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

Panle Jia Barwick Ashley Swanson Tianli Xia *

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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. The reform offered insurance coverage for innovative drugs, contingent on mutually-agreeable price reductions negotiated between the government and drug producers. 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, centralized bargaining is far more beneficial to patients in low- to moderate-income provinces compared to decentralized negotiation. Third, paradoxically, a regressive schedule with lower co-insurance rates for high-income households increases drug access for all consumers through increased bargaining leverage.

*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 Liran Einav, Matt Backus, Amanda Starc, Bob Town, and the seminar participants for their helpful comments. Jiyu Xia provided excellent research assistance. We are grateful to SinoHealth for generously providing the data.

1 Introduction

Making innovative drugs affordable and accessible is a pressing global challenge. Take, for example, Verzenio (Abemaciclib), 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 ($8570) per year in China. Such exorbitant prices place life-saving treatments out of reach for the majority of self-paying patients. Prescription drug insurance programs increase access to these drugs for a wider population, but they also come with substantial costs. For instance, the Medicare Part D prescription drug insurance program for the elderly in the U.S. allocates 61% of its budget to the top 100 highest-priced drugs (CMS, 2024). High-cost, innovative drugs can generate large social value, but creating efficient mechanisms to pay for them is a challenging economic problem.

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, where the patient's share of the drug cost — the coinsurance rate — ranges from 20% to 45% depending upon provincial subsidies. 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 equity and efficiency implications of observed and counterfactual drug market reforms. For motivation, note two striking features of the environment. First, 25% of negotiations fail. Second, coinsurance varies widely across high- and low-income provinces. We use these factors

[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" (Sun et al., 2021; 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.

to motivate a deep investigation into how policy choices impact bilateral gains from trade, and therefore determine the extensive margin of which drugs are covered, and the intensive margin of negotiated price levels.

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 significantly simplifies the modeling necessary to evaluate the effectiveness of central-government insurance expansion, by removing the complications of other insurers and insurance markets. 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 and allows us to investigate the optimal structure of coinsurance schedules. Finally, in contrast to many settings where only successful negotiation outcomes are observed, negotiation failures occur in approximately 25% of cases, providing a unique opportunity to infer government preferences and to estimate the shadow value of government expenditures.

Our analysis of the NRDL Reform utilizes a unique dataset that provides comprehensive coverage of drug sales across China from 2017 to 2023. The primary data source is SinoHealth, a publicly listed health consulting firm whose data are widely utilized by major international and domestic pharmaceutical companies.[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.

In this paper, we present to our knowledge the first comprehensive evidence on the price and quantity effects of China's NRDL Reform between 2017 and 2023. To do so, we aggregate drug sales data to the province-quarter level and 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 (out of the 643 drugs invited for negotiation) to over a billion people during our study period. The associated price negotiations resulted in a 48% reduction in retail price for the average drug and, due to the introduction of coinsurance at the same time, an even larger 80% reduction in patients' out-of-pocket prices. These sharp price drops drove large increases in the utilization of innovative drugs: the average successful negotiation was followed

[3]These include Pfizer, Roche, Bayer, AstraZeneca, GlaxoSmithKline, Merck, and Eli Lilly, among others.

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 firms negotiate prices to split surplus contingent on successful negotiations. The empirical framework for the supply side features centralized bargaining with heterogeneous households, bargaining breakdowns, and a government objective function that depends on measures of patient welfare and government expenditure. The structural model allows us to estimate several key parameters: patients' effective price elasticities of demand across different income levels, 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 central government places on patient surplus vs. government expenditures.

Several empirical challenges arise in this analysis. As is common in demand studies, drug prices are endogenous. We address this endogeneity using the NRDL policy shock as an instrumental variable, which, when interacted with local demographics, generates more granular variation. In addition, the marginal costs and bargaining parameters of drug companies are not observed. We recover them by inverting first-order conditions and imposing parametric restrictions on bargaining parameters. Our model shares similar 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 any drug in the NRDL formulary at a price acceptable to the drug company would be too costly for the government.[4]

[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.

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 flexible variation in bargaining parameters across negotiating pairs, we allow the shadow cost of the government's budget constraint to depend upon drug characteristics such as drug quality and foreign/domestic status. In doing so, we build upon 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 anti-cancer drugs: monoclonal antibodies and protein kinase inhibitors. Of the 97 such cancer drugs invited for negotiation, 57 were successful and accounted for two-thirds of revenues for successfully negotiated drugs in the NRDL program. Unit margins for these drugs are high (75% on average) in the pre-reform period; this is to be expected in pharmaceutical markets, where upfront costs of development are high but marginal costs of production and distribution are low. Consistent with prior work on global drug markets, price elasticities are somewhat low, around -1.6 for the median patient (Dubois et al., 2022). There is a substantial gradient in income—low-income patients are significantly more price-sensitive. The government assigns equal weight to consumer surplus and program expenditures for the median drug and higher weights to consumer surplus gains for more effective drugs that demonstrate larger survival improvements in phase III clinical trials. Firms have a bargaining parameter of 0.63, suggesting that while firms have considerable bargaining power, there is room for the government to bring down prices through central negotiation.

Turning to policy effectiveness, negotiation without insurance expansion has no impact on prices or quantities. This is because the government lacks the leverage to negotiate price discounts, as firms can simply sell at profit-maximizing prices in the retail market. On the other hand, insurance expansion alone reduces price sensitivity, leading to higher retail prices (though out-of-pocket prices are still lower); see Cutler and Reber (1998), Jaffe and Shepard (2020), and Liu and Jin (2015). The combination of negotiation and insurance expansion, as implemented in China's NRDL Reform, increases the market share of innovative drugs among all cancer drugs by 18 ppt, which exceeds the gains achieved by insurance alone (5 ppt) and negotiation alone (0 ppt, trivially). This double dose of reform with both central negotiation and insurance expansion reduces out-of-pocket costs by 89% and delivers the greatest consumer surplus gains compared to either insurance expansion alone or negotiation alone. Furthermore, the improved access to innovative drugs enhances average overall survival by four months per cancer patient during our sample period. Altogether, social surplus (consumer surplus plus producer surplus minus government expenditures) increases by ¥8,280 per cancer patient,

compared to only ¥5,720 with insurance expansion alone and ¥0 with negotiation alone.

We next turn to a series of exercises that shed light on optimal policy design. First, having noted that negotiation alone has no "teeth," we consider strengthening the government's leverage by modeling a "market access" negotiation, with and without insurance expansion, in which the government's threat point is the exclusion of the drug from the Chinese market entirely. This analysis contributes to recent work on bargaining with exclusion and alternative formulary structures (Ho and Lee, 2019, 2024). We do find stronger effects of negotiation in this case. If firms must negotiate with the government to access the market, even without insurance expansion, retail prices (which are equivalent to out-of-pocket prices absent insurance) would decrease by 53% at zero cost to the government. This expands the innovative drugs' share of the cancer drug market by 2.45 ppt. Nevertheless, we continue to find that insurance expansion reinforces the effects of negotiation. Market access negotiation *plus* insurance expansion reduces retail prices by 52% and OOP prices by 86%, expanding the negotiated drugs' share of the cancer drug market by 14 ppt.[5] Taken together, these results confirm our original finding that negotiation and insurance expansion reinforce one another.

Next, we examine the role of centralization in the NRDL Reform. As noted previously, 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 program in which each province negotiates its own prices. This analysis sheds light on recent policy debates and academic research regarding the costs and benefits of 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). We analyze the effects on both the extensive and intensive margins. On the extensive margin, decentralized bargaining leads to a 19% increase in negotiation failures, as the market expansion and gains in consumer surplus in lower-income regions are insufficient to justify the government's expenses. On the intensive margin, decentralized province-level negotiations result in retail prices that are 22% higher (for successfully negotiated drugs) and a 5.6 percentage point decline in these drugs' share of the cancer drug market compared to centralized negotiations. These effects vary significantly across regions: while most low- to moderate-income provinces suffer from fewer successful negotiations and higher prices under provincial-level negotiations,

[5]Note that "market access" negotiation plus insurance expansion delivers similar equilibrium outcomes as the current reform where negotiation is not tied to market access. This is because the government cares about losses in consumer surplus if a drug is excluded from the market. Consequently, the government might not have stronger bargaining power in the scenario where negotiation is tied to market access.

the highest-income provinces tend to benefit from decentralization.

The last set of counterfactual analyses examines the efficiency and equity implications of more and less regressive coinsurance schedules. Public insurance programs often include income-based subsidies. For example, the US 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 literature that examines income-based 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 and redistribution. We document a few notable results. First, our simulations characterize a key tradeoff in which 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, both low-income and high-income households benefit when high-income households receive lower coinsurance rates, as the more generous insurance 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, while 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 went 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 formal sectors, and the urban and rural resident basic medical insurance plan (URRBMI) for other residents and employees. The premium for these insurance plans is set at ¥1080, with individuals paying ¥380 in 2023 and the government subsidizing ¥700. The commercial insurance market in China is relatively small, 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 (NRDL) excluded innovative drugs due to budget considerations.[8] In recent years, CHS faced criticism for its lack of coverage for innovative drugs, resulting in limited access to effective treatments and high out-of-pocket prices. In response to public pressure, CHS launched a drug reform in 2016 that is ongoing 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 often 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, the government sends representatives and negotiates with delegates from each drug company simultaneously and independently. Table 1 summarizes the seven rounds of annual negotiations from 2016 to 2022, which had an average success rate of 76%.

There are three notable features of this negotiation process. First, both parties possess a lot of information about drug prices and demand, as most of the drugs on the eligible list were already sold in the private market. During the pre-negotiation stage, information is exchanged frequently between the parties. As a result of this process, 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

[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.

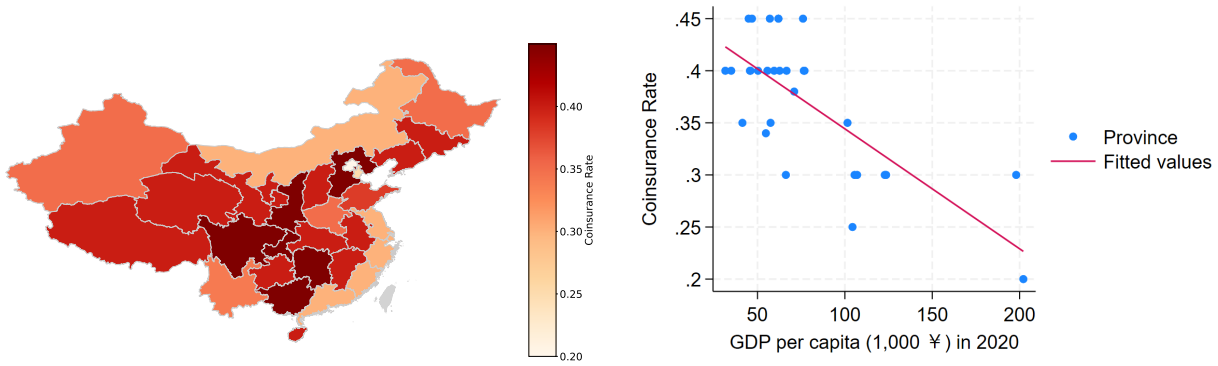
[7]China had various price caps and price regulations on pharmaceutical drugs during the 1980s-2000s. In 2015, China removed these price regulations and only kept anesthetics under price control. See https://www.gov.cn/gongbao/content/2015/content_2901387.htm.

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

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 each plan type, these 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 rate vs. provincial income. Patients in wealthier provinces like Beijing and Shanghai pay about 20-25% 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 in China's universal health insurance program for residents. Figure (b) presents the relationship between coinsurance and GDP per capita across provinces.

[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.

2.2 Data and Sample Description

The primary dataset we use 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 and 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 anti-cancer drugs is growing rapidly, with total sales reaching ¥140 billion (around 0.1% of China's GDP) in 2022. Second, anti-cancer drugs are the most critical category in NRDL negotiations, with successfully negotiated anti-cancer drugs comprising more than 60% of revenues among all successfully negotiated drugs.

To facilitate the analyses of cancer drugs, we have constructed several ancillary datasets. 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 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 the 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 (i.e., the difference in the ratio of survived patients over total patients relative

to the control group) and progression-free survival. Third, we collected provincial-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 anti-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 are effective in killing cancer cells but are associated with very strong 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. By 2022, there had been 97 negotiations of innovative anti-cancer drugs, with 57 successes.

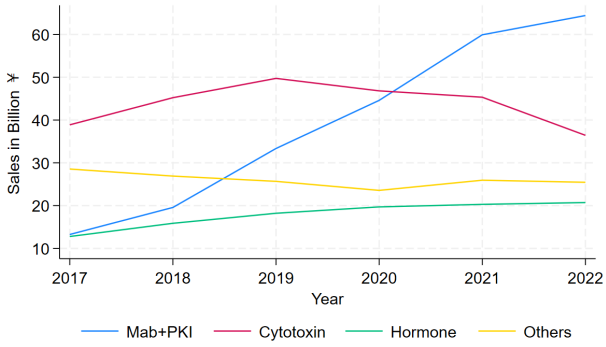
Figure 2 presents key data patterns regarding the cancer drug market. First, the NRDL Reform led to substantial market expansion for innovative cancer drugs (mAb and PKI). Sales skyrocketed from ¥13 billion in 2017 to ¥64 billion in 2022 (Figure 2(a)). At the same time, sales of traditional chemotherapy drugs declined, suggesting that there was some switching from cytotoxin treatment to innovative anti-cancer treatment. Figure 2(b) decomposes the sales of innovative cancer drugs into insured and non-insured products. In 2017, the innovative anti-cancer drug market was entirely uninsured and patients had to pay full retail price to receive treatment. In 2022, six years after the first round of negotiations, more than 80% of innovative cancer drug sales were from insured (successfully negotiated) products. Over the same time horizon, the average retail price of innovative cancer drugs declined substantially (Figure 2(c)). This effect is even more pronounced for residualized prices after partialing out brand fixed effects to account for price changes due to product entry and exit (Figure 2(d)).[10]

This period also saw significant market entry and a growing variety of innovative cancer drugs. Figure 2(e) shows that the number of innovative drugs available surged for the most common types of cancer between 2017 and 2022, and Figure 2(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]

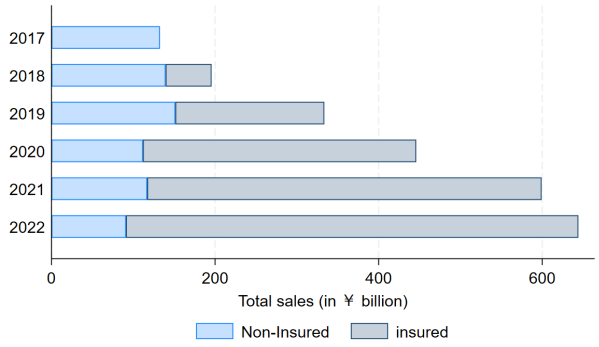
[10]There is a modest decline in prices for cytotoxin drugs, likely due to the 2019-20 introduction of a procurement auction program targeting generic drugs (Cao et al., 2022).

[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.

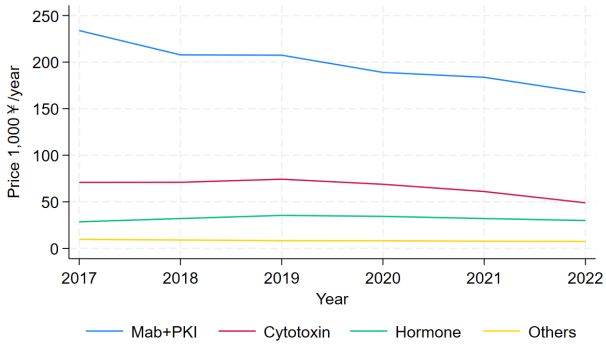
Figure 2: Overview of the Anti-Cancer Drug market



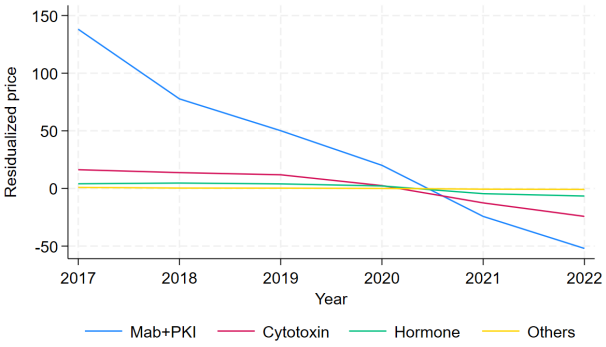
(a) Market Sales by Cancer Drug Category



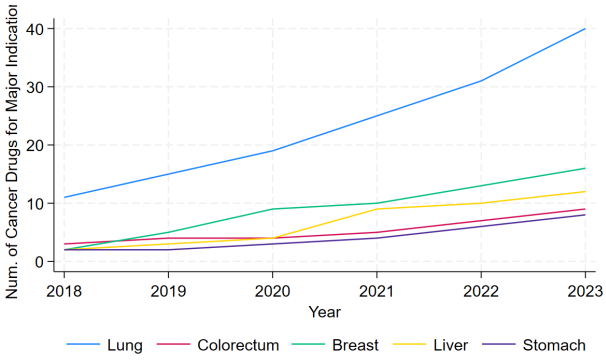
(b) Sales for Non/Insured Innovative Cancer Drugs



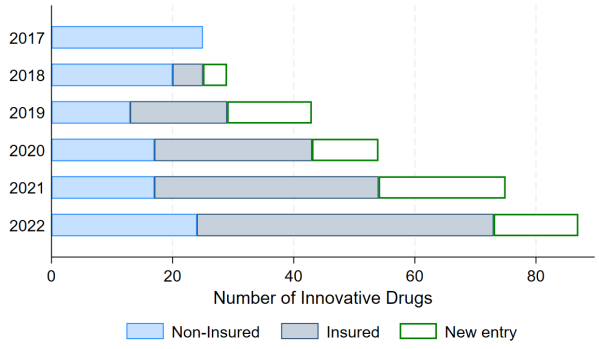
(c) Retail Price (raw)



(d) Residualized Price



(e) Num. of Drugs for Major Indications



(f) Number of Innovative Cancer Drugs on Market

Note: Figure (a) plots the sales of anti-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 the raw price. Figure (d) plots the residualized log price of drugs 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 on the market in each year, with incumbents denoted by the blue and grey solid bars and new entries denoted by the green-bordered bars.

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, first across all innovative drugs and then for cancer drugs specifically.

Prices and Quantities Table 1 summarizes the negotiation outcomes for all innovative drugs. 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%.

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), using the regression method in Callaway and Sant'Anna (2021). The program led to a 50% reduction in retail prices and a 350% increase in quantity.[12] The price response is immediate — retail prices adjust to the negotiated price within one quarter, while the 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. We present two robustness checks. Appendix Figure A2 plots the treatment effects by cohort (negotiation year). Appendix Figure A4 limits the regression sample to all successfully negotiated drugs and identify the treatment effect of successful negotiation using a Two-Way Fixed Effects (TWFE) regression that leverages the staggered timing of negotiation across drugs for identification. The results are qualitatively similar to those in Figure 3.[13]

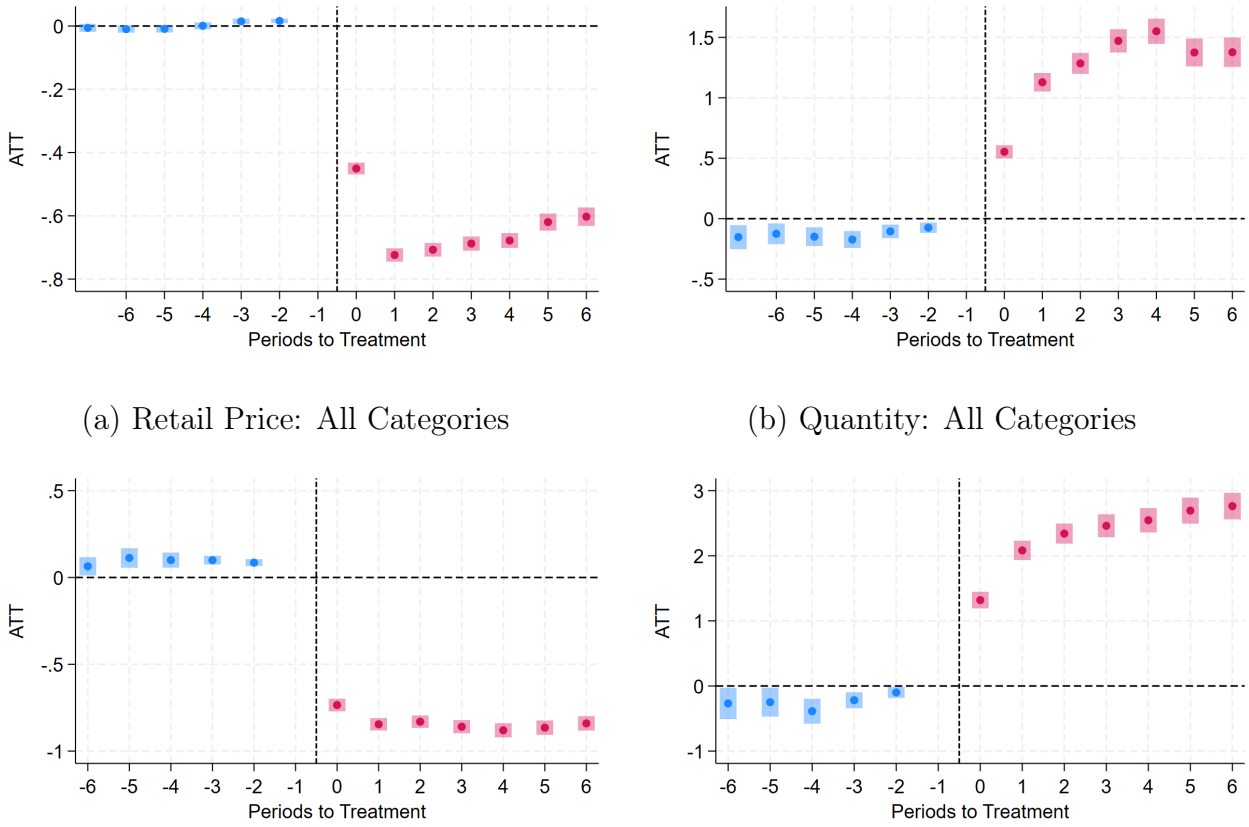
Panels (c) and (d) of Figure 3 present the event study estimates of the treatment effects for successfully negotiated cancer drugs. The control group consists of innovative anti-cancer drugs that are eligible for negotiation but have either not yet been included or have never been included in the formulary. Given the greater potential for competition (business stealing)

[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.

[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.

across drugs, these estimates are likely to underestimate the price response and overestimate the quantity response. The results align with, but 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.

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



(a) Retail Price: All Categories

(b) Quantity: All Categories

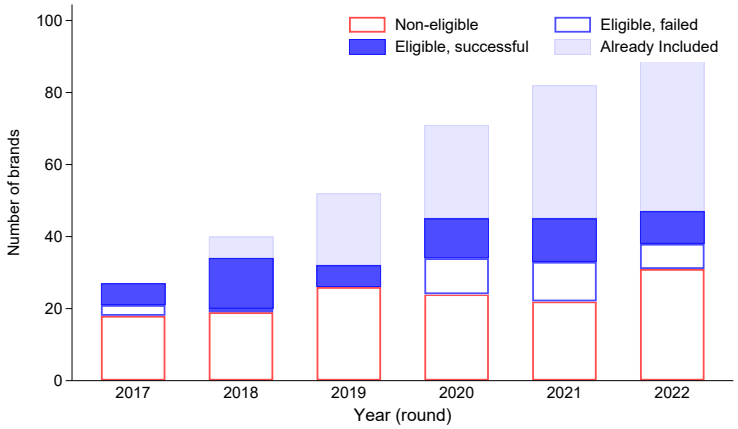
(c) Retail Price: Anti-cancer Drugs

(d) Quantity: Anti-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.

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 anti-cancer drugs, with

Figure 4: Summary of Negotiations with Cancer Drugs



Note: This figure presents the negotiation statuses 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)	0.023***						0.012*
	(0.007)						(0.007)
$\mathbb{1}$(1st negot. of an indication)		0.225*					0.238**
		(0.117)					(0.115)
#Indications			-0.094**				-0.122**
			(0.047)				(0.049)
International firm				0.008			-0.072
				(0.098)			(0.083)
#Year since entry					-0.057		-0.060
					(0.046)		(0.044)
log(sales$_{-1}$)						0.087***	0.081***
						(0.015)	(0.016)
Constant	0.406***	0.471***	0.626***	0.523***	0.620***	0.527***	0.676***
	(0.060)	(0.054)	(0.068)	(0.076)	(0.088)	(0.042)	(0.102)
R^2	0.084	0.034	0.037	0.000	0.014	0.245	0.369
Independent Variable Mean	5.20	0.21	1.05	0.60	1.62	-0.00	

Note: This table presents how the outcome of 97 observed negotiations depends on different features of the product. 58 of the negotiations result in a success. Years since entry denotes how long the drug has been sold on the Chinese market at the negotiation time. Δ Expected longevity (month) provides estimated improvement in overall survival from Phase III trial registered in China. Indications denotes the number of approved indications of the drug, and $\mathbb{1}$(First neg of an indication) takes the value of 1 if the drug has an indication that has not been covered by any other insured drugs. log(sales$_{-1}$) denotes the sales in the quarter before the negotiation.

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 longevity play a significant role — each additional month of survival benefit increases a drug's likelihood of NRDL inclusion by 1.5 to 2.3 percentage points. Second, negotiations are significantly more likely to succeed if the drug is the first to be negotiated for a given indication (i.e., a specific cancer target), aligning with the higher success rates observed in the early years of the NRDL reform. Third, higher lagged sales are positively correlated with negotiation success, suggesting that market demand and perceived quality influence outcomes. Finally, neither the drug company's origin (domestic vs. international) nor the number of years since its entry into the Chinese market appears to significantly impact negotiation results.

3 Model

We now present a model of China's anti-cancer drug market that formulates how key market primitives, such as demand, cost, 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 product j in market m, defined as

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

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

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 product 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), which exogenously shifts the retail price and out-of-pocket price; (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). These assumptions are supported by the institutional features of the NRDL Reform, wherein each group of experts designated by the government is responsible for negotiating 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. Typically, negotiation breakdowns would result in the product being excluded from the market entirely. 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 would bear 100% of the retail price, compared to the 20%-40% 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 estimation procedure accommodates multi-product firms. With a slight abuse of notation, we use j to denote the firm producing the drug. Specifically, 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 insurance network $\mathcal{G}$ is:

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

Firm j's payoff with a failed negotiation is the profit achieved from selling the drug in the retail market a la Bertrand-Nash competition:

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

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

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 inverse-income weighted consumer surplus following the public finance literature (Saez, 2002; Hendren, 2020). 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 spending:

$$V(p_j; \mathbf{p_{-j}}, \mathcal{G}) = CS(p_j; \mathbf{p_{-j}}, \mathcal{G}) - \beta TC(p_j; \mathbf{p_{-j}}, \mathcal{G}),$$

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:

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

where MS_m is the market size (number of patients diagnosed with cancer) in province m and $\text{Welfare}_{im} = \mathbb{E} \max_j u_{ijm}$ denotes the ex-ante utility of patient i in market m from having different medication choices. Patient utility u_{ijm} is defined in Equation (1). Government spending, TC, consists of expenditure on all drugs covered by the NRDL formulary:

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

The government's gains from covering drug j at the negotiated price p_j are $\Delta V(p_j; \mathbf{p_{-j}}, \mathcal{G}) = \Delta CS(p_j; \mathbf{p_{-j}}, \mathcal{G}) - \beta \Delta TC(p_j; \mathbf{p_{-j}}, \mathcal{G})$.[15]

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):

$$\begin{aligned} V(p_j; \mathbf{p_{-j}}, \mathcal{G}) &= \int_i \frac{\text{income}_i^{-\nu}}{\int_i \text{income}_i^{-\nu} d_i} CS_i(p_j; \mathbf{p_{-j}}, \mathcal{G}) di - \beta TC \\ &= \frac{1}{H} \int_i \text{income}_i^{-\nu} CS_i(p_j; \mathbf{p_{-j}}, \mathcal{G}) di - \beta TC \end{aligned} \tag{2}$$

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 $H = \int_i \text{income}_i^{-\nu} d_i$ 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 gov-

[15] 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. Understanding the dynamic incentives is beyond the scope of this paper.

ernment'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 collapse, 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 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:

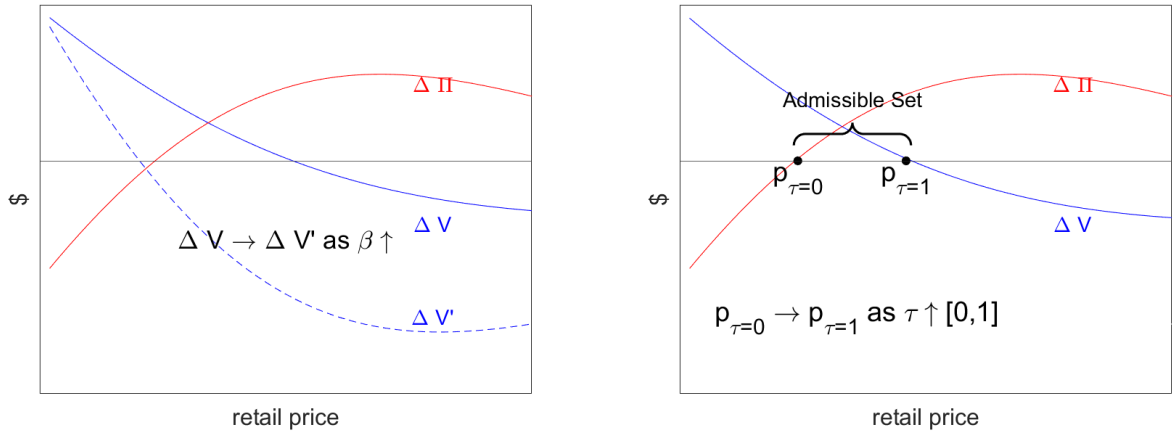
$$p_j = \arg\max_{p_j} \left(\Delta \pi_j\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right)\right)^{\tau_j} \left(\Delta V\left(p_j; \mathbf{p_{-j}}, \mathcal{G}\right)\right)^{1-\tau_j},$$

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

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

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

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. Firm's gains from trade is $\Delta\Pi$ in red, and the government's gains from trade is $\Delta V(\beta)$ in blue. 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 ($\Delta V'$). When β is low, there exists a set of retail prices that result in positive gains from trades for both parties: $\{p : \Delta V > 0 \text{ and } \Delta\Pi > 0\}$. However, when β is high enough, the admissible set is empty, leading to negotiation failures. Panel (b) plots changes in the negotiated price when firm's bargaining power τ increases. If the firm holds all the bargaining power, the negotiated price aligns with the upper bound of the admissible set that maximizes the firm's surplus. Conversely, if the government wields all the bargaining power, the negotiated price is at the lower bound of the admissible set that maximizes the government's surplus.

(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).

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.[16] 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 β follows a log-exponential 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 successful 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:

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

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

[16] 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.

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.

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

Table 3: Demand Estimates

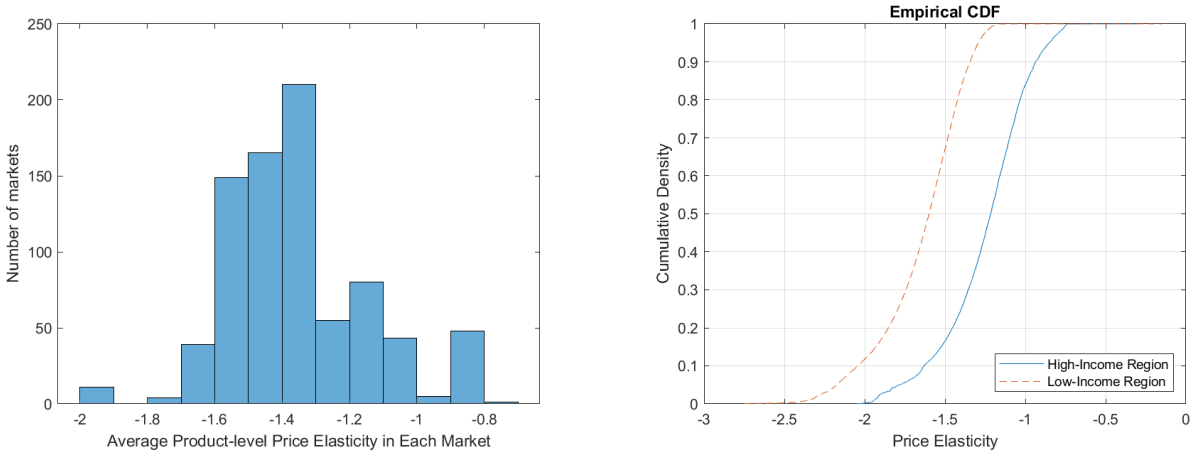
	OLS	IV	IV+RC		
	(1)	(2)	(3)	(4)	(5)
log(OOP)	-0.716	-1.211	-10.542	-9.783	-9.482
	(0.009)	(0.022)	(0.654)	(0.640)	(0.711)
log(OOP) × log(income)			0.865	0.795	0.692
			(0.060)	(0.059)	(0.059)
log(OOP) × ν_r					0.605
					(0.236)
Indication					
Lung cancer	0.531	0.264	0.224	0.227	0.159
	(0.056)	(0.058)	(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.

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. The standard deviation of the random component is estimated at 0.6, though with a large standard error, reflecting the limited variation in our instrument (the number of rival products across markets).

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 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.

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 anti-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.

The bottom panel of the table indicates that the average bargaining power of firms, τ, is roughly 0.6, with the difference in bargaining power between foreign multinationals and domestic firms being small and imprecisely measured. At $\tau = 0.6$, firms hold more bargaining 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.

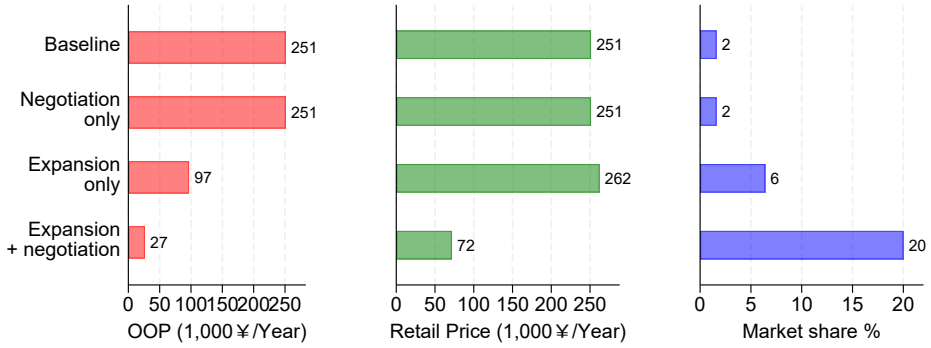
During our study period (2017–2023), 57 drugs were included in the NRDL formulary. The analyses here take each drug's negotiation status as given. We revisit the issue of bargaining failure in Section 5, where we examine alternative policy designs. We conduct simulations using the second quarter of 2023 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 anti-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 were sold exclusively in the retail 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 anti-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.

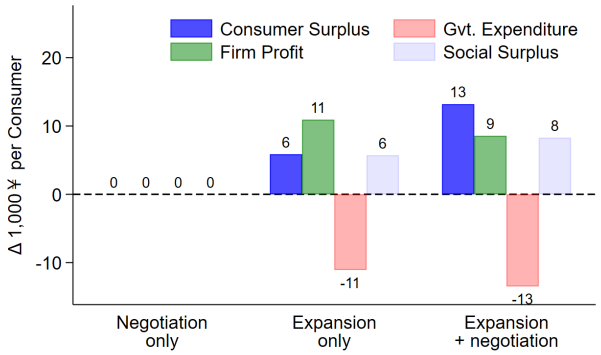
Changes in Prices and Quantity The top row of Figure 7(a) reports baseline price and quantity estimates.[17] Absent the NRDL Reform, both OOP and the retail price for an annual dosage would average about ¥251,000 per year (equivalent to $35,900), with the focal

[17] See Appendix Table A2 for numbers.

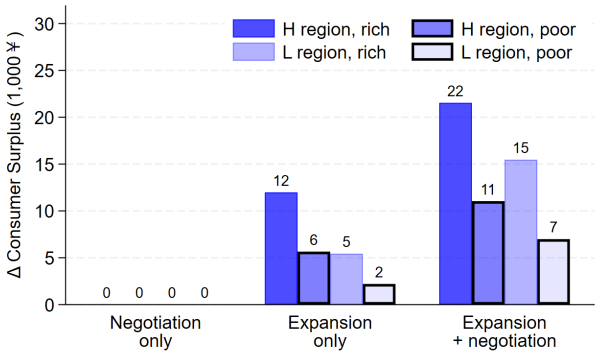
Figure 7: NRDL Reform—Decomposition Results



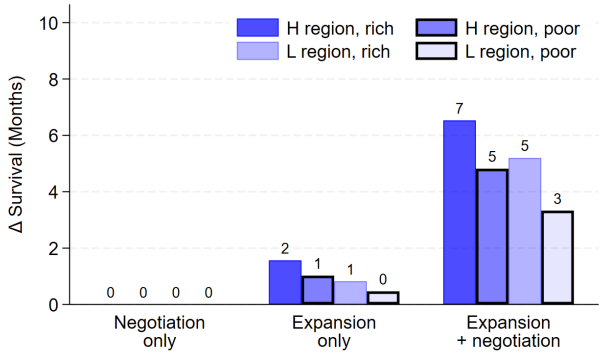
(a) Price and Market Share



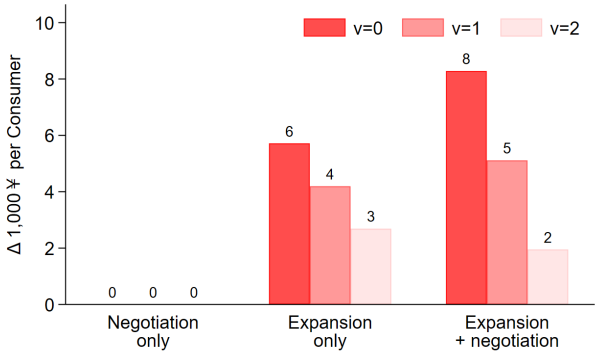
(b) Welfare Breakdown



(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.

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 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 performance of the observed NRDL Reform design to several feasible alternative designs. We use these comparisons to shed light on how policy choices impact the firms' and governments' gains from trade and, in turn, the welfare effects of drug market reforms.

In each of these simulations, we discuss both extensive margin and intensive margin effects.

Regarding the extensive margin, each of the policy alternatives we consider can alter the range of prices that would be mutually acceptable to the firm and government, and thereby increase or decrease the number of successful negotiations. Regarding the intensive margin, the simulated policies also alter the government's and firm's surplus; this, in turn, changes negotiated prices, realized quantities, and welfare conditional on negotiation success.

In the simulations in this Section, we allow the government to negotiate over the 13 drugs in the 2023Q4 market that failed the negotiations in the data. Because these drugs failed the negotiations, we cannot recover their $\boldsymbol{\beta}$s from the negotiated prices. Rather, we observe the lower bound $\underline{\boldsymbol{\beta}}$s, the thresholds at which each negotiation would have failed. In the counterfactual simulations in the main text, we set $\boldsymbol{\beta} = \underline{\boldsymbol{\beta}}$ for these drugs, implying that even a minor increase in the gains from trade on either side would make these failed negotiation succeed. In the Appendix, we make the extreme alternative assumption that these 13 failed negotiations always fail (effectively setting $\boldsymbol{\beta} = \boldsymbol{\infty}$). Because one drug's negotiation success or failure may in general affect the gains from trade of other negotiations, there may be multiplicity concerns in the counterfactual equilibrium. We impose the equilibrium selection rule that the more popular drugs (measured by quantity sold) move first.

5.1 Market Access Negotiation

In Section 4.3, we noted that negotiation for NRDL formulary inclusion alone has no effect; negotiation must be paired with insurance expansion in order to induce firms to participate. In this Section, we consider strengthening the government's leverage by modeling a "market access" negotiation, in which the government negotiates with firms over drug entry. That is, in this negotiation regime, a failed negotiation blocks the drug from being sold in the Chinese market entirely. This is termed the "Canadian regime" in Dubois et al. (2022).

For these simulations, we consider two scenarios: with or without insurance expansion. First, consider negotiation over market access without insurance expansion. In contrast to the ineffective "Negotiation alone" scenario presented in Section 4.3, the government does have leverage in this negotiation. Let $\mathcal{D}^{ma,ni}$ denote the set of innovative drugs in the Chinese market; the superscript ma reflects that this is a "market access" negotiation and ni reflects that there is "no insurance." The formulary of innovative drugs covered by insurance is trivially an empty set because there is no insurance coverage ($\mathcal{G}^{ma,ni} = \varnothing$). Let the vector of negotiated prices be $\mathbf{p}^{ma,ni}$.

Given that negotiation failure implies that product j is excluded from the market, the firm's gains from trade at price $p_j^{ma,ni}$ and network $\mathcal{D}^{ma,ni}$ will equal: $\Delta\pi_j(\mathbf{p}^{ma,ni}; \mathcal{D}^{ma,ni}) \equiv$

$\pi_j(p_j^{ma,ni}; \mathbf{p}_{-j}^{ma,ni}, \mathcal{D}^{ma,ni}) - 0$.

In the absence of insurance expansion, government expenditures are zero regardless of negotiation outcomes. The government's objective is then to maximize consumer surplus. Therefore we can write down the government's gains from trade as:

$$\Delta V_j^{ma,ni}\left(\mathbf{p}^{ma,ni}; \mathcal{D}^{ma,ni}\right) \equiv CS\left(p_j^{ma,ni}; \mathbf{p}_{-j}^{ma,ni}, \mathcal{D}^{ma,ni}\right) - CS\left(\infty; \mathbf{p}_{-j}^{ma,ni}, \mathcal{D}^{ma,ni} \setminus \{j\}\right).$$

In this negotiation, the Nash-in-Nash first-order condition is

$$\sum_m \frac{\partial q_{jm}}{\partial p_j^{ma,ni}}\left(p_j^{ma,ni} - mc_j\right) = -\left(1 - \frac{1-\tau}{\tau}\frac{\Delta \pi_j^{ma,ni}}{\Delta V_j^{ma,ni}}\right)\left(\sum_m q_{jm}\right), \ \forall j \in \mathcal{D}^{ma,ni}.$$

Second, consider the market access negotiation *with* insurance expansion. The government includes the drug in the NRDL with coinsurance if the negotiation is successful, but denies market access if the negotiation fails. As a result, the set of drugs in the market $\mathcal{D}^{ma,wi}$ is equivalent to the set of drugs covered by insurance $\mathcal{G}^{ma,wi}$. The firm's gains from trade at price $p_j^{ma,wi}$ and network $\mathcal{G}^{ma,wi}$ will equal: $\Delta\pi_j(\mathbf{p}^{ma,wi}; \mathcal{G}^{ma,wi}) \equiv \pi_j(p_j^{ma,wi}; \mathbf{p}_{-j}^{ma,wi}, \mathcal{G}^{ma,wi}) - 0$. The government's objective is to maximize consumer surplus minus expenditure given coinsurance. Therefore, we can write down the government's gains from trade as:

$$\begin{aligned}\Delta V_j^{ma,wi}\left(\mathbf{p}^{ma,wi}; \mathcal{G}^{ma,wi}\right) \ &\equiv \ CS\left(p_j^{ma,wi}; \mathbf{p}_{-j}^{ma,wi}, \mathcal{G}^{ma,wi}\right) - CS\left(\infty; \mathbf{p}_{-j}^{ma,wi}, \mathcal{G}^{ma,wi} \setminus \{j\}\right) \\ &- \ \beta\left(TC(p_j^{ma,wi}; \mathbf{p_{-j}}^{ma,wi}, \mathcal{G}^{ma,wi}) - TC(\infty; \mathbf{p_{-j}}^{ma,wi}, \mathcal{G}^{ma,wi} \setminus \{j\})\right).\end{aligned}$$

In this negotiation, the Nash-in-Nash first-order condition is

$$\sum_m \left(p_j^{ma,wi} - mc_{jm}\right)\frac{\partial q_{jm}}{\partial p_j} = -\sum_m \frac{q_{jm}}{\text{Coins}_m} + \left(\frac{1-\tau_j}{\tau_j} \times \frac{\Delta \pi_j^{ma,wi}}{\Delta V_j^{ma,wi}}\frac{d\Delta V_j^{ma,wi}}{dp_j^{ma,wi}}\right), \ \forall j \in \mathcal{G}^{ma,wi}.$$

The results are shown in Figure 8, with detailed calculations in Appendix Table A3. Figure 8(a) presents simulated prices and quantities for the "Baseline" Bertrand-Nash scenario without negotiation or insurance, then for the alternative "Market access negotiation" regime without insurance expansion, then for the "Expansion+market access negotiation" regime with insurance, and finally, for comparison with our original results, the "Expansion+formulary access negotiation" regime (i.e., the combined NRDL Reform). The Baseline and "Expansion+formulary access negotiation" results differ from those shown previously in Figure 7 because they cover all 70 innovative anticancer drugs, rather than just the 57 that were suc-

cessfully negotiated under the NRDL Reform.

First, consider the "Market access negotiation" regime. Due to the low marginal costs of innovative drugs relative to consumer surplus, the model will always predict a successful negotiation. Moreover, under the threat of market exclusion, the government can obtain a large price decrease. We estimate that the average drop in the (unweighted) retail price for all 70 eligible drugs is ¥134,000 (53%) per year. Because there is no accompanying insurance expansion in this regime, the benefits of negotiation pass through to patients and the OOP price decrease is also ¥133,000 per year. This results in a market expansion of 2.45 ppt, or 151% of baseline.

Next, consider the "Expansion+market access negotiation" regime. There are several key differences between this bargaining regime and the NRDL Reform's "Expansion+formulary access negotiation" regime. Negotiation for market access effectively increases the price under a failed negotiation from p^{BN} to ∞. This implies worse disagreement payoffs, and higher gains from trade, for both the government and firm. These upward shifts in gains from trade unambiguously widen the set of admissible prices: the firm is willing to accept any price above marginal cost, and the government is willing to pay any price such that consumer surplus exceeds government expenditure. Thus, switching from a formulary access negotiation to a market access negotiation increases the likelihood of negotiation success. Conditional on negotiation success, however, the effect of negotiation regime on price is ambiguous. Each of these effects is illustrated in Appendix Figure A5(a).

In Figure 8(a), we see that "Expansion+market access negotiation" reduces retail prices by ¥155,000 (62%), and OOP prices by ¥216,000 (86%). The resulting market expansion is 14 ppt (859%) for the average drug. These results, and the accompanying welfare and survival results in the remainder of Figure 8, are quite similar to the results achieved by the "Expansion+formulary access negotiation" regime. The "Expansion+market access negotiation" entails larger extensive margin effects, as it results in more successful negotiations. This can be seen in the larger quantities for "Expansion+market access negotiation" in panel (a). However, the "Expansion+formulary access negotiation" entails larger intensive margin effects, in that it results in larger price decreases for the 57 drugs that are included under both regimes.

These results imply that, while market access negotiation is (infinitely) more effective than formulary access negotiation when there is no benefit to being on-formulary (i.e., absent insurance expansion), negotiation for formulary access performs similarly to negotiation for market access when negotiation is accompanied by insurance expansion. These results are intuitive in light of the fact that the documented market expansion effects of insurance

expansion are so high in this setting. However, the role of extensive and intensive margin effects introduces some nuance. Social surplus as a function of consumer surplus is higher under the "Expansion+market access negotiation". However, "Expansion+formulary access negotiation" has a larger effect on overall survival, as the larger intensive margin effects under "Expansion+formulary access negotiation" outweigh the extensive margin effects under the "Expansion+market access negotiation" regime. This is because the additional included drugs under "Expansion+market access negotiation" are of lower quality.

5.2 Centralized vs. Decentralized Negotiation

The findings in Section 4.3 on the distributional effects of the NRDL Reform motivate two sets of counterfactuals that explicitly investigate the geographic variation and regressivity of the program. Focusing first on geography, we contrast the effects of centralized national bargaining (the status quo) with those of a counterfactual program that allows each province to negotiate its own prices. This analysis sheds light on recent policy debates and academic research regarding the costs 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).

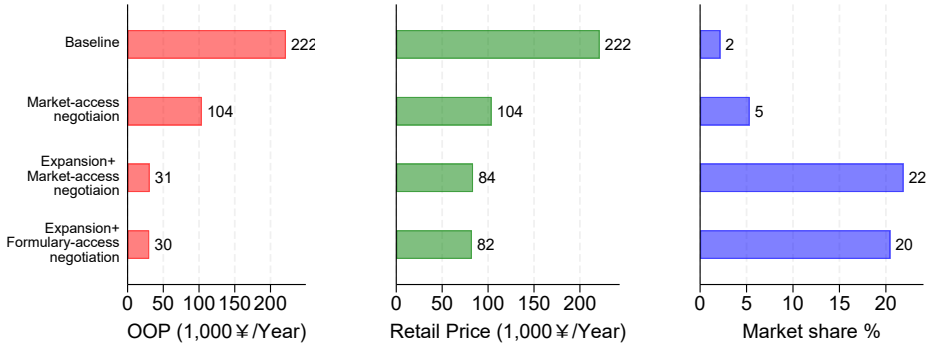
In the decentralized negotiation setting, we assume each provincial government manages their own formulary. Each provincial government negotiates with the innovative drug firms for formulary access, and the threat point is the exclusion from the provincial formulary. In these simulations, we set the local coinsurance rate equal to the national average level (0.37) across all provinces. Fixing the coinsurance rates across province allows us to isolate the distributional effects of centralized negotiation without having to microfound the provincial coinsurance rates, which might change under decentralization.

In all the results below, we compare the counterfactual negotiated outcome and prices under centralized and decentralized negotiations.[18] Figure 9 shows the distributional impacts of centralization across provinces.

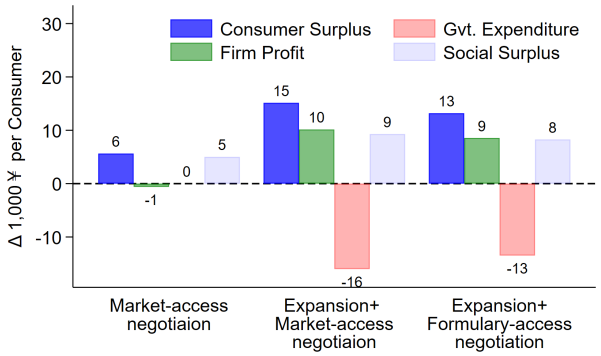
Aggregate Effects of Centralization The aggregate effects of centralization are shown in Appendix Table A3. There are important intensive and extensive margin effects. On the extensive margin, centralized bargaining would result in a 19% increase in negotiation success relative to decentralized bargaining. On the intensive margin, average retail (OOP) prices would be 60% (64%) lower and the innovative drug market share would be 5.6 ppt higher

[18] We also recalibrate the centralized negotiations because the coinsurance rate across provinces is set at the uniform level now.

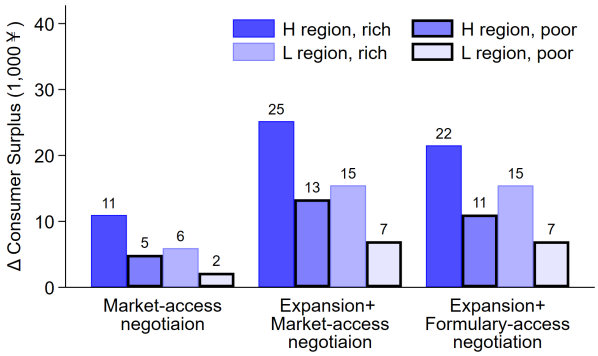
Figure 8: Counterfactual Results: Alternative Bargaining Formats ($\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$)



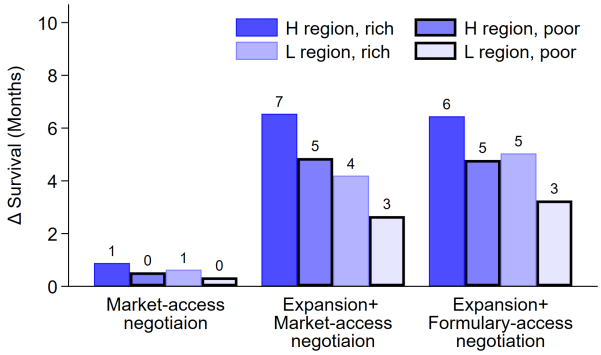
(a) Price and Market Share



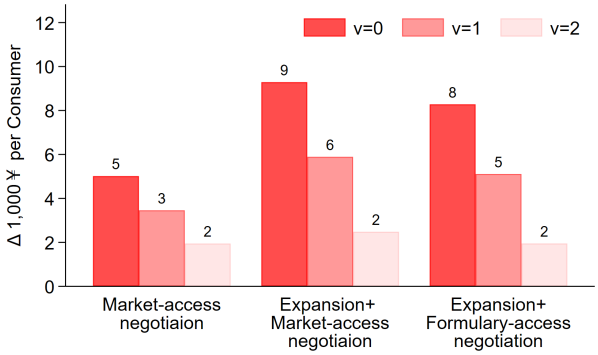
(b) Welfare Breakdown



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



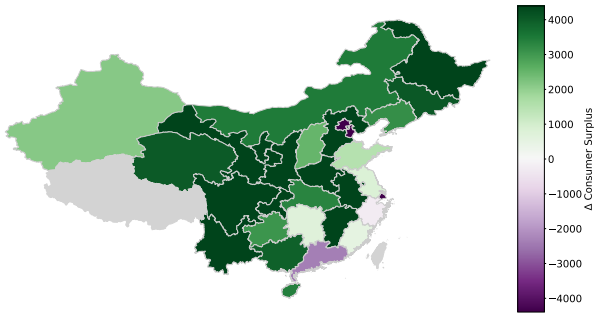
(d) Δ Survival across Income Groups



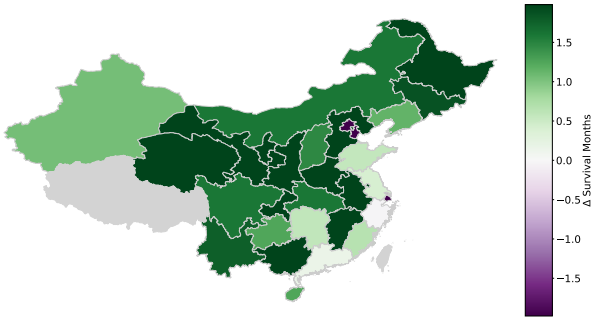
(e) Alternative Social Surplus Measures

Note: Alternative negotiation scenarios allow negotiation for 70 innovative anticancer 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. Panels (b)-(e) compare outcomes in each scenario to the "Baseline" scenario.

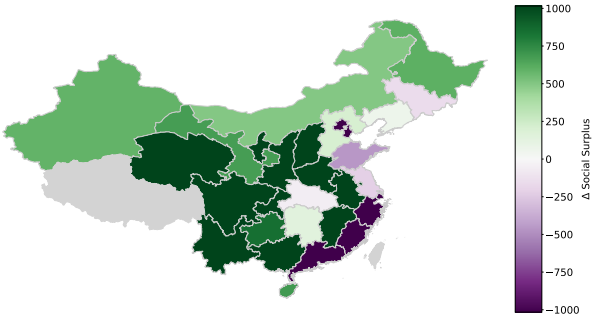
Figure 9: Effects of Centralized vs. Decentralized Negotiations



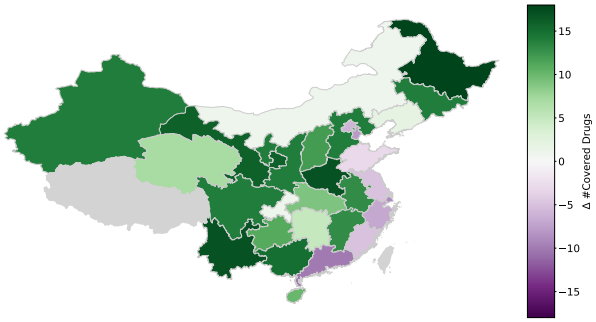
(a) Δ CS (¥/Patient)



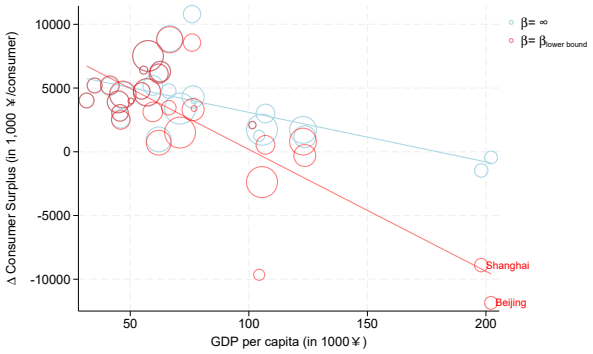
(b) Δ Survival Months (per Patient)



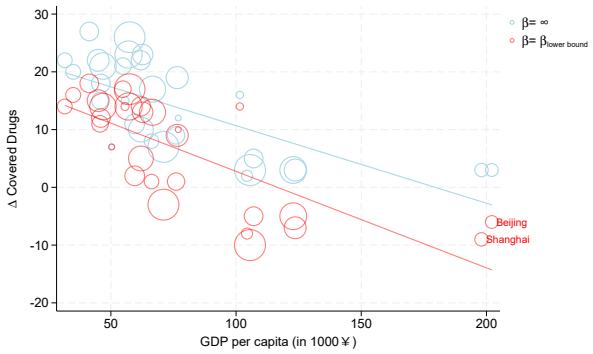
(c) Δ Social Surplus (¥/Patient)



(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 province population. The blue bubbles are based on simulations that set $\boldsymbol{\beta} = \boldsymbol{\infty}$ for failed negotiations, and the red bubbles and line are based on simulations that set $\boldsymbol{\beta} = \underline{\boldsymbol{\beta}}$ for failed negotiations.

under centralized negotiation relative to decentralized negotiation.

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 would be agreeable to firms, ΔV is also higher in high-income provinces, as the market expansion effects of formulary inclusion are insufficient to justify the government's expenditures in lower-income regions.[19] This is illustrated in Appendix Figure A5(b). As a result, decentralization results in fewer negotiation successes in low-income provinces and more negotiation successes in high-income provinces.

Welfare Effects of Centralization by Province Given the above discussion, the distributional impacts of centralized bargaining are intuitive. Centralization increases the leverage of poor provinces at the expense of rich provinces. Figure 9 panels (a) and (b) plot the differences in consumer surplus as measured by WTP and survival, between the centralized and decentralized negotiation regimes. Centralized negotiation benefits patients in most regions by either metric, especially regions in the center and west of China. To put a finer point on this, Figure 9(e) shows that there is a fairly steep income gradient in the consumer surplus effects of centralization.

Figure 9(c) plots the change in Social Surplus in each region under centralization, calculated as $CS + Profit - Expenditure$ in that region. Some richer coastal provinces have lower Social Surplus under centralization. These are typically the same provinces that have fewer covered drugs under centralization, as shown in Figure 9(d). Figure 9(f) shows the income gradient in drug coverage.

5.3 Efficiency vs. Equity in Coinsurance Design

As a last exercise, motivated by the efficiency and equity effects of the NRDL Reform's current regressive provincial coinsurance schedule, we explore the welfare effects of alternative income-based coinsurance schedules. For the sake of simplicity, we focus on a two-tier structure with different coinsurance rates for households with above- and below-median income. We simulate equilibrium prices, quantities, and surplus as we vary the coinsurance rates for high-income

[19] Interestingly, this is no longer the case at higher prices, where the larger demand in high-income provinces becomes prohibitively expensive.

and low-income patients between 20% and 50%, roughly the range observed in the data.[20] In order to allow for preferences over equity in the social planner's objective, we present multiple measures of surplus in which we weight a given household's consumer surplus by $income^{-\nu}$. The scenario with $\nu = 0$ reflects the preference weights of a utilitarian social planner, and higher values of ν reflect stronger preferences for equity and redistribution.

The effects of higher coinsurance on market 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. Coinsurance rates may also affect negotiation outcomes. To provide some intuition, Appendix Figure A5(c) presents an example where the government's gains from trade are higher under higher coinsurance. In such an example, higher coinsurance has an ambiguous effect on negotiation success, but results in higher retail and out-of-pocket prices for successfully negotiated drugs. Intuitively, conditional on negotiation success, higher coinsurance rates increase firms' gains from trade, thereby decreasing the government's bargaining leverage.

Importantly, the magnitude and direction of these effects depends upon *who* is subject to coinsurance increases. Appendix Figure A5(d) extends the example from Appendix Figure A5(c), presenting the firm's and government's gains from trade under four different income-based coinsurance schedules where high- and low-income patients face either 20% coinsurance or 50% coinsurance. In this example, an increase in either coinsurance rate decreases the firm's gains from trade $\Delta\Pi$, and increases the government's gains from trade ΔV. However, these effects are much larger for an increase in the high-income coinsurance rate than for an increase in the low-income coinsurance rate. In this particular parameterization, the most generous coinsurance schedule (0.2, 0.2) leads to negotiation failure. All other schedules increase the size of the admissible price set, benefiting patients on the extensive margin, and also increase the negotiated price, harming patients on the intensive margin. The most important takeaways are that the intensive and extensive effects of coinsurance schedules can be quite complex, and that outcomes are more sensitive to high-income than low-income coinsurance.

The effects of alternative coinsurance schedules in our empirical setting, across all 70 eligible drugs, are presented in Figure 10.[21] First, Figure 10(a) confirms that low coinsurance rates increase the rate of negotiation failure, particularly when they apply to high-income

[20] High-income patients are defined as those with incomes above the national median income.

[21] Figure A7 in the Appendix fixes the negotiation outcomes of all negotiations that failed under the NRDL Reform as implemented. The patterns described below hold under both (extremal) assumptions.

patients. For example, when coinsurance equals 20% across all patients, the model predicts that half of negotiations will fail.

Figure 10(b) shows the average retail price of innovative cancer drugs, weighted by market shares of each drug. The diagonal terms show that lowering coinsurance rates tends to decrease the average retail price despite more negotiation failures. This is because the government gains more leverage conditional on successful negotiations and can negotiate a better deal. However, this leverage effect dominates only when we lower high-income consumers' coinsurance rates (across rows). When we only lower low-income coinsurance rates (across columns), the gains in the government's leverage are more than offset by the increase in negotiation failures, which tends to increase negotiated retail prices. Intuitively, the market expansion effect from lowering coinsurance rates is much more substantial for high-income consumers, leading to higher gains from trade for firms and stronger leverage for the government.

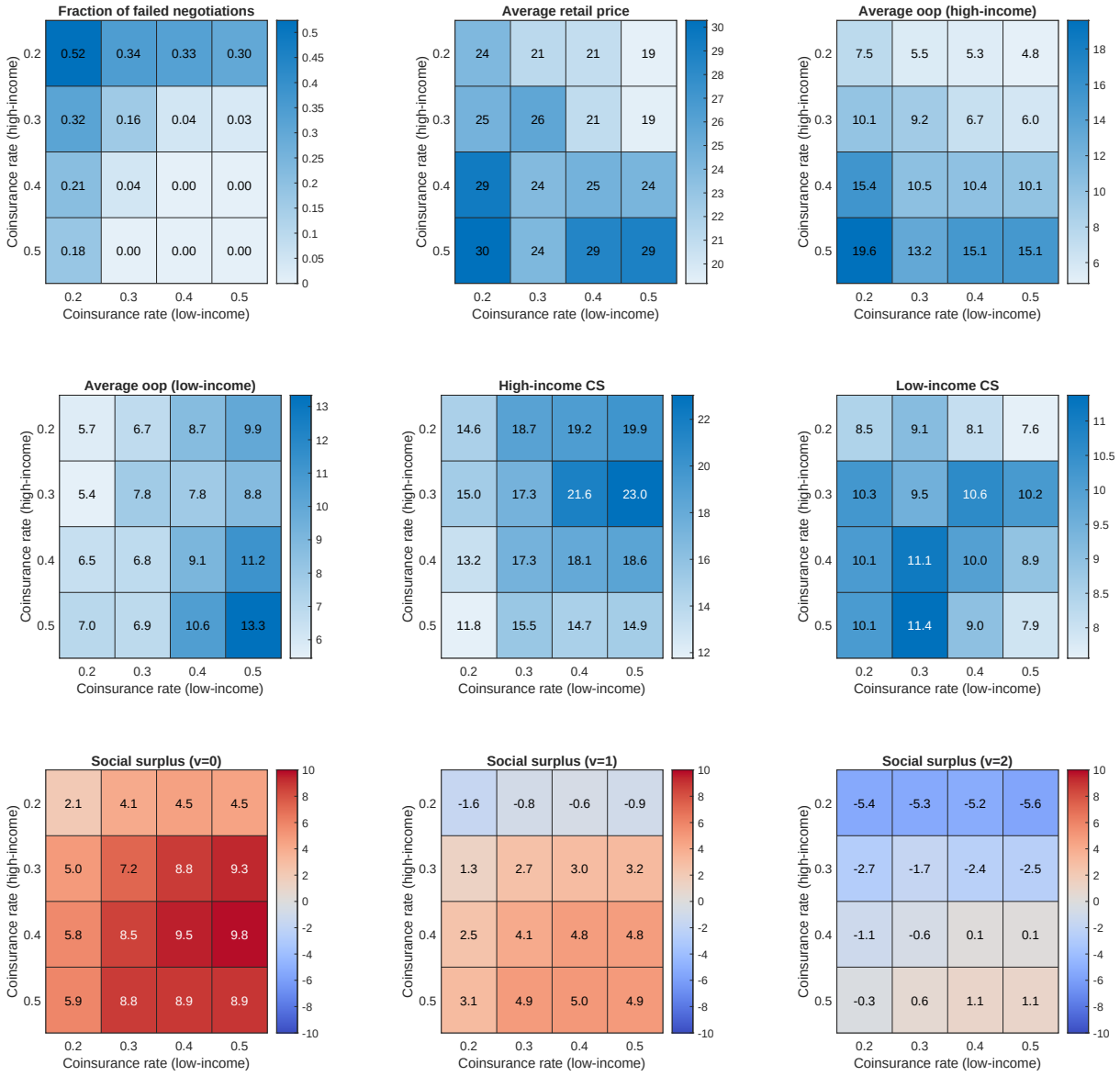
Figure 10(c) shows that the high-income patients' out-of-pocket price decreases as we decrease their own coinsurance rate (because of both the direct coinsurance effect and the leverage effect), but increases as we decrease the low-income coinsurance rate (through the negotiation failure channel). Hence, Figure 10(c) implies that the least-cost coinsurance schedule from the high-income patients' perspective would be the highly regressive (H 0.2, L 0.5).

In contrast, Figure 10(d) shows that low-income patients sometimes receive spillover benefits from decreases in high-income coinsurance. That is, low-income patients' out-of-pocket price decreases as we decrease their own coinsurance rate, and also at times decreases as we decrease the high-income coinsurance rate (due to the net effects of the leverage and negotiation failure channels). The least-cost coinsurance schedule from the low-income patients' perspective would be the slightly progressive (H 0.3, L 0.2).

Figure 10 panels (e) and (f) illustrate how coinsurance schedules impact high- and low-income patients' consumer surplus, given the effects of coinsurance on the extensive and intensive margins. The optimal coinsurance schedule from the high-income patients' perspective would be (H 0.3, L 0.5). The optimal coinsurance schedule from the low-income patients' perspective would be (H 0.5, L 0.3).

Lastly, Figure 10(g) shows that if the social planner's goal is to maximize Social Surplus, the optimal coinsurance rate is (H 0.4, L 0.5). This is quite close to the schedule observed in practice. However, a more Rawlsian social surplus goal ($\nu = 1, 2$), as shown in Figure 10 panels (h) and (i), would prefer a higher coinsurance rate for high-income patients. This is because lowering coinsurance rates allows marginal patients to adopt the innovative drug and, at the same time, transfers subsidies to inframarginal patients who would have purchased

Figure 10: 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 anticancer 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 70 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.

the drug anyway. A higher portion of the government spending on high-income consumers is pure transfers to high-income households who would have bought the innovative drug anyway. Rawlsian social surplus penalizes this type of expenditure. Hence, it is much harder to rationalize low coinsurance rates when equity concerns are high. Ultimately, an optimal coinsurance schedule must strike a balance between these competing factors—equitable benefit distribution and 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 optimal design of coinsurance schedules and 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.

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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 Solution Algorithm

This section describes our algorithm for solving negotiated prices in the counterfactual analysis. I apply an iterative Gauss-Seidel method to solve the new equilibrium prices. I 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. I 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: $j \in \mathcal{G}^*$.

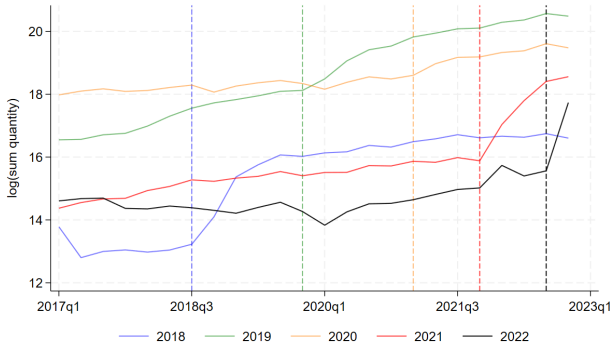
   (b) If the price of drug j is not negotiated, or if the negotiation fails:

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

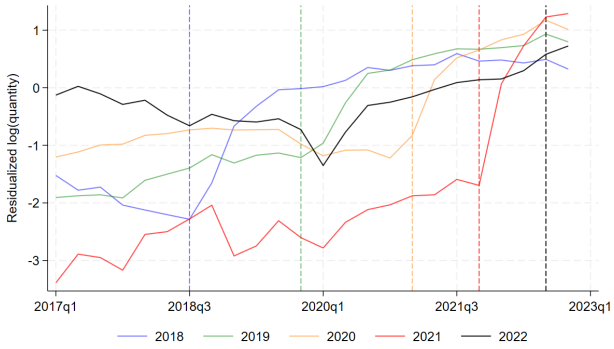
3. The algorithm converges to the equilibrium formulary and price if $|\mathbf{p}^* - \mathbf{p}^t| < \epsilon$ and $\mathcal{G}^t = \mathcal{G}^*$, otherwise reset $\mathbf{p}^{t+1} = \mathbf{p}^*$ and $\mathcal{G}^{t+1} = \mathcal{G}^*$ move to step 2.

C Appendix Figures

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



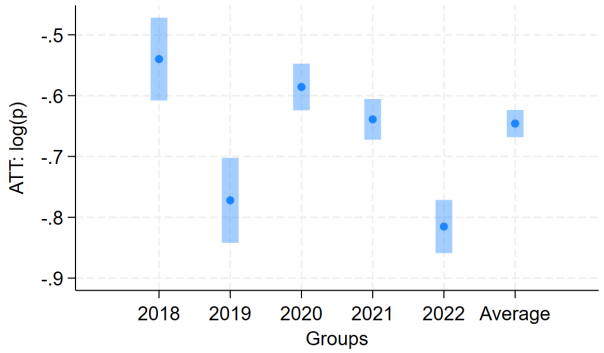
(a) Total quantity: raw data



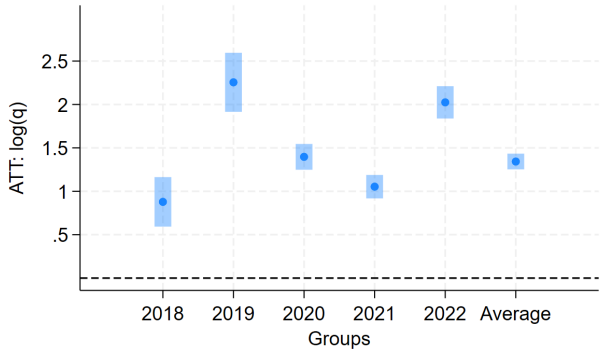
(b) Residualized Quantity: all categories

Note: This figure reports the total quantity sold for drug included in NRDL. Different colors indicate drugs included in different rounds of negotiations. Each dahsed lines denote 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 Centralized Negotiation Program on Price and Quantity



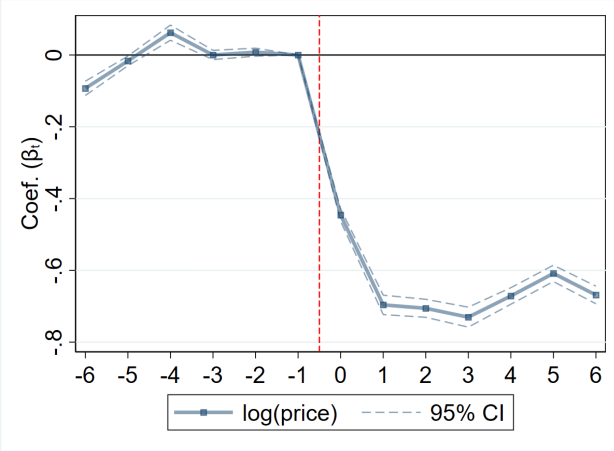
(a) Retail price: all categories



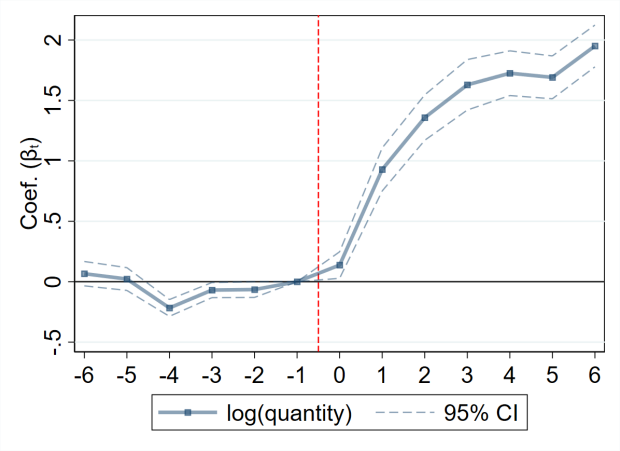
(b) Quantity: all categories

Note: This figure reports the effects by negotiation years of the centralized negotiation on the retail prices of quantities of successfully negotiated drugs. The horizontal axis denotes the relative quarters to the negotiation period. The vertical axis reports Callaway Sant'Anna's CSDID estimated dynamic treatment effects.

Figure A3: TWFE: Centralized Negotiation Program on Price and Quantity



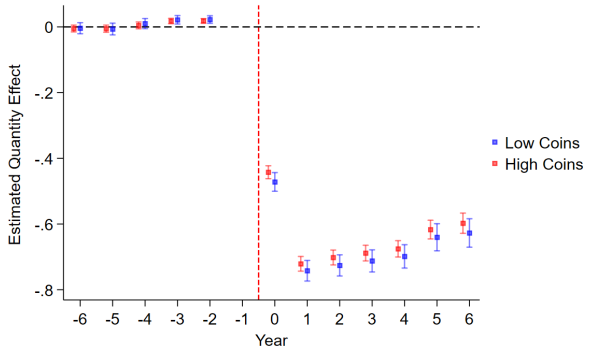
(a) Retail price: all categories



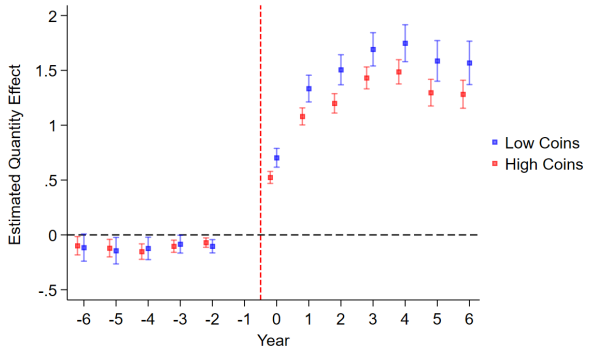
(b) Quantity: all categories

Note: This figure reports the event study (Two-way-fixed-effects) estimates of retail prices of quantities of successfully negotiated drugs. The specification is $y_{jt} = \sum_{\tau \neq -1} \beta_\tau \mathbb{1}(\chi_{te} = \tau) + \eta_j + \lambda_t + \epsilon_{jt}$, where χ_t is the period t relative to the formulary inclusion, and therefore, the omitted group $\tau = -1$ is one period before the formulary inclusion. The horizontal axis denotes the relative quarters to the negotiation period. The vertical axis reports the estimated β_τ.

Figure A4: CSDID: Centralized Negotiation Program on Price and Quantity



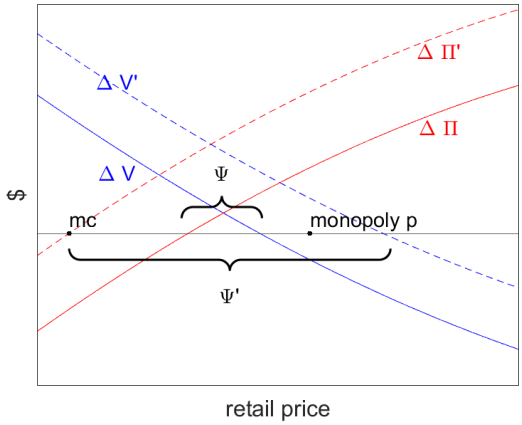
(a) Retail price: all categories



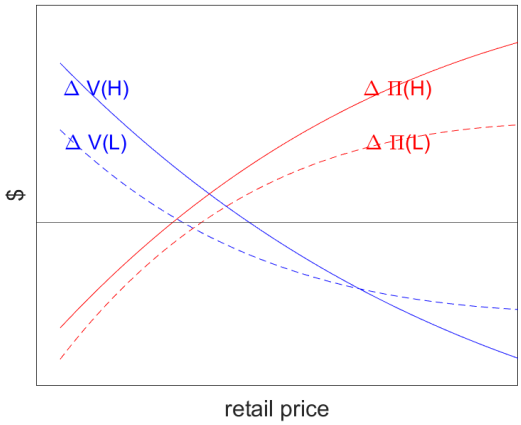
(b) Quantity: all categories

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.

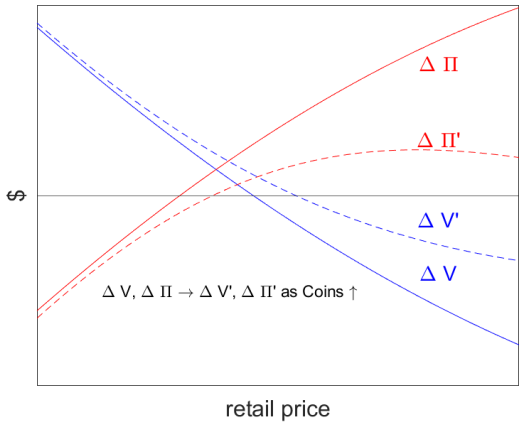
Figure A5: Effects of Policy on Gains from Trade



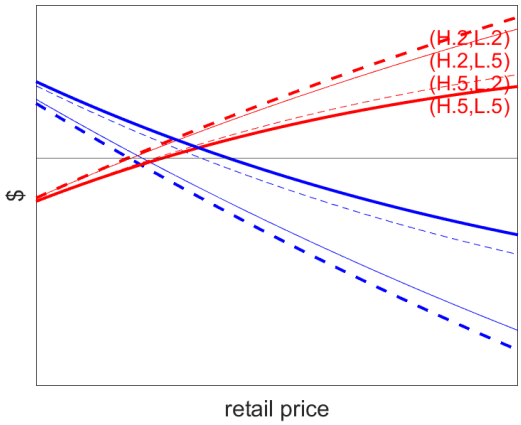
(a) Comparison with Market Access as Threat Point



(b) The Effect of Income



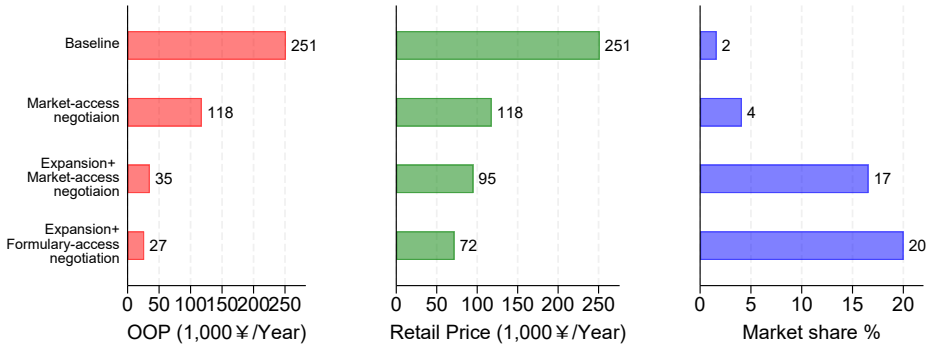
(c) The Effect of Coinsurance



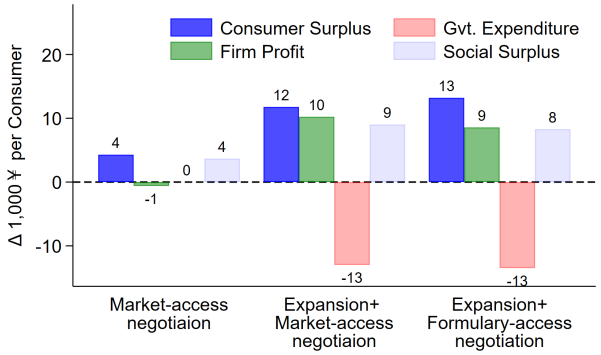
(d) The Effect of Income-specific Coinsurance

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 $(0.5, 0.5)$.

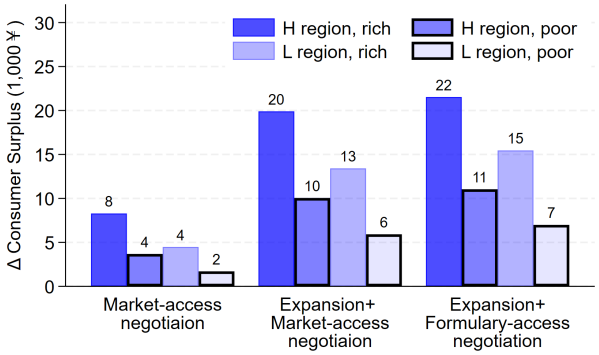
Figure A6: Counterfactual Results: Alternative Bargaining Formats ($\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$)



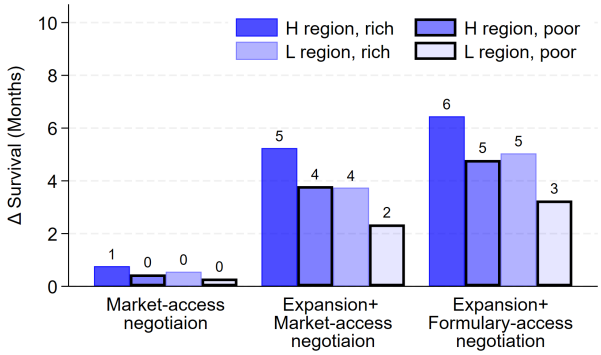
(a) Price and Market Share



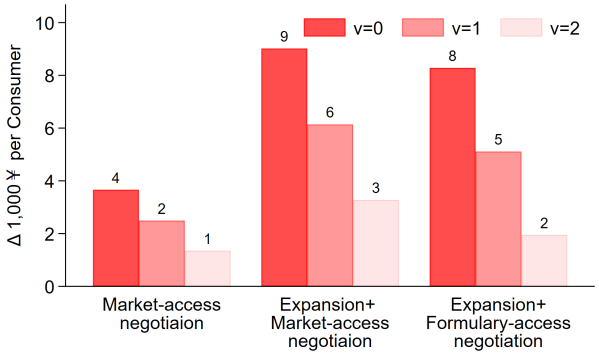
(b) Welfare Breakdown



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



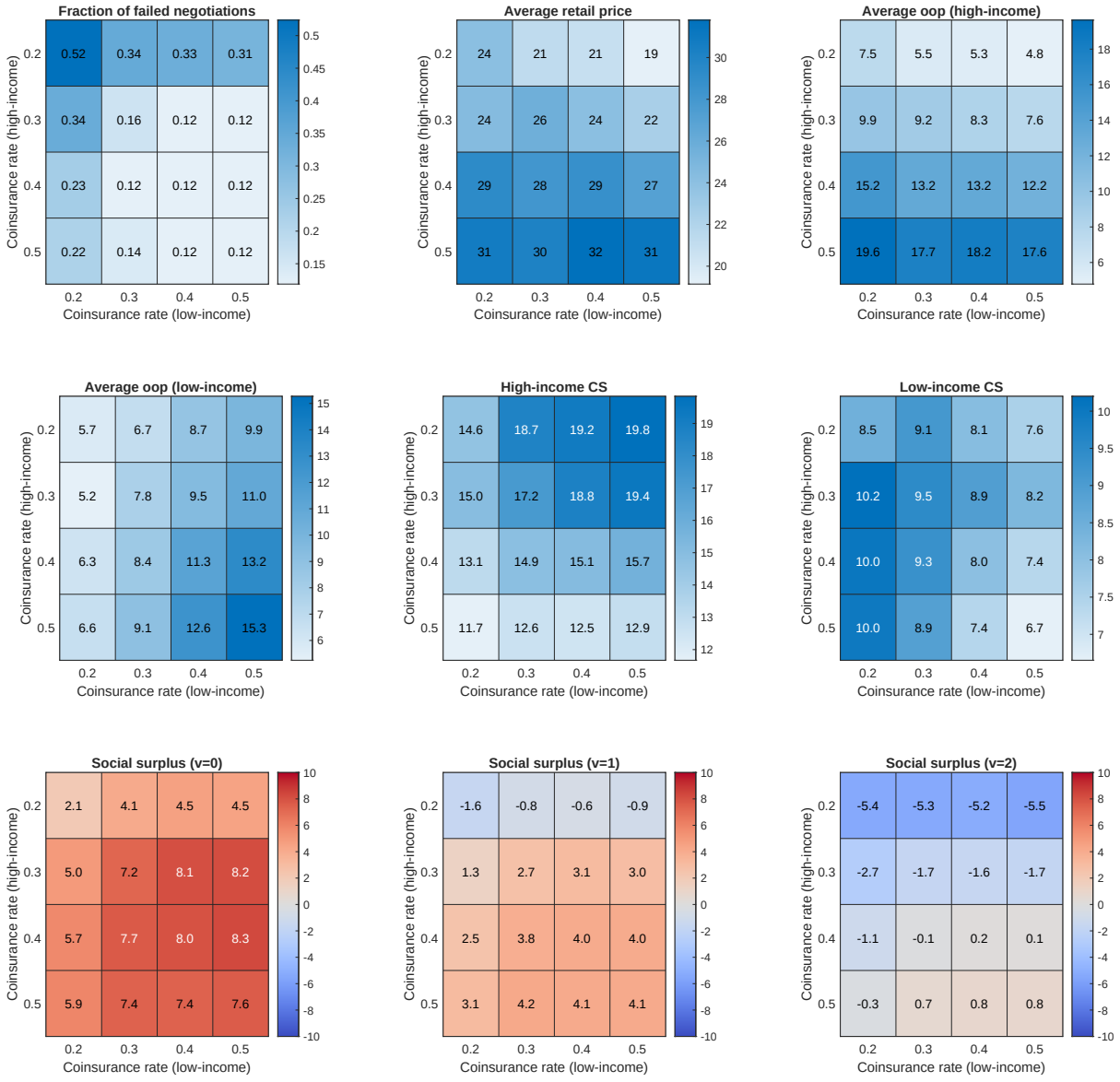
(d) Δ Survival across Income Groups



(e) Alternative Social Surplus Measures

Note: Alternative negotiation scenarios allow negotiation for 57 innovative anticancer 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 A7: 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 anticancer 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: Decomposition of the Effects of Expansion & Negotiation

		(1) Baseline	(2)	(3)	(4)	(5)
			+ Expansion Only		+ Expansion &Negotiation	
		y	Δy	Δy%	Δy	Δy%
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 anti-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 anti-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 Δy% 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 A3: 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 anticancer 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. "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 A4: 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 anticancer 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. "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.