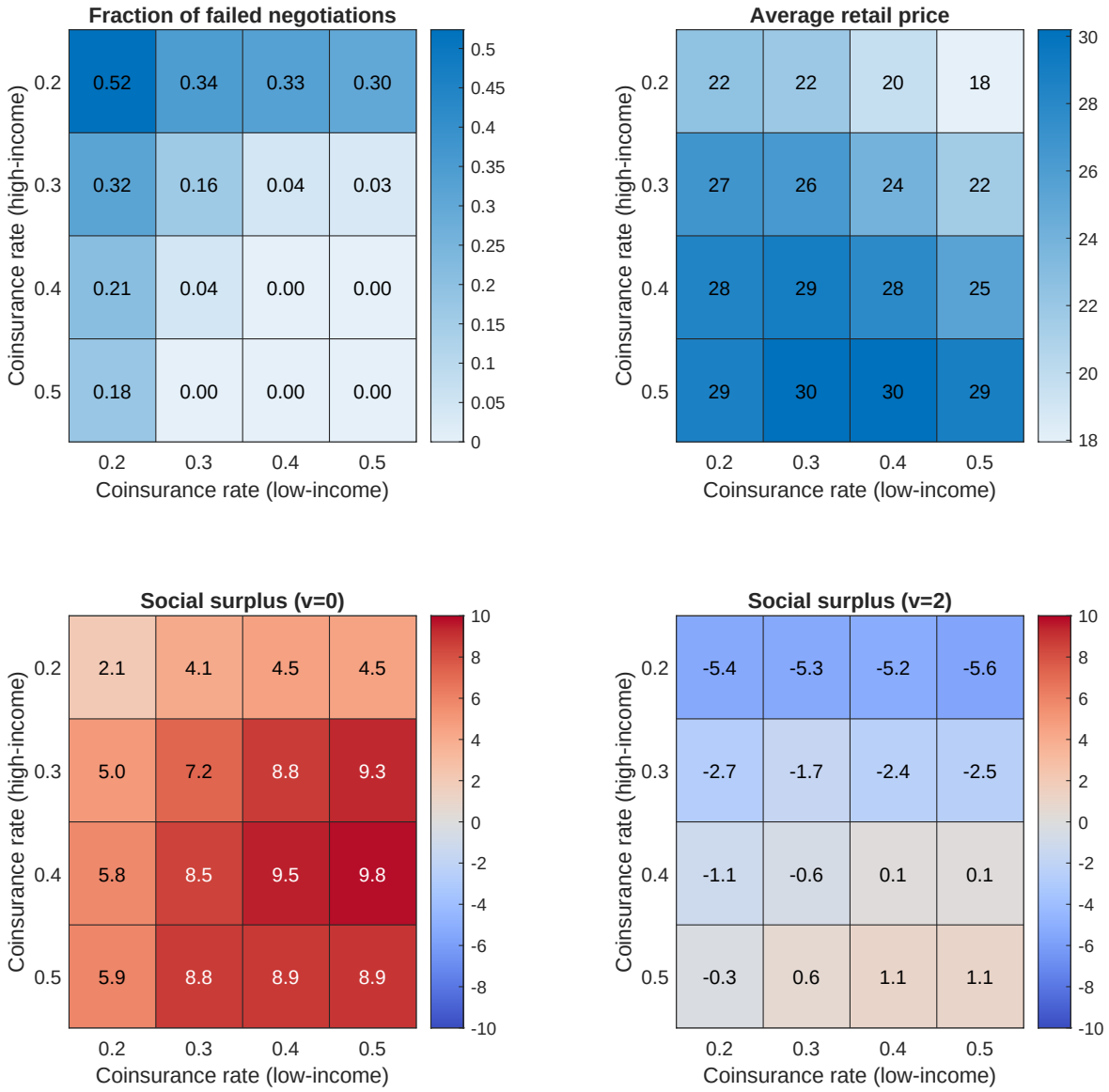
Prices Figure 11(b) shows the average retail price of innovative cancer drugs, weighted by market shares. The diagonal terms indicate that lowering coinsurance tends to reduce average retail prices despite more negotiation failures. This is because lower coinsurance enhances the government's bargaining leverage, enabling it to negotiate lower prices for drugs with successful negotiations. This leverage effect is far stronger when we lower high-income patients' coinsurance rates (moving across rows). In contrast, lowering only low-income patients' coinsurance rates (moving across columns) provides little benefit in terms of bargaining leverage and is more likely to increase retail prices due to negotiation failures. This asymmetry arises because the market expansion effect from lowering coinsurance rates is much larger for high-income patients, increasing firms' gains from trade and strengthening the government's bargaining position.

Optimal Coinsurance Design The differential impact of coinsurance changes on high- vs. low-income patients generates spillover effects across income groups, shaping the optimal policy design. Figure 11(c) examines the optimal coinsurance rate under different social welfare criteria. If the social planner's goal is to maximize total social surplus, the optimal schedule is (H 0.4, L 0.5) – a moderately regressive structure that closely resembles the geographic regressivity seen in practice.

However, a more Rawlsian objective ($\nu = 2$), shown in Figure 11(d), favors a higher coinsurance rate for high-income patients. This is because lowering coinsurance expands drug adoption among marginal patients but also transfers subsidies to inframarginal patients who

[26] Appendix Figure A11 fixes the negotiation outcomes of all negotiations that failed under the NRDL Reform as implemented. The patterns described below hold under both (extremal) assumptions.

Figure 11: Optimal Coinsurance Design ($\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$)



Note: This set of heatmaps presents simulated outcomes under income-based coinsurance schedules. Each horizontal axis shows the coinsurance rate for low-income (below median) patients, while each vertical axis shows the coinsurance rate for high-income (above median) patients. Simulations allow negotiation for 70 innovative cancer drugs and assume $\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$ for drugs that failed the NRDL negotiations. "Fraction of failed negotiations" reports the model-predicted count of failed negotiations under each coinsurance rate design. "Average retail price" is the share-weighted average retail price across the 33 always included negotiated products. "Social surplus" is reported based on different equity criteria ($\nu = 0, 1, 2$). All surplus measures compare surplus under the given coinsurance schedule to the Baseline scenario with no insurance.

would have purchased the drug anyway. A higher portion of the government spending on high-income patients is pure transfers to those who would have bought the innovative drug regardless. Rawlsian social surplus penalizes this type of expenditure. Hence, it is difficult to rationalize low coinsurance rates when equity concerns are high. Ultimately, an optimal coinsurance schedule must strike a balance between these competing objectives – ensuring equitable access, minimizing unnecessary government transfers, and preserving effective negotiation leverage.

6 Conclusion

Innovative drugs have the potential to significantly increase human life expectancy; for example, 35% of the increase in life expectancy in the U.S. between 1990 and 2015 was attributable to pharmaceuticals (Buxbaum et al., 2020). However, many of the most promising new drugs have extremely high prices, to the point where they're mostly inaccessible to self-payers and place a large burden on public and private insurance systems (CMS, 2024). The reforms studied in this project occurred amid substantial political momentum in favor of centralized drug procurement both within and across countries. Most recently, the U.S. Inflation Reduction Act of 2022 announced that the Medicare program would negotiate prices for 10 prescription drugs directly with participating manufacturers (The White House, 2023). Similarly, the European Parliament's Pharmaceutical Proposal of 2024 aims to create a single market for medicines with centralized pricing for all member states (Ho and Pakes, 2024).

This project provides unique new evidence on the cost, access, health, and welfare effects of national drug policy reforms, on differences between formulary-access vs. market-access negotiations, optimal design of coinsurance schedules, the tradeoffs of centralization, and more broadly on competition in drug markets. The proposed frameworks and results can be used to evaluate drug pricing proposals in a variety of settings, and thereby have practical relevance for government agencies and other payers. To put the potential impact of this research in context, our work indicates that the degree of reform achieved by 2023 led to consumer surplus gains of nearly ¥40 billion per year ($5.6 billion) and a total survival increase of 900,000 life-years among Chinese cancer patients.

References

Abaluck, Jason, Jonathan Gruber, and Ashley Swanson, "Prescription Drug Use under Medicare Part D: A Linear Model of Nonlinear Budget Sets," *Journal of Public Economics*, August 2018, *164*, 106–138.

Atal, Juan Pablo, José Ignacio Cuesta, and Morten Sæthre, "Quality Regulation and Competition: Evidence from Pharmaceutical Markets," August 2022. Working Paper.

Ausubel, Lawrence M., Peter Cramton, and Raymond J. Deneckere, *Bargaining with Incomplete Information*, Amsterdam: Elsevier,

Branstetter, Lee, Chirantan Chatterjee, and Matthew J. Higgins, "Regulation and Welfare: Evidence from Paragraph IV Generic Entry in the Pharmaceutical Industry," *The RAND Journal of Economics*, 2016, *47* (4), 857–890.

Buxbaum, Jason D., Michael E. Chernew, A. Mark Fendrick, and David M. Cutler, "Contributions Of Public Health, Pharmaceuticals, And Other Medical Care To US Life Expectancy Changes, 1990-2015," *Health Affairs*, 2020, *39* (9), 1546–1556. PMID: 32897792.

Callaway, Brantly and Pedro H.C. Sant'Anna, "Difference-in-Differences with multiple time periods," *Journal of Econometrics*, 2021, *225* (2), 200–230. Themed Issue: Treatment Effect 1.

Cao, Shengmao and Chirantan Chatterjee, "Equilibrium Effects of Pharmaceutical Bundling: Evidence from India," January 2022. Working paper.

_ , Xuejie Yi, and Chuan Yu, "Competitive Bidding in Drug Procurement: Evidence from China," October 2022. Working paper.

Chaudhuri, Shubham, Pinelopi K. Goldberg, and Panle Jia, "Estimating the Effects of Global Patent Protection in Pharmaceuticals: A Case Study of Quinolones in India," *American Economic Review*, December 2006, *96* (6), 1477–1514.

CMS, "Medicare Part D Spending by Drug," https://data.cms.gov/summary-statistics-on-use-and-payments/medicare-medicaid-spending-by-drug/medicare-part-d-spending-by-drug 2024. Accessed: 2024-07-26.

Collard-Wexler, Allan, Gautam Gowrisankaran, and Robin S. Lee, ""Nash-in-Nash" Bargaining: A Microfoundation for Applied Work," *Journal of Political Economy*, February 2019, *127* (1), 163–195. Publisher: The University of Chicago Press.

Crawford, Gregory S., Robin S. Lee, Michael D. Whinston, and Ali Yurukoglu, "The Welfare Effects of Vertical Integration in Multichannel Television Markets," *Econometrica*, 2018, *86* (3), 891–954.

Cutler, David M. and Richard J. Zeckhauser, *The Anatomy of Health Insurance*, Amsterdam: Elsevier Science,

_ and Sarah J. Reber, "Paying for Health Insurance: The Trade-Off between Competition and Adverse Selection," *The Quarterly Journal of Economics*, May 1998, *113* (2), 433–466.

Dalton, Christina M, Gautam Gowrisankaran, and Robert J Town, "Salience, Myopia, and Complex Dynamic Incentives: Evidence from Medicare Part D," *The Review of Economic Studies*, 04 2019, *87* (2), 822–869.

Dubois, Pierre and Morten Sæthre, "On the Effect of Parallel Trade on Manufacturers' and Retailers' Profits in the Pharmaceutical Sector," *Econometrica*, 2020, *88* (6), 2503–2545.

_ , Ashvin Gandhi, and Shoshana Vasserman, "Bargaining and International Reference Pricing in the Pharmaceutical Industry," April 2022. Working paper.

_ , Yassine Lefouili, and Stéphane Straub, "Pooled procurement of drugs in low and middle income countries," *European Economic Review*, 2021, *132*, 103655.

Duggan, Mark and Fiona Scott Morton, "The Effect of Medicare Part D on Pharmaceutical Prices and Utilization," *American Economic Review*, March 2010, *100* (1), 590–607.

Einav, Liran, Amy Finkelstein, and Maria Polyakova, "Private Provision of Social Insurance: Drug-Specific Price Elasticities and Cost Sharing in Medicare Part D," *American Economic Journal: Economic Policy*, August 2018, *10* (3), 122–53.

_ , _ , and Paul Schrimpf, "The Response of Drug Expenditure to Nonlinear Contract Design: Evidence from Medicare Part D *," *The Quarterly Journal of Economics*, 02 2015, *130* (2), 841–899.

Fang, Hanming, Xiaoyan Lei, Julie Shi, and Lisa Xuejie Yi, "Physician-Induced Demand: Evidence from China's Drug Price Zero-Markup Policy," June 2021. Working paper.

Finkelstein, Amy, Nathaniel Hendren, and Mark Shepard, "Subsidizing Health Insurance for Low-Income Adults: Evidence from Massachusetts," *American Economic Review*, April 2019, *109* (4), 1530–67.

Gowrisankaran, Gautam, Aviv Nevo, and Robert Town, "Mergers when prices are negotiated: Evidence from the hospital industry," *The American Economic Review*, 2015, *105* (1), 172–203.

Grennan, Matthew, "Price Discrimination and Bargaining: Empirical Evidence from Medical Devices," *American Economic Review*, February 2013, *103* (1), 145–77.

_ , "Bargaining Ability and Competitive Advantage: Empirical Evidence from Medical Devices," *Management Science*, 2014, *60* (12), 3011–3025.

_ **and Ashley Swanson**, *Bargaining*, Cham: Palgrave MacMillan, 2022.

Hendren, Nathaniel, "Measuring economic efficiency using inverse-optimum weights," *Journal of Public Economics*, 2020, *187*, 104198.

Ho, Kate and Ariel Pakes, "Evaluating Pharmaceutical Policy Options," June 2024. Working paper.

_ **and Robin S. Lee**, "Equilibrium Provider Networks: Bargaining and Exclusion in Health Care Markets," *American Economic Review*, February 2019, *109* (2), 473–522.

_ **and Robin S Lee**, "Contracting over Pharmaceutical Formularies and Rebates," Working Paper 32790, National Bureau of Economic Research August 2024.

Ho, Katherine and Robin S. Lee, "Insurer Competition in Health Care Markets," *Econometrica*, 2017, *85* (2), 379–417.

Horn, Henrick and Asher Wolinsky, "Bilateral Monopolies and Incentives for Merger," *The RAND Journal of Economics*, 1988, *19* (3), 408–419.

Jaffe, Sonia and Mark Shepard, "Price-Linked Subsidies and Imperfect Competition in Health Insurance," *American Economic Journal: Economic Policy*, August 2020, *12* (3), 279–311.

Lewis, Matthew S. and Kevin E. Pflum, "Diagnosing Hospital System Bargaining Power in Managed Care Networks," *American Economic Journal: Economic Policy*, February 2015, *7* (1), 243–74.

Liu, Yiyan and Ginger Zhe Jin, "Employer contribution and premium growth in health insurance," *Journal of Health Economics*, January 2015, *39*, 228–247.

Lu, Chia-Feng and Dawn(Dan) Zhang, "China on the Move: Lesson from China's National Negotiation of Drug Prices in 2022," https://www.gtlaw.com/en/insights/2023/2/china-on-the-move-lesson-from-chinas-national-negotiation-of-drug-prices-in-2022 February 2023. Accessed: 2024-08-11.

Macabeo, Bérengère, Liam Wilson, Jianwei Xuan, Ruichen Guo, Petar Atanasov, Linda Zheng,

Clement François, and Philippe Laramée, "Access to Innovative Drugs and the National Reimbursement Drug List in China: Changing Dynamics and Future Trends in Pricing and Reimbursement," *Journal of Market Access & Health Policy*, June 2023, *11* (1), 2218633.

Maini, Luca and Fabio Pammolli, "Reference Pricing as a Deterrent to Entry: Evidence from the European Pharmaceutical Market," April 2023. Working paper.

National Health Commission of the PRC, "2022 Health Statistics Yearbook," 2023. Accessed: 2024-07-30.

Nyman, J. A., "The Value of Health Insurance: The Access Motive," *Journal of Health Economics*, 1999, *18* (2), 141–152.

Polyakova, Maria and Stephen P. Ryan, "Market Power and Redistribution: Evidence from the Affordable Care Act," August 2022. Working paper.

Saez, Emmanuel, "Optimal Income Transfer Programs: Intensive versus Extensive Labor Supply Responses," *The Quarterly Journal of Economics*, 08 2002, *117* (3), 1039–1073.

The White House, "Fact Sheet: Biden-Harris Administration Announces New Actions to Lower Health Care and Prescription Drug Costs by Promoting Competition," https://www.whitehouse.gov/briefing-room/statements-releases/2023/12/07/fact-sheet-biden-harris-administration-announces-new-actions-to-lower-health-care-and-prescription-dr December 2023. Accessed: 2024-07-26.

Xia, Tianli, "Welfare Effects of Resale Price Maintenance: Evidence from the Chinese Pharmaceutical Industry," April 2024. Working paper.

Yu, Hao, "Universal health insurance coverage for 1.3 billion people: What accounts for China's success?," *Health Policy*, 2015, *119* (9), 1145–1152.

Zhou, Jing, Tianjiao Lan, Hao Lu, and Jay Pan, "Price negotiation and pricing of anticancer drugs in China: An observational study," *PLOS Medicine*, 01 2024, *21*, 1–18.

Online Appendix

A Data Construction

A.1 Clinical Data

In our preferred analysis in the main text, we draw on clinical data from clinicaltrials.gov. All clinical trials involving drugs that are regulated by the FDA must be registered publicly at this site. We focus on Phase III Interventional studies with results. These are large scale evaluations of the drugs' safety and efficacy relative to a control group. In each trial, the focal innovator drug is the treatment group, and the standard of care, typically an older therapy, is the control group.
For each trial, we collect the following fields:

- Innovator drug name
- Indication (cancer type)
- Sample details if specified (this might specify an age range or treatments that were tried previously
- Treatment therapy (this will include the name of the innovator drug, plus any treatments it's bundled with in the trial)
- Control therapy
- Units in which outcomes are evaluated; days/weeks/months
- For each of the following outcomes (overall survival (OS); overall survival rate (OSR); progression-free survival (PFS); overall response rate (ORR)):
  - Time frame for evaluation; e.g., could say "up to 43 months"
  - Lower bound of 95% confidence interval of outcome for treatment group if reported
  - Upper bound of 95% confidence interval of outcome for treatment group if reported
  - Median outcome for treatment group if reported

  - Lower bound of 95% confidence interval of outcome for control group if reported
  - Upper bound of 95% confidence interval of outcome for control group if reported
  - Median outcome for control group if reported
- National Clinical Trial (NCT) indicator (==1 for observations meeting the above criteria, ==0 otherwise)
- NCTID
- Pub Med ID (PMID)
- Indicator for the control therapy being another innovator drug in our sample

Using these data, we create a survival treatment effect for each innovator drug. We use overall survival if reported, then overall survival rate, then progression free survival, then overall response rate.
For all sample innovator drugs missing survival data after following the above process using NCTs, we augment the dataset using the package the drug company submitted to the NHSA, populating the same fields in the same way, but setting the NCT indicator equal to 0.
In choosing the survival data to include in our supply estimation and counterfactuals, we prioritize NCT studies using the following rubric. If possible, we limit the data to completed NCT trials, with overall survival reported, that were highlighted in the package the drug company submitted to the NHSA. If such results are not available, we base the survival calculation on all other NCT trials with the most-preferred outcome available. If no NCT trials are available, we use the results in the package submitted to the NHSA.
If the above process results in multiple trials for a given innovative drug, we take a simple average across studies.

B Details on Counterfactual Simulations

B.1 Solution Algorithm

This section describes our algorithm for solving negotiated prices in the counterfactual analysis. We apply an iterative Gauss-Seidel method to solve the new equilibrium prices. We assume that negotiated drugs and non-negotiated drugs set prices simultaneously. The contract equilibrium is such that given the prices, no drug firms have incentives to renegotiate (or change) the retail prices unilaterally. For each vector of $\{\gamma, \beta, \tau\}$:

1. **Outer loop:** In iteration t, start with the old equilibrium price $\mathbf{p}^t = \mathbf{p}^{t-1}$ (or an initial price vector if $t = 0$) and the formulary $\mathcal{G}^{t-1}$.

2. **Inner loop:** For product $j = 1, ..., J$ (ranked by the quantity sold):

   (a) If the price of drug j is negotiated:

   - Calculate the deviation price $\mathbf{p}_j^{BN}$ for each negotiated drug if the negotiation fails. This step forms a **threat point** for each negotiation. This depends on the belief about what would happen if a negotiation breaks down. We assume that firms' beliefs follow a single-deviation rule, i.e., a negotiation does not affect the outcome of other negotiations. Therefore the firm is going to choose the best-response price $\mathbf{p}_j^{BN} = BR_j(\mathbf{p}_{-j}^t, \mathcal{G}^t/\{j\})$.
   - Given the deviation price $\mathbf{p}_j^{BN}$, we can calculate the admissible set: $[p_j^l, p_j^u]$, where p_j^l denotes the lower bound (the price such that the firm j's gains from trade is zero: $\Delta\Pi(p_j^l, \mathbf{p}_{-j}^t) = 0$) and p_j^u denotes the upper bound (the price such that the government's gains from trade is zero: $\Delta V(p_j^u, \mathbf{p}_{-j}^t) = 0$).
   - If the admissible set is empty, the negotiation fails, and we move to step (b).
   - If the admissible set is non-empty, solve for the negotiated outcome given τ: $p_j^*(\tau)$ according to the FOC (3). Also add drug j into the formulary: $j \in \mathcal{G}^*$.

   (b) If the price of drug j is not negotiated, or if the negotiation fails:

   - the firm is simply going to choose the best-response price $p_j^* = \mathbf{p}_j^{BN}$.

3. The algorithm converges to the equilibrium formulary and price if $|\mathbf{p}^* - \mathbf{p}^t| < \epsilon$ and $\mathcal{G}^t = \mathcal{G}^*$, otherwise reset $\mathbf{p}^{t+1} = \mathbf{p}^*$ and $\mathcal{G}^{t+1} = \mathcal{G}^*$ move to step 2.

Note we can show that the equilibrium exists (Collard-Wexler et al., 2019). The algorithm convergence guarantees the resulting $(\mathbf{p}, \mathcal{G})$ is a contract equilibrium in the sense that no unilateral deviation is profitable. In practice, we impose the selection rule and let drugs with bigger market demand move first, and this guarantees uniqueness. Generally speaking, multiple equilibria are theoretically possible but not a primary concern in this setting for two reasons. First, patented products in cancer drugs are differentiated. For an average drug j, the admissible set only shrinks by 2% if we change the $\mathcal{G}_{-j}$ from $\varnothing$ to the full set. Therefore, in our case, the inclusion status of competing drugs affects the negotiation outcome mostly through the intensive margin (negotiated price) but not the extensive margin (formulary access). Second, we randomize the sequence of moves in our counterfactual analysis, and we do not find multiple equilibria in our setting.

B.2 Comparisons between MA-I and FA-I

For the simplicity of notation, we assume a single-product firm produces product j, and the logic applies to multiproduct firms. Assuming a single-product firm makes the deviation payoff under MA-I=0 and simplifies the math. On the extensive margin, MA-I always leads to more bargaining success. This is because the admissible set is expanded:

$$\Psi^{FA-I} = \{p_j : V_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right) \geq V_j\left(p_j^{dev}; \mathbf{p_{-j}}, \mathcal{G}/\{j\}\right) \text{ and } \pi_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right) \geq \pi_j\left(p_j^{dev}; \mathbf{p_{-j}}, \mathcal{G}/\{j\}\right)\}.$$
$$\Psi^{MA-I} = \{p_j : V_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right) \geq 0 \text{ and } \pi_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right) \geq 0\}$$

$\Psi^{FA-I} \subset \Psi^{MA-I}$ if $V_j(p_j; \mathbf{p_{-j}}, \mathcal{G})$ is decreasing in p^j and $\pi_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right)$ is a increasing function of p^j.

On the intensive margin, which works better depends on the demand structure and the bargaining power.

Proposition: The price under formulary access (p_F) is lower (equal to) [bigger] than the price under market access (p_M) if and only if:

$$\frac{V(p^*, \mathcal{G})}{\Pi(p^*, \mathcal{G})} > (=)[<] \frac{V(p_{\text{dev}}, \mathcal{G}/j)}{\Pi(p_{\text{dev}}, \mathcal{G}/j)}. \tag{5}$$

Proof: The equilibrium price satisfies the first-order condition:

$$\tau \frac{d\Delta\Pi}{dp}\frac{1}{\Delta\Pi} + (1-\tau)\frac{d\Delta V}{dp}\frac{1}{\Delta V} = 0. \tag{6}$$

Rearranging,

$$\frac{\Delta V}{\Delta\Pi} = -\frac{1-\tau}{\tau}\frac{d\Delta V/dp}{d\Delta\Pi/dp}. \tag{7}$$

Suppose price $p^M = p^*$ is the negotiated price under MA-I,

$$\Delta\Pi_M = \Pi(p^*, \mathcal{G}) - 0,$$
$$\Delta V_M = V(p^*, \mathcal{G}) - 0.$$
$$\frac{\Delta V_M}{\Delta\Pi_M} = -\frac{1-\tau}{\tau}\frac{dV'(p^*)}{d\Pi'(p^*)}.$$

If we plug in p^* formulary access FOC, and see whether the FOC is satisfied at p^*, and if

not, whether we need a bigger or smaller p_F:

$$\Delta\Pi_F = \Pi(p^*, \mathcal{G}) - \Pi(p_{\text{dev}}, \mathcal{G}/j), \tag{8}$$

$$\Delta V_F = V(p^*, \mathcal{G}) - V(p_{\text{dev}}, \mathcal{G}/j) \tag{9}$$

$$\frac{\Delta V_F}{\Delta\Pi_F} \stackrel{?}{=} -\frac{1-\tau}{\tau}\frac{dV'(p^*)}{d\Pi'(p^*)}. \tag{10}$$

Since the value of inclusion remains unchanged for both cases ($\frac{d\Delta V}{dp}$ and $\frac{d\Delta\Pi}{dp}$ are the same for MA-I and PA-I), the FOC for FA-I will hold if and only if

$$\frac{\Delta\Pi_F}{\Delta V_F} = \frac{\Delta\Pi_M}{\Delta V_M} \Leftrightarrow \frac{V(p^*, \mathcal{G})}{\Pi(p^*, \mathcal{G})} = \frac{V(p_{\text{dev}}, \mathcal{G}/j)}{\Pi(p_{\text{dev}}, \mathcal{G}/j)}. \tag{11}$$

If LHS$>$ RHS, then $p^F < p^*$ and vice-versa. Note that LHS is a decreasing function of firm bargaining power, and RHS is independent of bargaining power and depends on the demand and cost curve.[27] Therefore, when the firm holds more bargaining power, or when the value of the product on the private market is higher for the government than the firm, LHS is smaller, and hence $p^{FA-I} > P^{MA-I}$ is more likely to hold. Intuitively, the government may prefer FA-I for intensive products if the WTP for the product on the private market is big, the profit for the product on the private market is small, and when the firm holds more bargaining power.

□

B.3 Effects of Coinsurance Rate on Gains from Trade

The effects of higher coinsurance on negotiation outcomes are theoretically ambiguous. Higher coinsurance unambiguously decreases firms' gains from trade, as it increases patients' out-of-pocket prices and reduces demand. However, the government's perspective is more nuanced. High coinsurance rates decrease government expenditure, but decrease consumer surplus and expected survival.

When $\beta > 1$, conditioning on the negotiated price, the government's gains from trade

[27]
$$LHS = \frac{V(p^*, \mathcal{G})}{\Pi(p^*, \mathcal{G})} = -\frac{1-\tau}{\tau}\frac{V'(p^*)}{\Pi'(p^*)} = -\frac{1-\tau}{\tau}\frac{1-\beta(1-\gamma)}{e^{\frac{p^*-mc}{p^*}}+1},$$
where e is the elasticity at a price p^*.

increase with the coinsurance rate γ. This is because:

$$\begin{aligned}
\frac{d\Delta\Pi}{d\gamma} &= \frac{\partial s}{\partial \gamma}(p - mc) < 0 \\
V &= \int_{\gamma p}^{\infty} s(p)dp - \beta(1-\gamma)ps - \text{Disagreement Payoff} \\
\frac{d\Delta V}{d\gamma} &= \frac{dCS}{d\gamma} - \beta\frac{dTC}{d\gamma} = -sp - \beta(-sp + (1-\gamma)p^2\frac{\partial s}{\partial \gamma}) \\
&= (\beta - 1)sp - \underbrace{\beta(1-\gamma)p\frac{\partial s}{\partial \gamma}}_{<0} \quad > 0 \quad \text{if } \beta \geq 1.
\end{aligned}$$

Note that the government's disagreement payoff does not depend on γ. As a result, the gains-from-trade curve for the government shifts up with the coinsurance rate when the cost of government funds is high ($\beta > 1$). Therefore, we can show that the equilibrium negotiated price p^N will go up as the coinsurance increases (as long as the negotiation still succeeds). To see this, note that the from bargaining FOC:

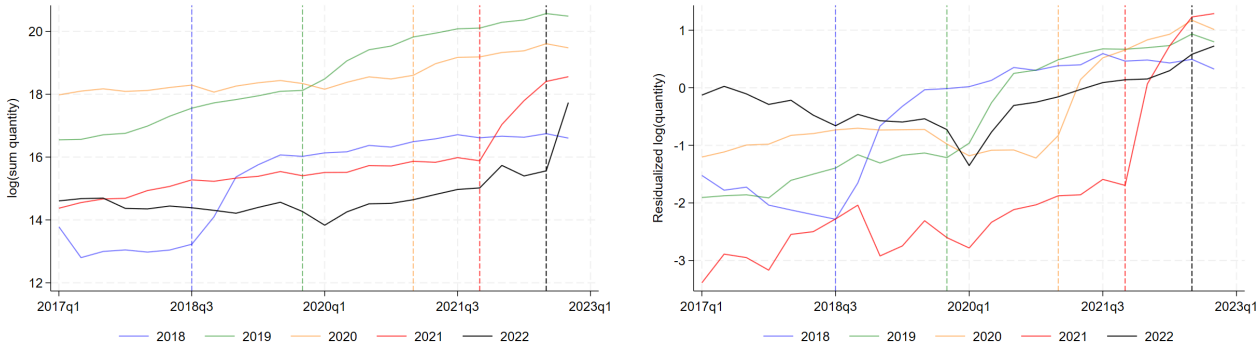
$$\tau\frac{\frac{d\Delta\Pi(p^N)}{dp^N}}{\Delta\Pi(p^N, \gamma^0)} + (1-\tau)\frac{\frac{d\Delta V(p^N)}{dp^N}}{\Delta V(p^N, \gamma^0)} = 0$$

Suppose $p^N(\gamma^0)$ solves this equation. Now suppose we shift γ^0 to $\gamma^1 > \gamma^0$. What happens to the FOC? It no longer holds at $p = p^N$ because $\Delta V(p^N, \gamma^1) > \Delta V(p^N, \gamma^0)$ and $\Delta\Pi(p^N, \gamma^1) < \Delta\Pi(p^N, \gamma^0)$. Also note that $\frac{d^2\Delta\Pi(p^N)}{dp^N d\gamma} = \frac{d^2\Delta\Pi(p^N)}{d(p^N)^2}\gamma < 0$ and $\frac{d^2\Delta V(p^N)}{dp^N d\gamma} = \frac{d^2\Delta V(p^N)}{d(p^N)^2}\gamma < 0$ under fairly generous conditions. Therefore we know $p^N(\gamma^1) > p^N(\gamma^0)$ to satisfy the FOC. (This can be more formally proved via the implicit function theorem.)

If $\beta < 1$, how the coinsurance rate affects the equilibrium negotiated price (hence the equilibrium gains from trade evaluated at such prices) is ambiguous and depends on demand and supply.

C Appendix Figures

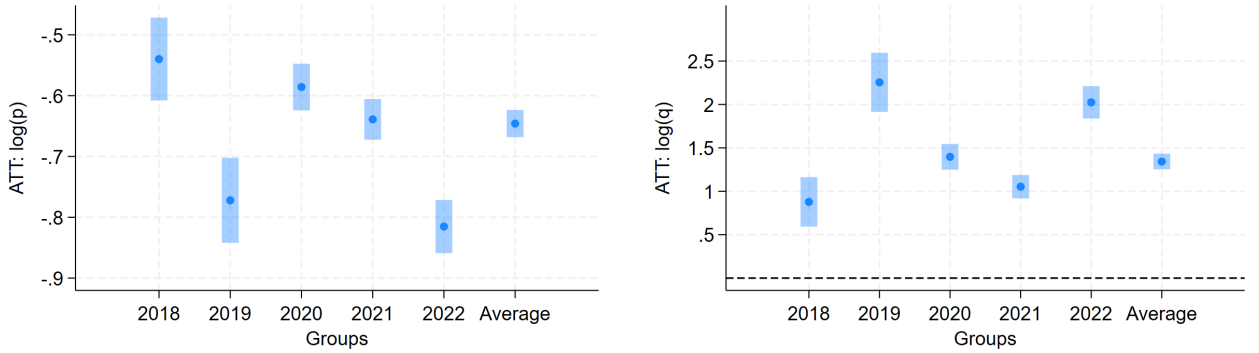
Figure A1: Impact of NRDL Inclusion on Drug Sales: Total Quantity Sold Over Time



(a) Total Quantity: Raw Data (b) Residualized Quantity: All Categories

Note: This figure reports the total quantity sold for drugs included in NRDL. Different colors indicate drugs included in different rounds of negotiations. Each dashed line denotes the time of the formulary inclusion for each round. We observe a jump in quantity post-formulary inclusion.

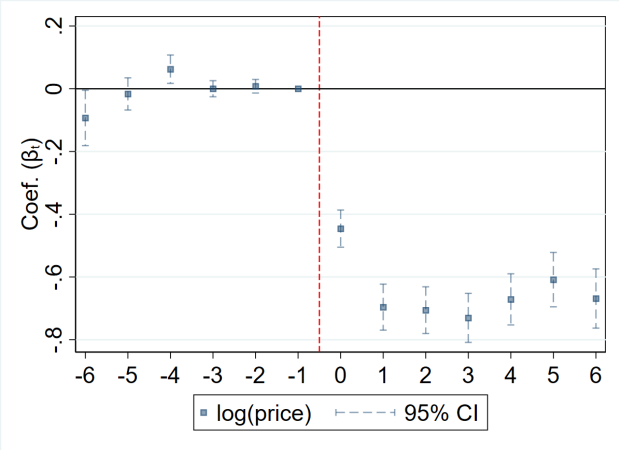
Figure A2: Cohort-Specific Effects of the NRDL Reform on Price and Quantity



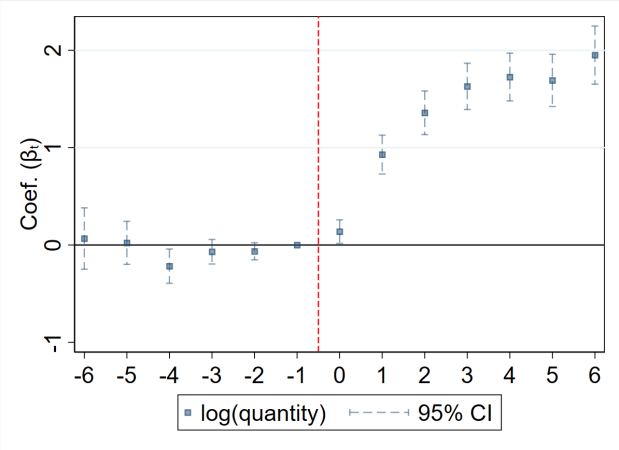
(a) Retail Price: All Categories (b) Quantity: All Categories

Note: This figure reports the treatment effects of the NRDL Reform on the retail prices and quantities of successfully negotiated drugs, separately for each negotiation cohort. The horizontal axis denotes the year in which the drug was negotiated. The vertical axis reports the pooled post-period treatment effect for each negotiation cohort, estimated using Callaway and Sant'Anna (2021)'s CSDID package.

Figure A3: Effects of the NRDL Reform on Price and Quantity—TWFE Estimates



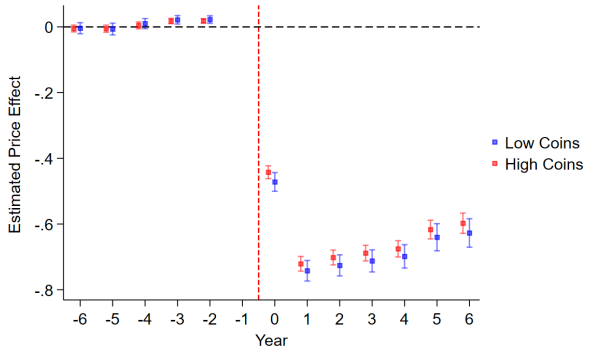
(a) Retail Price: All Categories



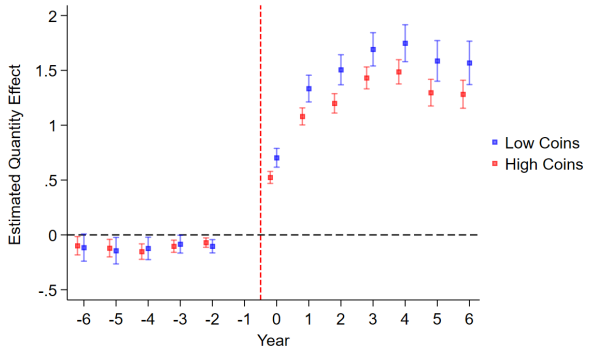
(b) Quantity: All Categories

Note: This figure reports the dynamic treatment effects of the NRDL Reform on the retail prices and quantities of successfully negotiated drugs, estimated via standard two-way fixed effects. The specification is $y_{jmt} = \sum_{\tau \neq -1} \beta_\tau 1\{\text{Insured}_j\} \times 1\{t - t_j = \tau\} + \eta_{jm} + \eta_{mt} + \epsilon_{jmt}$, where τ_j is the period of drug j's formulary inclusion, and the omitted group $\tau = -1$ is one period before formulary inclusion. We limit the regression sample to successfully negotiated drugs only. The horizontal axis denotes quarters relative to the negotiation period. The vertical axis reports the estimated β_τ.

Figure A4: Effects of the NRDL Reform on Price and Quantity, by High/Low Coinsurance



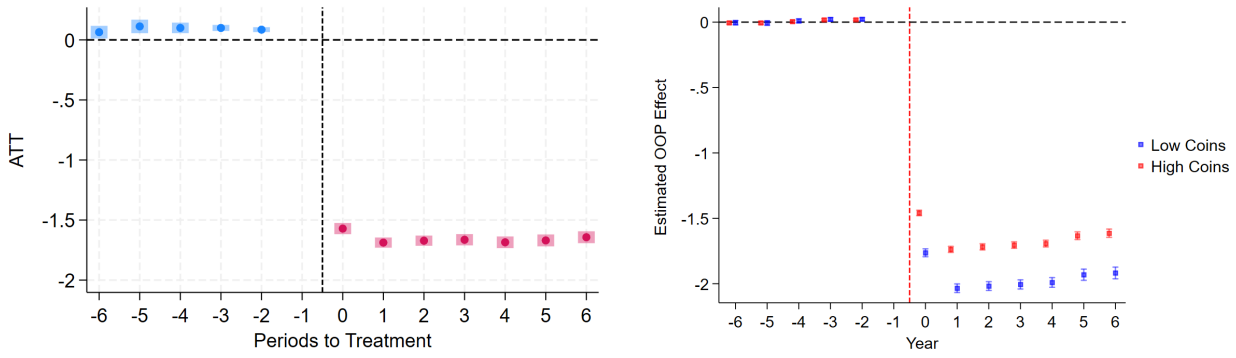
(a) Retail price: All Categories



(b) Quantity: All Categories

Note: This figure reports the Callaway and Sant'Anna (2021)'s estimated treatment effects of the NRDL inclusion on the retail price and quantity sold in high-coinsurance (≥ 0.3) and low-coinsurance (< 0.3) provinces separately. The price effects are similar in both regions, while the quantity expansion is more salient in regions with low-coinsurance rates.

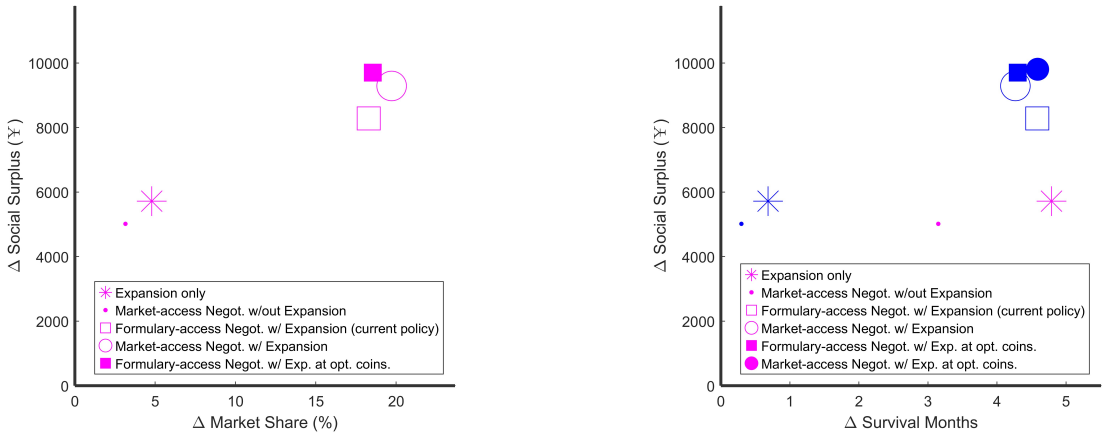
Figure A5: Effects of the NRDL Reform on Out-of-pocket Price



(a) Overall (b) Low- vs. High-Coinsurance Provinces

Note: This figure reports the Callaway and Sant'Anna (2021)'s estimated treatment effects of the NRDL inclusion on the out-of-pocket prices in high-coinsurance (≥ 0.3) and low-coinsurance (< 0.3) provinces separately. The low-coinsurance regions have a significantly bigger oop reduction for included drugs.

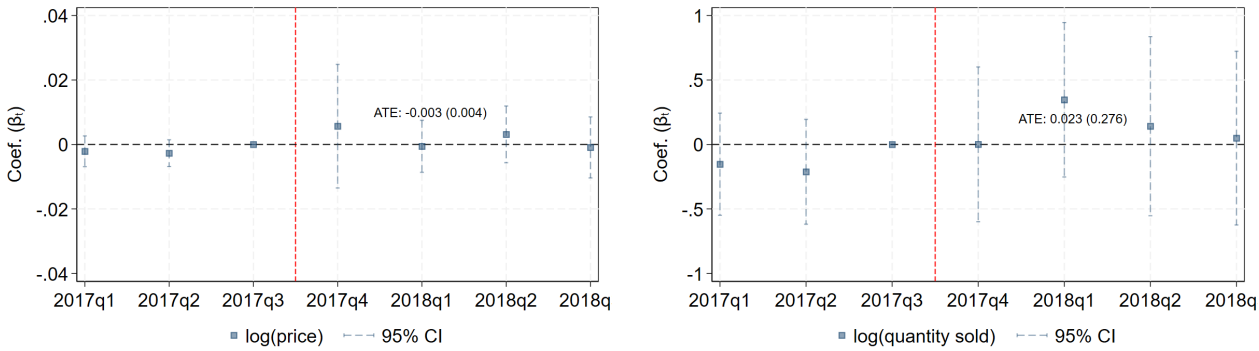
Figure A6: Welfare Comparison



(a) CS - Expenditure (b) Add Firm Profit

Note: This graph compares the social surplus (efficiency) and innovative drug quantity sold (access) under six different policy scenarios. The combination of negotiation and expansion achieves higher surplus than each policy on its own. Both formulary-access and market-access can achieve high efficiency and access at their respective optimal coinsurance rates.

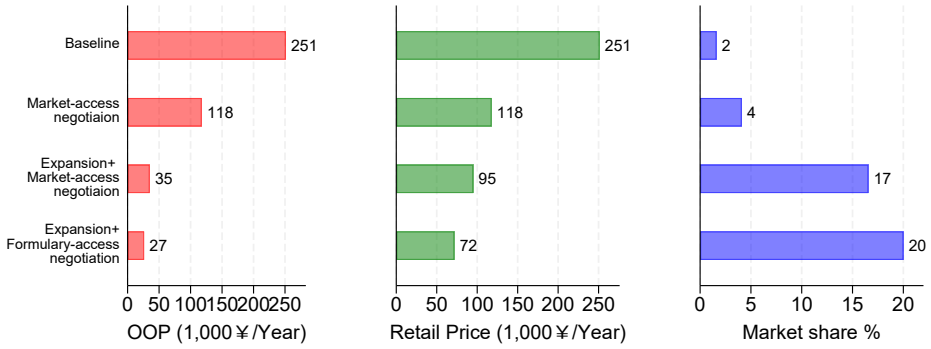
Figure A7: Spillover Effects of the Negotiation on Competing Drugs



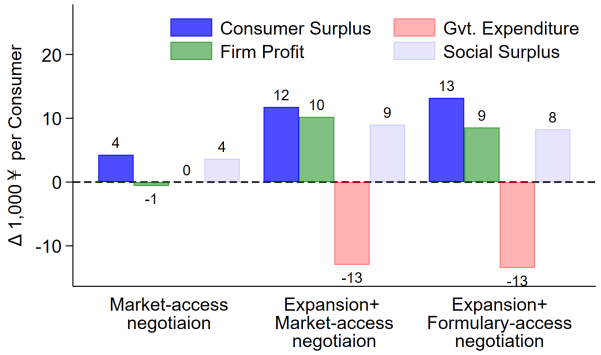
(a) log(Retail Price) (b) log(Quantity)

Note: This event study examines the potential spillover effects of the negotiation on closely competing drugs. All non-included drugs which have at least one same indication as any included drugs in the 2017 negotiation cohort are treated groups (15 drugs in *lung, liver, breast, kidney, stomach, ovarian* categories), and other non-included drugs that have zero overlapping indications as control groups (27 drugs). I compare the prices and quantity of treated drug between 2016 and 2018 (After 2018, nearly all drugs are treated.) The price effect is very precisely estimated to be around 0— indicating the strategic responses on prices are weak. The quantity effect is noisy but shows no clear evidence that treated drugs are more affected by the negotiation. This finding supports the hypothesis that patented cancer drugs are overall sufficiently differentiated.

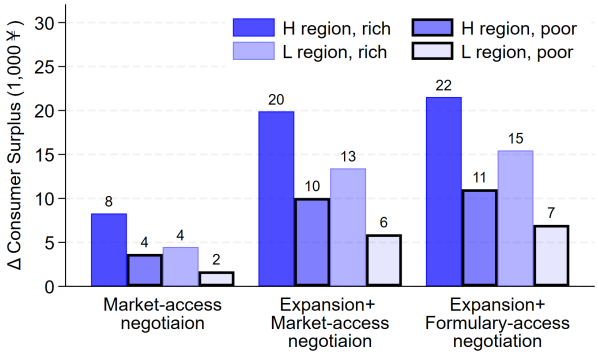
Figure A8: Counterfactual Results: Alternative Bargaining Formats ($\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$)



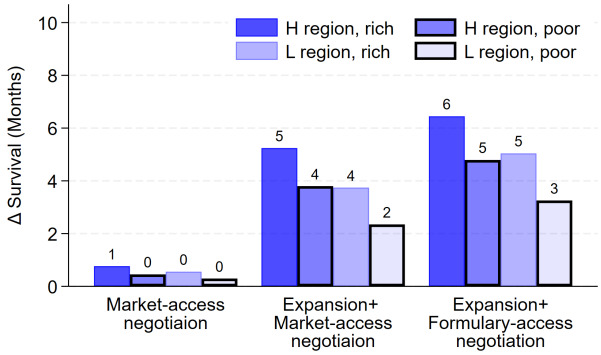
(a) Price and Market Share



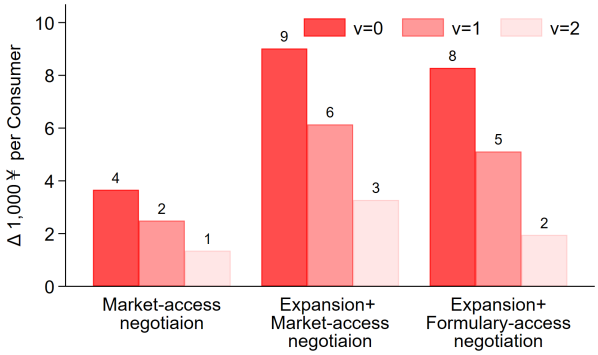
(b) Welfare Breakdown



(c) Δ Consumer Surplus (WTP) across Income Groups



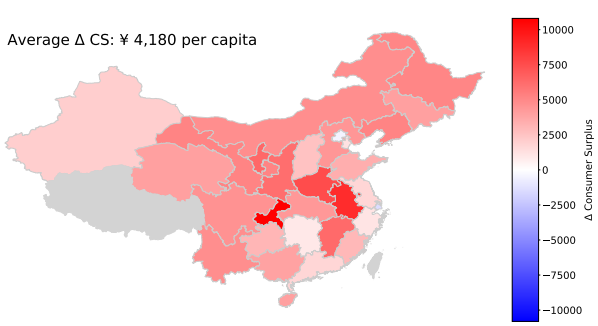
(d) Δ Survival across Income Groups



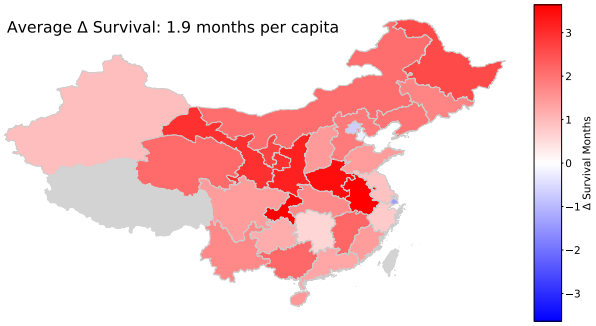
(e) Alternative Social Surplus Measures

Note: Alternative negotiation scenarios allow negotiation for 57 innovative cancer drugs that were successfully negotiated in the NRDL Reform. In panel (a), we compare four scenarios. "Baseline" denotes Bertrand-Nash pricing without insurance coverage. "Market access negotiation" assumes that, in the event of bargaining failure, the government excludes the drug from the market. Bargaining power is fixed at the estimated values. "Expansion + Market access negotiation" further provides insurance coverage at observed provincial coinsurance rates if the negotiation is successful. "Expansion + Formulary access negotiation" is the NRDL Reform. Panels (b)-(e) compare outcomes in each scenario to the "Baseline" scenario.

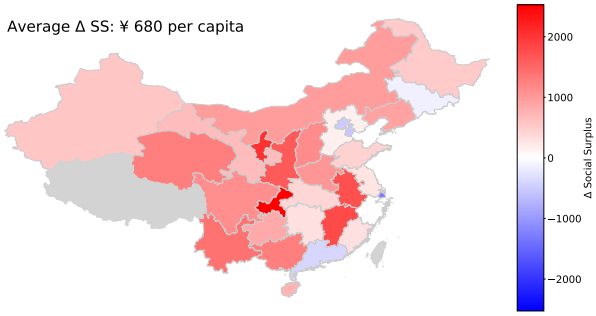
Figure A9: Effects of Centralized vs. Decentralized Negotiations ($\boldsymbol{\beta}_{failed} = \infty$)



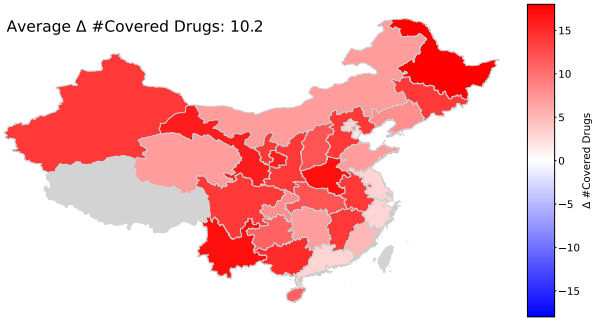
(a) Δ CS (¥/Patient)



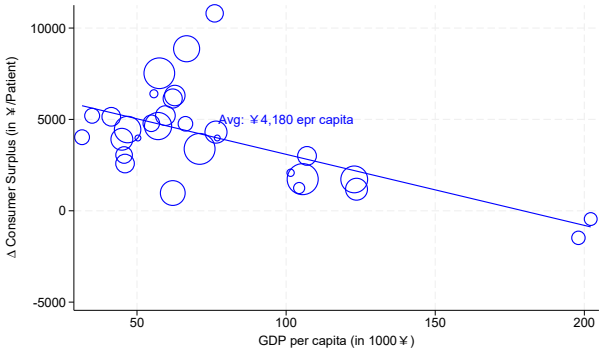
(b) Δ Survival Months (per Patient)



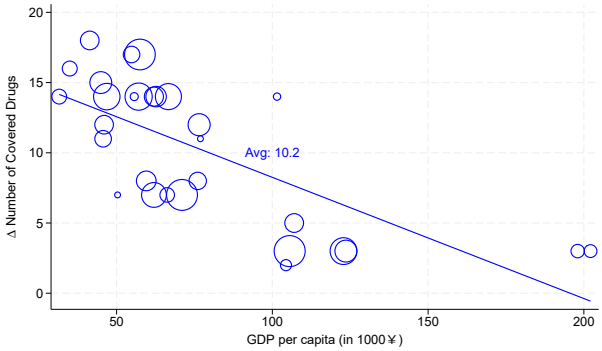
(c) Δ Social Surplus (¥/Patient)



(d) Δ Number of Covered Drugs



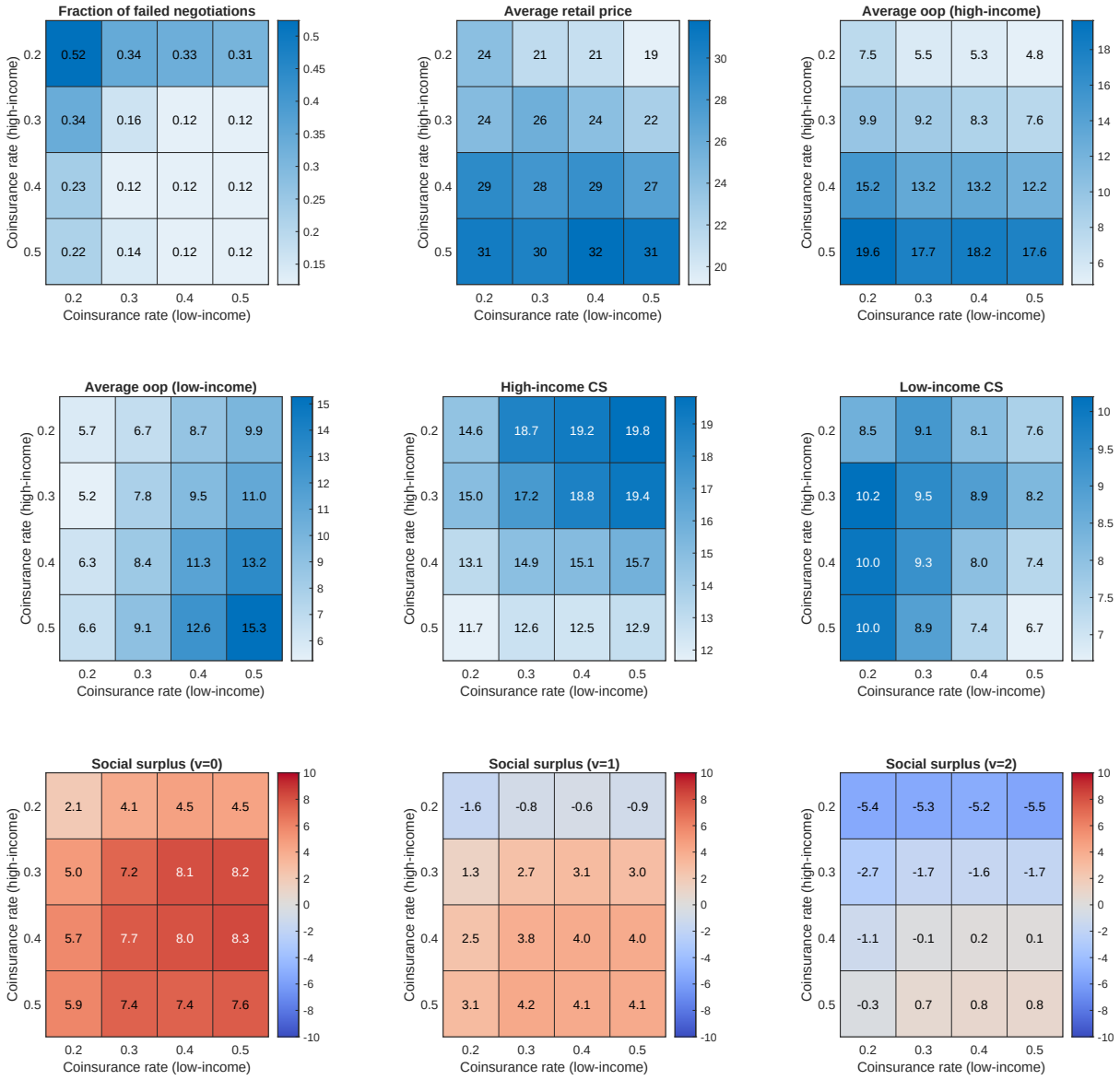
(e) Δ CS vs. Income



(f) Δ Number of Covered Drugs vs. Income

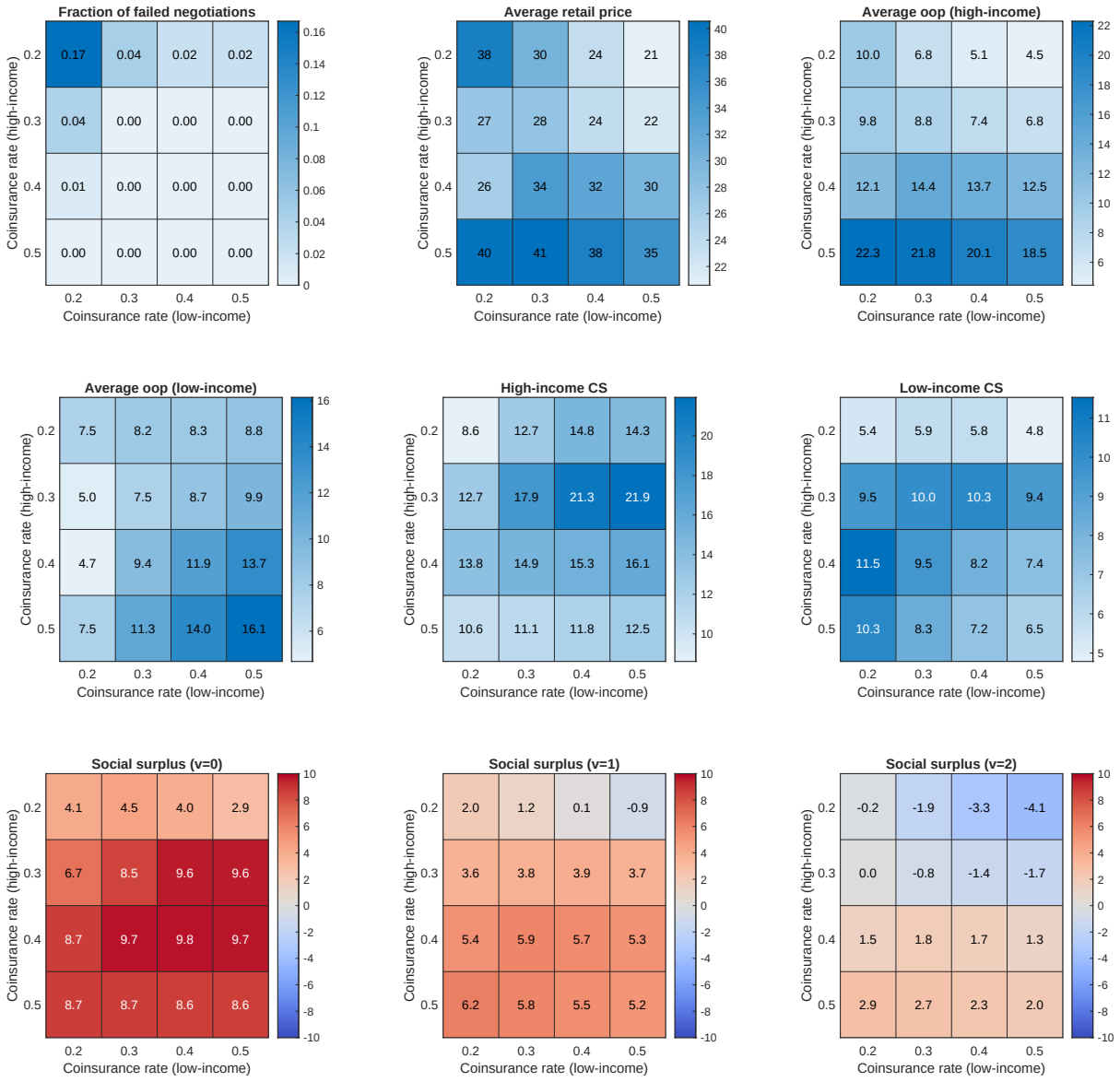
Note: Figures (a)-(d) show the geographic distributions of several outcomes, comparing centralized negotiation paired with insurance expansion to decentralized negotiation paired with insurance expansion. Figures (e) and (f) present bubble plots of the change in consumer surplus under centralized vs. decentralized negotiation, with income on the x-axis. Each bubble indicates one province; bubble size scales with the province population. All the results are based on simulations that set $\boldsymbol{\beta} = \infty$ for failed negotiations, so these drugs will always be excluded from the formulary.

Figure A10: Optimal Coinsurance Design ($\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$)



Note: This set of heatmaps presents simulated outcomes under income-based coinsurance schedules. Each horizontal axis shows the coinsurance rate for low-income (below median) patients, while each vertical axis shows the coinsurance rate for high-income (above median) patients. Simulations allow negotiation for 57 innovative cancer drugs and assume $\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$ for drugs that failed the NRDL negotiations. "Fraction of failed negotiations" reports the model-predicted count of failed negotiations under each coinsurance rate design. "Average retail price" is the unweighted average retail price across the 57 negotiated products. "Average OOP" is the unweighted average out-of-pocket price for patients. "High-income CS" denotes the consumer surplus for high-income patients, "High-income CS" denotes the consumer surplus for high-income patients. "Social surplus" is reported based on different equity criteria ($\nu = 0, 1, 2$). All surplus measures compare surplus under the given coinsurance schedule to the Baseline scenario with no insurance.

Figure A11: Optimal Coinsurance Design for Market-access Negotiation with Insurance Expansion ($\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$)



Note: This set of heatmaps presents simulated outcomes under income-based coinsurance schedules. Each horizontal axis shows the coinsurance rate for low-income (below median) patients, while each vertical axis shows the coinsurance rate for high-income (above median) patients. Simulations allow negotiation for 57 innovative cancer drugs and assume $\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$ for drugs that failed the NRDL negotiations. "Fraction of failed negotiations" reports the model-predicted count of failed negotiations under each coinsurance rate design. "Average retail price" is the unweighted average retail price across the 57 negotiated products. "Average OOP" is the unweighted average out-of-pocket price for patients. "High-income CS" denotes the consumer surplus for high-income patients, "High-income CS" denotes the consumer surplus for high-income patients. "Social surplus" is reported based on different equity criteria ($\nu = 0, 1, 2$). All surplus measures compare surplus under the given coinsurance schedule to the Baseline scenario with no insurance.

D Appendix Tables

Table A1: Overview of Top 20 Innovative Cancer Drugs in China

Drug	Success in	Eligible since	Global Entry Time	Local Entry Time	Company	Sales (bn ¥)	Type
Bevacizumab	2019	2017		2010	Roche	8.31	mAb
Trastuzumab	2017	2017	1998	2009	Roche	6.00	mAb
Osimertinib	2018	2018	2015	2017.3	AZ	5.56	PKI
Rituximab		2017	1997	2006	Roche	3.82	mAb
Pertuzumab	2019	2019	2011	2018	Roche	3.29	mAb
Anlotinib	2018	2018	2021	2018	Chia Tai*	2.74	PKI
Alectinib	2019	2021	2017	2018.8	Roche	2.38	PKI
Tislelizumab	2020	2020	2019.12	2019.12	Baiji*	2.15	mAb
Cetuximab	2018	2017	2004	2007	Merck	1.85	mAb
Lenvatinib	2020	2020	2019	2018	Eisai	1.85	PKI
Almonertinib	2020	2020	2021	2020.3	Hansoh*	1.78	PKI
Camrelizumab	2020	2020	2019.5	2019	Hengrui*	1.62	mAb
Pembrolizumab		2020	2014	2018.7	Merck	1.53	mAb
Sintilimab	2020	2020	2018.12	2018	Xinda*	1.47	mAb
Imatinib Mesylate			2001	2002.4	Novartis	1.43	PKI
Icotinib	2021	2021	2011	2011	Betta*	1.34	PKI
Pyrotinib	2019	2021	2022	2018	Hengrui*	1.18	PKI
Regorafenib	2018	2018	2012	2017.3	Bayer	1.15	PKI
Nimotuzumab	2017	2017	2002	2008	Baitai*	1.07	mAb
Crizotinib	2018	2018	2011	2013	Pfizer	1.01	PKI

Note: This table lists the top 20 cancer drugs by annual sales in China for the year 2022. Eligible denotes the first year the drug appeared on the eligible list for the centralized negotiation program. Success indicates the year of a successful negotiation. Target denotes the mechanism of action aimed at particular targets within the body of each drug, and company with asterisks denotes domestic firms.

Table A2: Overview of Clinical Effects of Innovative Cancer Drugs

Drug Name	Year entering NRDL	Eligible for negotiation	Effects on survival (months)	Data Source	Type
Dasatinib	N/A	No	0.3	Phase III- OSR	PKI
Gilteritinib	N/A	No	3.7	Phase II	PKI
Ivosidenib	N/A	No	2.8	Phase III- OS	PKI
Pemigatinib	N/A	No	13.3	Phase II	PKI
Zimberelimab	N/A	No	0.0	Imputed	PKI
Avapritinib	N/A	Yes	1.8	Phase III- OS	PKI
Axicabtagene	N/A	Yes	11.0	Phase III- PFS	PKI
Entrectinib	N/A	Yes	4.7	Phase II	PKI
Pralsetinib	N/A	Yes	0.0	Imputed	PKI
Relma-cel	N/A	Yes	0.0	Imputed	PKI
Staphylococcal	N/A	Yes	0.0	Imputed	PKI
Atezolizumab	N/A	Yes	5.5	Phase III- OS	mAb
Blinatumomab	N/A	Yes	3.7	Phase III- OS	mAb
Cadonilimab	N/A	Yes	9.4	Phase II	mAb
Dinutuximab beta	N/A	Yes	5.0	Phase II	mAb
Durvalumab	N/A	Yes	2.9	Phase III- OS	mAb
Envafolimab	N/A	Yes	0.0	Imputed	mAb
Inotuzumab	N/A	Yes	1.5	Phase III- OS	mAb
Ipilimumab	N/A	Yes	1.2	Phase III- OS	mAb
Nivolumab	N/A	Yes	2.8	Phase III- OS	mAb
Pembrolizumab	N/A	Yes	2.3	Phase III- OS	mAb
Ramucirumab	N/A	Yes	2.6	Phase III- OS	mAb
Rituximab	N/A	Yes	4.2	Phase III- OSR	mAb
Serplulimab	N/A	Yes	4.5	Phase II	mAb
Sugemalimab	N/A	Yes	5.7	Phase II	mAb
Gefitinib	2016	Yes	1.0	Phase III- OSR	PKI
Erlotinib	2017	Yes	1.8	Phase III- OS	PKI
Sorafenib	2017	Yes	0.8	Phase III- OS	PKI
Nimotuzumab	2017	Yes	2.4	Phase III- OS	mAb
Trastuzumab	2017	Yes	7.6	Phase III- OS	mAb
Afatinib	2018	Yes	0.8	Phase III- OS	PKI
Anlotinib	2018	Yes	3.3	Phase III- OS	PKI
Axitinib	2018	Yes	2.2	Phase III- PFS	PKI
Crizotinib	2018	Yes	3.0	Phase III- OS	PKI
Ensartinib	2018	Yes	8.5	Phase III- PFS	PKI
Ibrutinib	2018	Yes	10.9	Phase III- OS	PKI
Nilotinib	2018	Yes	4.8	Phase III- OS	PKI
Osimertinib	2018	Yes	22.2	Phase III- OSR	PKI
Pazopanib	2018	Yes	1.7	Phase III- OS	PKI
Regorafenib	2018	Yes	3.1	Phase III- OS	PKI
Sunitinib	2018	Yes	2.2	Phase III- OS	PKI
Vemurafenib	2018	Yes	0.6	Phase III- OSR	PKI
Cetuximab	2018	Yes	1.1	Phase III- OS	mAb
Alectinib	2019	Yes	9.5	Phase III- PFS	PKI
Apatinib	2019	Yes	3.8	Phase III- OS	PKI
Fruquintinib	2019	Yes	2.6	Phase III- OS	PKI
Pyrotinib	2019	Yes	13.9	Phase II	PKI
Bevacizumab	2019	Yes	5.2	Phase III- OS	mAb
Pertuzumab	2019	Yes	5.4	Phase III- OSR	mAb
Almonertinib	2020	Yes	9.4	Phase II	PKI
Dabrafenib	2020	Yes	2.4	Phase III- OSR	PKI
Denosumab	2020	Yes	0.0	Phase III- OS	PKI
Flumatinib	2020	Yes	0.0	Imputed	PKI
Lenvatinib	2020	Yes	17.5	Phase III- OS	PKI
Ruxolitinib	2020	Yes	4.7	Phase III- PFS	PKI
Trametinib	2020	Yes	3.5	Phase III- OS	PKI
Zanubrutinib	2020	Yes	0.0	Imputed	PKI
Camrelizumab	2020	Yes	4.5	Phase III- OS	mAb
Daratumumab	2020	Yes	9.9	Phase III- OS	mAb
Inetetamab	2020	Yes	25.1	Phase II	mAb
Sintilimab	2020	Yes	4.1	Phase III- PFS	mAb
Tislelizumab	2020	Yes	5.2	Phase III- OS	mAb
Toripalimab	2020	Yes	7.2	Phase III- OS	mAb
Abemaciclib	2021	Yes	8.6	Phase III- PFS	PKI
Dacomitinib	2021	Yes	3.8	Phase III- OS	PKI
Donafenib	2021	Yes	6.0	Phase II	PKI
Ensartinib	2021	Yes	20.3	Phase II	PKI
Furmonertinib	2021	Yes	0.0	Imputed	PKI
Icotinib	2021	Yes	0.6	Phase III- OS	PKI
Neratinib	2021	Yes	1.8	Phase III- OS	PKI
Orelabrutinib	2021	Yes	21.8	Phase II	PKI
Pamiparib	2021	Yes	1.8	Phase II	PKI
Surufatinib	2021	Yes	7.2	Phase II	PKI
Disitamab vedotin	2021	Yes	2.9	Phase II	mAb
Obinutuzumab	2021	Yes	18.6	Phase III- PFS	mAb
Brigatinib	2022	Yes	12.9	Phase III- PFS	PKI
Lorlatinib	2022	Yes	0.0	Imputed	PKI
Olverembatinib	2022	Yes	0.0	Imputed	PKI
Palbociclib	2022	Yes	2.7	Phase III- OS	PKI
Ripretinib	2022	Yes	9.2	Phase III- OS	PKI
Savolitinib	2022	Yes	12.5	Phase III- PFS	PKI
Venetoclax	2022	Yes	12.9	Phase III- OS	PKI
Ado-trastuzumab	2022	Yes	12.9	Phase III- OS	mAb
Brentuximab	2022	Yes	16.0	Phase III- PFS	mAb

Note: This table lists all innovative cancer drugs (mAb and PKI) and their overall survival effects collected from published clinical trials. Column Source denotes how we collect the number.

Table A3: Demand Estimates: Robustness

	Logit		Nested Logit		
	(1)	(2)	(3)	(4)	(5)
log(OOP)	-1.196***	-1.346***	-0.858***	-1.411***	-1.235***
	(0.081)	(0.020)	(0.034)	(0.039)	(0.025)
ρ (nesting para.)			0.465***	-0.107***	0.139***
			(0.033)	(0.033)	(0.023)
Indication					
Lung cancer		0.468***	0.313***	0.258***	0.439***
		(0.050)	(0.032)	(0.061)	(0.045)
Breast cancer		0.343***	0.211***	-0.048	0.314***
		(0.096)	(0.063)	(0.121)	(0.086)
Colon cancer		0.771***	0.247***	0.751***	0.740***
		(0.075)	(0.057)	(0.096)	(0.067)
Stomach cancer		0.430***	0.135**	0.615***	0.468***
		(0.076)	(0.057)	(0.098)	(0.068)
#Indication		0.101***	0.171***	0.098***	0.112***
		(0.011)	(0.008)	(0.013)	(0.010)
Nesting level			1(mAb/PKI)	ATC3	ATC4
Mean elasticity	-1.20	-1.35	-1.60	-1.28	-1.40
Median elasticity	-1.20	-1.35	-1.60	-1.28	-1.43
P75 elasticity	-1.20	-1.35	-1.60	-1.28	-1.43
P25 elasticity	-1.20	-1.35	-1.60	-1.28	-1.39
Product FE		Yes	Yes	Yes	Yes
Product*Time FE	Yes				
Province*Time FE	Yes	Yes	Yes	Yes	Yes

Note: The table shows the demand estimates for alternative specifications. Column (1) reports logit with Product*Time FEs and uses the negotiation dummy $\times$ local coinsurance rate as instruments. Column (2) restricts the sample to innovative drugs (mAb/pKI) only. and Column (3)-(5) report nested logit estimates with different nesting structures: Column (3) uses innovative drugs (mAb/pKI) or not, Column (4) uses ATC3 (20 types), and Column (5) uses ATC4 (67 types). Column (2)-(5) instruments: negotiation dummy. The median elasticity reported in this table is the median individual-level elasticity ($\frac{ds_{ij}/s_{ij}}{dp_j/p_j}$) across products.

Table A4: Decomposition of the Effects of Expansion & Negotiation

		(1) Baseline	(2)	(3)	(4)	(5)
			+ Expansion Only		+ Expansion &Negotiation	
		y	Δy	$\Delta y\%$	Δy	$\Delta y\%$
Market Outcomes						
Avg. Retail Price	Inno, Success	251.37	32.50	12.93	-181.51	-72.21
(¥1,000 per year)	Inno, Others	52.60	-0.09	-0.17	-0.09	-0.17
	Traditional	13.54	-0.02	-0.14	-0.02	-0.14
Avg. Out-of-pocket Price	Inno, Success	251.37	-154.24	-61.36	-224.78	-89.42
(¥1,000 per year)	Inno, Others	52.60	-0.09	-0.17	-0.09	-0.17
	Traditional	12.96	-0.02	-0.12	-0.02	-0.12
Market Share	Inno, Success	1.62	4.79	295.06	18.40	1133.28
(%|inside)	Inno, Others	0.56	-0.03	-5.01	-0.11	-19.10
	Traditional	97.82	-4.76	-4.87	-18.29	-18.70
Welfare Effects in 1,000 ¥per consumer per year						
Consumer Surplus	H region, Rich	4.78	11.98	250.55	21.53	450.48
	H region, Poor	1.90	5.65	297.21	11.04	580.91
	L region, Rich	3.76	5.43	144.50	15.46	411.21
	L region, Poor	1.30	2.21	170.40	6.99	539.47
	Average	2.87	5.91	206.24	13.34	465.22
Share-weight OS	H region, Rich	0.46	1.59	346.39	6.45	1404.06
(months per consumer)	H region, Poor	0.23	1.04	463.43	4.79	2128.44
	L region, Rich	0.48	0.83	172.80	5.04	1054.41
	L region, Poor	0.21	0.47	226.97	3.26	1574.17
	Average	0.34	0.93	270.72	4.76	1390.97
Gvt. Expenditure		1.43	11.08	774.31	13.48	942.27
Variable Profits	Inno, Success	4.30	10.93	253.87	8.56	198.95
	Inno, Others	0.89	-0.00	-0.44	-0.01	-1.51
	Traditional	12.40	-0.03	-0.27	-0.13	-1.01
Welfare	$\nu = 0$	19.04	5.72	30.03	8.28	43.50
	$\nu = 1$	18.19	4.19	23.06	5.11	28.10
	$\nu = 2$	17.39	2.69	15.46	1.95	11.22

Note: This table decomposes the effect of all rounds of policy reform (as of the year 2023) into its two main channels. The baseline scenario excluded all 57 cancer drugs that were included due to the program. We report consumer surplus in four groups: "H region, Rich" denotes high-income patients (above median) in high-income (above median) provinces. Total welfare is reported according to different weights on households, as a function of income: $income^{-\nu}$ where $\nu = 0$ is utilitarian and $\nu \to \infty$ is Rawlsian. To compute baseline patient welfare, we calculate the change in consumer surplus between the baseline equilibrium and an alternative equilibrium in which only outside option treatments (i.e., no cancer drugs) are available. Share-weight OS is based on clinical evidence of increased months of survival collected from Phase III trial data. Results for market outcomes report the national averages. Δy is the average level change in an outcome relative to baseline across markets, and $\Delta y\%$ is the average percentage change in an outcome relative to baseline across markets. Welfare is reported on a per capita basis, where the denominator includes all patients who seek pharmaceutical cancer treatment.

Table A5: Counterfactual: Alternative Negotiation Regimes ($\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$)

		(1) Baseline	(2) + Market Access &Negotiation	(3)	(4) + Market Access Expansion&Negotiation	(5)	(6) + Decentralized &Negotiation	(7)
		y	Δy	Δy%	Δy	Δy%	Δy	Δy%
Market Outcomes								
Avg. Retail Price	Inno, Success	251.37	-133.52	-53.12	-155.32	-61.79	-156.34	-62.19
(¥1,000 per year)	Inno, Others	52.60	-27.81	-52.87	-30.14	-57.30	-20.03	-38.08
	Traditional	13.54	-0.02	-0.11	0.56	4.11	-0.59	-4.37
Avg. Out-of-pocket Price	Inno, Success	251.37	-133.52	-53.12	-216.14	-85.99	-209.61	-83.39
(¥1,000 per year)	Inno, Others	52.60	-27.81	-52.87	-45.86	-87.19	-23.37	-44.44
	Traditional	12.96	-0.02	-0.12	-0.02	-0.12	-0.02	-0.12
Market Share	Inno, Success	1.62	2.45	151.07	13.95	859.46	11.79	726.16
(%|inside)	Inno, Others	0.56	0.70	124.99	5.77	1034.73	6.82	1223.62
	Traditional	97.82	-3.15	-3.22	-19.72	-20.16	-18.61	-19.02
Welfare Effects in 1,000 ¥per consumer per year								
Consumer Surplus	H region, Rich	4.78	10.98	229.66	25.21	527.37	25.30	529.31
	H region, Poor	1.90	4.93	259.41	13.36	702.87	13.60	715.35
	L region, Rich	3.76	5.94	158.10	15.47	411.58	10.03	266.77
	L region, Poor	1.30	2.21	170.79	7.00	540.14	4.72	364.15
	Average	2.87	5.69	198.65	14.59	509.04	12.41	432.87
Share-weight OS	H region, Rich	0.46	0.88	192.68	6.54	1424.87	5.60	1220.48
(months per consumer)	H region, Poor	0.23	0.53	236.08	4.86	2160.51	4.27	1896.78
	L region, Rich	0.48	0.63	132.37	4.20	878.15	2.90	606.24
	L region, Poor	0.21	0.34	165.01	2.66	1287.84	1.93	933.39
	Average	0.34	0.58	169.20	4.38	1278.98	3.47	1012.53
Gvt. Expenditure		1.43	-0.00	-0.13	16.01	1119.17	10.25	716.52
Variable Profits	Inno, Success	4.30	-0.62	-14.45	10.15	235.85	7.21	167.49
	Inno, Others	0.89	-0.04	-4.25	0.71	79.49	0.66	74.23
	Traditional	12.40	-0.02	-0.17	-0.16	-1.26	-0.33	-2.66
Welfare	$\nu = 0$	19.04	5.02	26.34	9.29	48.79	9.70	50.96
	$\nu = 1$	18.19	3.46	19.03	5.89	32.39	6.91	38.00
	$\nu = 2$	17.39	1.95	11.19	2.48	14.28	4.07	23.42

Note: Column 1 presents outcomes in the baseline scenario (Bertrand-Nash competition) without the reform. Columns 2-7 present outcomes for alternative negotiation scenarios, allowing negotiation for 70 innovative cancer drugs and assuming $\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$ for drugs that failed the NRDL negotiations. Columns 2 and 3 present a counterfactual scenario where the government negotiates with drug manufacturers for market access but provides no insurance coverage. Columns 4 and 5 present a counterfactual scenario where the government negotiates with drug manufacturers for both market access and insurance coverage. Columns 6 and 7 present a counterfactual scenario where NRDL formulary access and insurance coverage are determined at the provincial level. In all the simulations, τ is set at the estimate of 0.68 presented in Table 4). "H region, Rich" denotes rich (above median income) people in high-income (low-coinsurance) provinces. Total welfare is reported according to different weights on income: $income^{-\nu}$ where $\nu = 0$ is utilitarian and $\nu \to \infty$ is Rawlsian. To compute baseline patient welfare, we calculate the difference in consumer surplus between the baseline equilibrium and an alternative environment in which only the outside option is available. Share-weighted overall survival (OS) is based on clinical evidence of improved survival months.

Table A6: Counterfactual: Alternative Negotiation Regimes (Decentralized Negotiation)

		(1) Centralized $\beta_{failed} = \beta_l$ y	(2) Provincial $\beta_{failed} = \beta_l$ Δy	(3) Δy%	(4) Centralized $\beta_{failed} = \infty$ y	(5) Provincial $\beta_{failed} = \infty$ Δy	(6) Δy%
Market Outcomes							
Avg. Retail Price	Inno, Success	69.85	25.18	36.05	69.85	25.18	36.05
(¥1,000 per year)	Inno, Others	33.08	-0.51	-1.53	52.51	0.00	0.00
	Traditional	12.95	0.00	0.00	12.95	0.00	0.00
Avg. Out-of-pocket Price	Inno, Success	26.13	15.63	59.82	26.13	15.63	59.82
(¥1,000 per year)	Inno, Others	12.37	16.85	136.22	52.51	0.00	0.00
	Traditional	12.95	0.00	0.00	12.95	0.00	0.00
Market Share	Inno, Success	17.64	-4.23	-23.97	18.41	-3.96	-21.54
(%|inside)	Inno, Others	4.61	2.76	59.91	0.46	0.02	4.69
	Traditional	77.75	1.46	1.88	81.13	3.94	4.86
Welfare Effects in 1,000 ¥per consumer per year							
Consumer Surplus	H region, Rich	29.80	0.28	0.95	24.28	-1.41	-5.80
	H region, Poor	14.77	0.73	4.91	11.62	-0.55	-4.75
	L region, Rich	22.37	-8.58	-38.35	19.67	-7.25	-36.84
	L region, Poor	9.90	-3.89	-39.26	8.54	-3.20	-37.53
	Average	18.70	-3.42	-18.31	15.71	-3.46	-22.00
Share-weight OS	H region, Rich	5.79	0.27	4.71	5.21	-0.58	-11.06
(months per consumer)	H region, Poor	4.01	0.49	12.12	3.58	-0.29	-8.16
	L region, Rich	6.23	-2.85	-45.81	5.80	-2.63	-45.31
	L region, Poor	3.97	-1.83	-46.16	3.68	-1.69	-46.02
	Average	5.02	-1.21	-24.09	4.60	-1.44	-31.34
Gvt. Expenditure		14.92	-3.24	-21.70	12.71	-2.60	-20.43
Variable Profits	Inno, Success	11.15	0.36	3.26	11.18	0.41	3.64
	Inno, Others	2.63	-0.80	-30.47	0.88	-0.00	-0.10
	Traditional	12.10	-0.03	-0.25	12.14	0.01	0.08
Welfare	$\nu = 0$	29.66	-0.65	-2.20	27.20	-0.44	-1.63
	$\nu = 1$	25.09	0.29	1.16	23.25	0.44	1.91
	$\nu = 2$	20.54	1.19	5.80	19.37	1.30	6.69

Note: Column 1 presents outcomes under centralized negotiation with formulary access at the uniform coinsurance rate 0.37. Columns 2-3 present outcomes for decentralized negotiation scenarios, allowing negotiation for 70 innovative cancer drugs and assuming $\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$ for drugs that failed the NRDL negotiations. Columns 4 and 5 present outcomes by assuming $\boldsymbol{\beta}_{failed} = \infty$ for drugs that failed the NRDL negotiations. In all the simulations, τ is set at the estimate of 0.68 presented in Table 4). "H region, Rich" denotes rich (above median income) people in high-income (low-coinsurance) provinces. Total welfare is reported according to different weights on income: $income^{-\nu}$ where $\nu = 0$ is utilitarian and $\nu \to \infty$ is Rawlsian. To compute baseline patient welfare, we calculate the difference in consumer surplus between the baseline equilibrium and an alternative environment in which only the outside option is available. Share-weighted overall survival (OS) is based on clinical evidence of improved survival months.

Table A7: Counterfactual: Alternative Negotiation Regimes ($\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$)

		(1) Baseline	(2) + Market Access &Negotiation	(3)	(4) + Market Access Expansion&Negotiation	(5)	(6) + Decentralized &Negotiation	(7)
		y	Δy	Δy%	Δy	Δy%	Δy	Δy%
Market Outcomes								
Avg. Retail Price	Inno, Success	251.37	-133.52	-53.12	-155.32	-61.79	-139.73	-55.59
(¥1,000 per year)	Inno, Others	52.60	-0.09	-0.17	-0.09	-0.17	-0.09	-0.17
	Traditional	13.54	-0.02	-0.11	0.56	4.11	-0.59	-4.37
Avg. Out-of-pocket Price	Inno, Success	251.37	-133.52	-53.12	-216.14	-85.99	-209.61	-83.39
(¥1,000 per year)	Inno, Others	52.60	-0.09	-0.17	-0.09	-0.17	-0.09	-0.17
	Traditional	12.96	-0.02	-0.12	-0.02	-0.12	-0.02	-0.12
Market Share	Inno, Success	1.62	2.48	152.90	14.95	920.67	12.82	789.87
(%|inside)	Inno, Others	0.56	-0.01	-2.55	-0.09	-15.55	-0.07	-13.39
	Traditional	97.82	-2.47	-2.52	-14.86	-15.19	-12.75	-13.03
Welfare Effects in 1,000 ¥per consumer per year								
Consumer Surplus	H region, Rich	4.78	8.29	173.34	19.90	416.41	18.09	378.47
	H region, Poor	1.90	3.69	193.92	10.05	528.81	9.17	482.52
	L region, Rich	3.76	4.48	119.14	13.42	356.92	8.67	230.56
	L region, Poor	1.30	1.71	131.70	5.92	456.99	4.04	311.66
	Average	2.87	4.30	149.97	11.88	414.55	9.39	327.49
Share-weight OS	H region, Rich	0.46	0.76	166.56	5.24	1141.78	4.18	910.11
(months per consumer)	H region, Poor	0.23	0.45	201.46	3.80	1688.46	3.06	1361.36
	L region, Rich	0.48	0.56	116.12	3.74	783.07	2.70	564.03
	L region, Poor	0.21	0.30	143.43	2.35	1135.52	1.78	859.63
	Average	0.34	0.50	146.73	3.66	1069.57	2.81	822.17
Gvt. Expenditure		1.43	-0.00	-0.10	12.99	908.01	8.68	607.13
Variable Profits	Inno, Success	4.30	-0.62	-14.41	10.23	237.76	7.28	169.22
	Inno, Others	0.89	-0.00	-0.20	-0.01	-1.25	-0.01	-1.18
	Traditional	12.40	-0.02	-0.13	-0.10	-0.82	-0.26	-2.08
Welfare	$\nu = 0$	19.04	3.66	19.24	9.02	47.36	7.72	40.54
	$\nu = 1$	18.19	2.49	13.70	6.14	33.74	5.51	30.28
	$\nu = 2$	17.39	1.35	7.78	3.28	18.84	3.28	18.87

Note: Column 1 presents outcomes in the baseline scenario (Bertrand-Nash competition) without the reform. Columns 2-7 present outcomes for alternative negotiation scenarios, allowing negotiation for 57 innovative cancer drugs and assuming $\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$ for drugs that failed the NRDL negotiations. Columns 2 and 3 present a counterfactual scenario where the government negotiates with drug manufacturers for market access but provides no insurance coverage. Columns 4 and 5 present a counterfactual scenario where the government negotiates with drug manufacturers for both market access and insurance coverage. Columns 6 and 7 present a counterfactual scenario where NRDL formulary access and insurance coverage are determined at the provincial level. In all the simulations, τ is set at the estimate of 0.68 presented in Table 4). "H region, Rich" denotes rich (above median income) people in high-income (low-coinsurance) provinces. Total welfare is reported according to different weights on income: $income^{-\nu}$ where $\nu = 0$ is utilitarian and $\nu \to \infty$ is Rawlsian. To compute baseline patient welfare, we calculate the difference in consumer surplus between the baseline equilibrium and an alternative environment in which only the outside option is available. Share-weighted overall survival (OS) is based on clinical evidence of improved survival months.