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

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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.

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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 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.

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

[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.

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 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 af-

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

fordability 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] 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

[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.

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 59% at zero cost to the government. This expands the innovative drugs' share of the cancer drug market by 3 ppt. Nevertheless, we continue to find that insurance expansion reinforces the effects of negotiation. Market access negotiation *plus* insurance expansion reduces retail prices by 65% and OOP prices by 87%, expanding the negotiated drugs' share of the cancer drug market by 16 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, 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

[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.

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 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

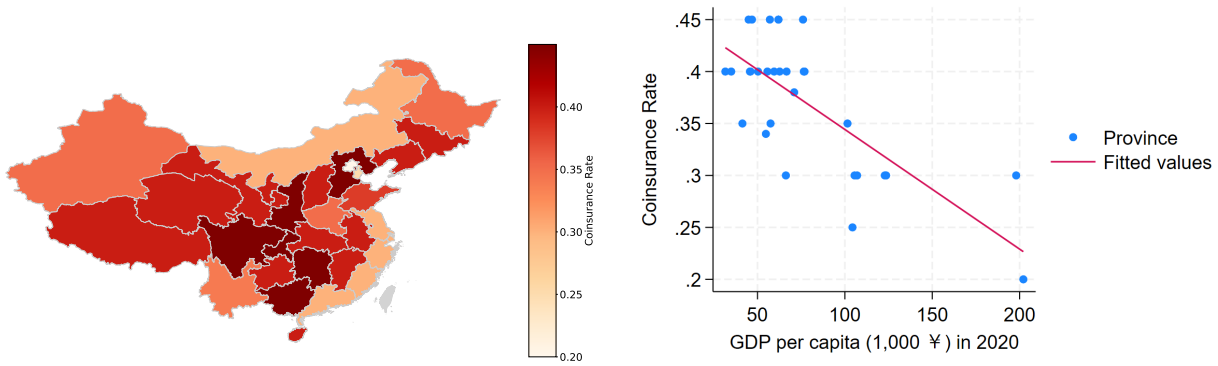
[6]Source: China Health Statistical Yearbook 2020, https://pmc.ncbi.nlm.nih.gov/articles/PMC9335887/. Besides prescription drugs, China's health insurance program also covers inpatient care, emergency care, preventive care (such as vaccines), and maternity benefits.

[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.

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.

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

[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.

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]

2.3 Descriptive Patterns

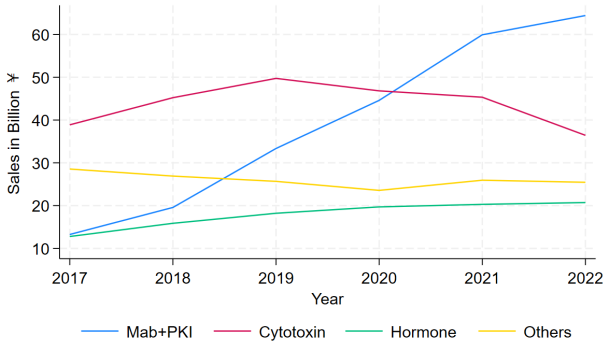
In this Section, we present event study evidence on what happens to prices and quantities after drugs are included in NRDL, first across all innovative drugs and then for cancer drugs specifically.

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

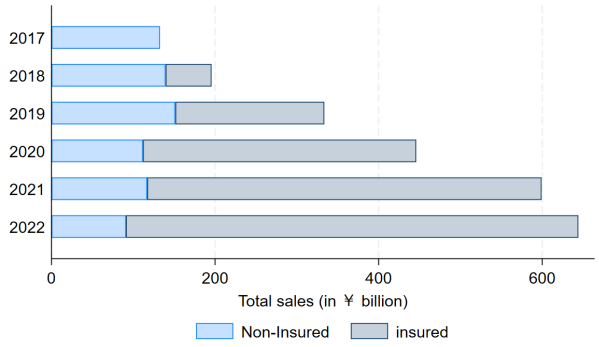
[10]There is a modest decline in prices for cytotoxin drugs, likely due to the 2019-20 introduction of a procurement auction program targeting generic drugs (Cao et al., 2022).

[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.

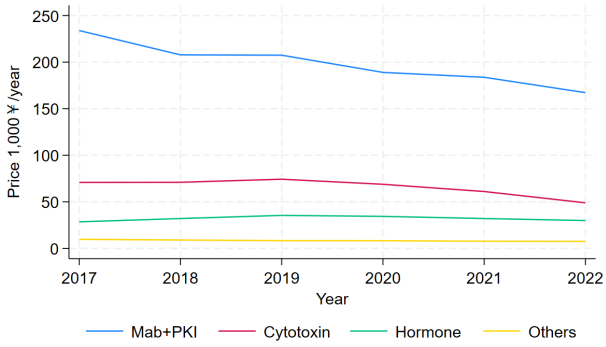
Figure 2: Overview of the Anti-Cancer Drug market



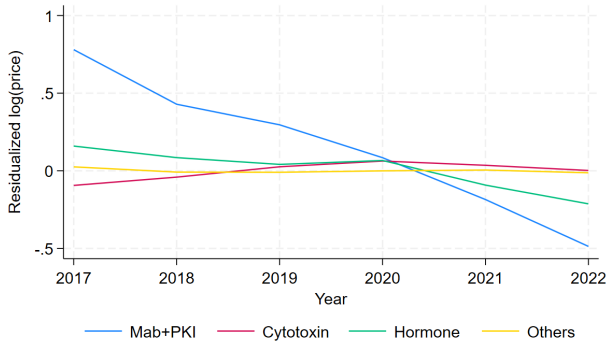
(a) Market Sales by Cancer Drug Category



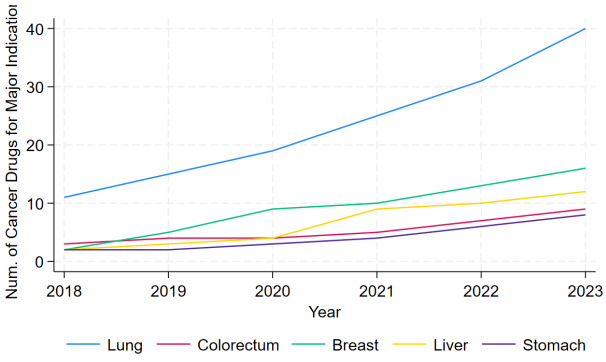
(b) Sales for Non/Insured Innovative Cancer Drugs



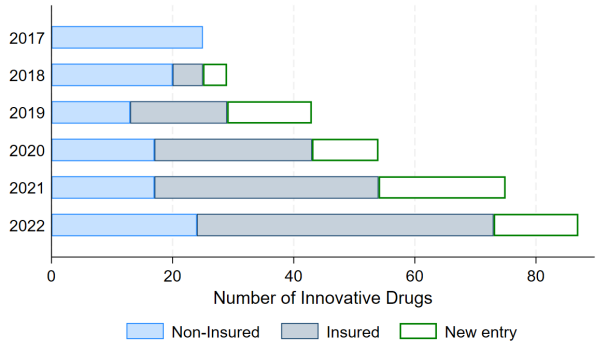
(c) Retail Price (raw)



(d) Residualized Price (log)



(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.

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 A1 plots the treatment effects by cohort (negotiation year). Appendix Figure A2 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]

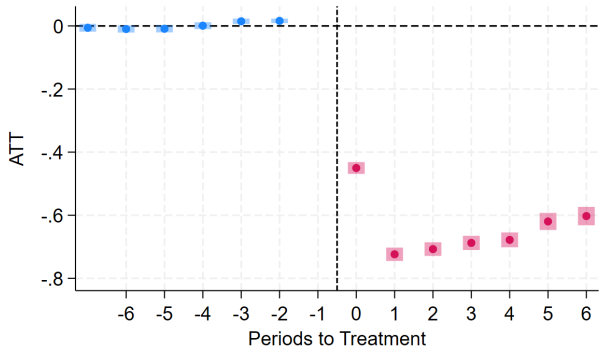
Panels (c) and (d) of Figure 3 present the event study estimates of the treatment effects for successfully negotiated cancer drugs. The control group consists of innovative anti-cancer drugs that are eligible for negotiation but have either not yet been included or have never been included in the formulary.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

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

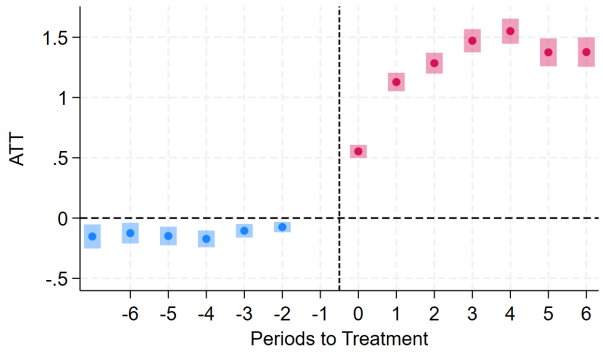
[12] A few innovative drug companies offer a "Patient Assistance Program" that provides discounts off the retail price to patients. We have adjusted the retail prices to reflect these discounts.

[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.

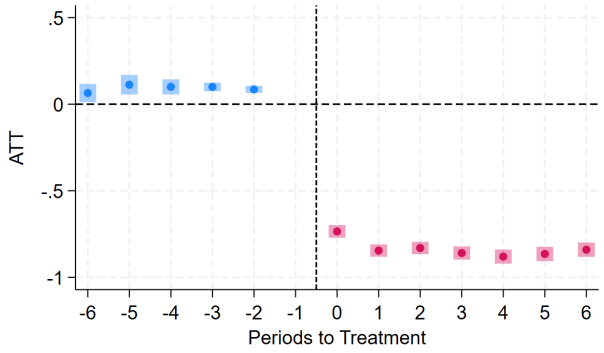
Figure 3: Effects of the NRDL Reform on Price and Quantity



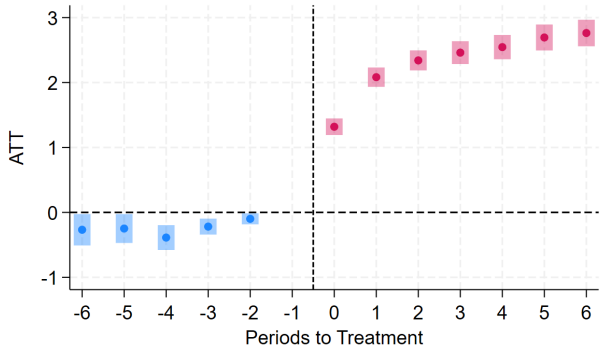
(a) Retail Price: All Categories



(b) Quantity: All Categories



(c) Retail Price: Anti-cancer Drugs



(d) Quantity: Anti-cancer Drugs

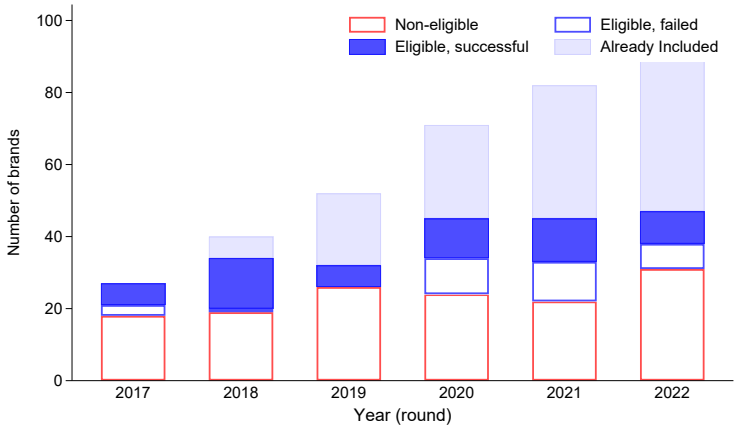
Note: This figure reports the effects of the NRDL Reform on the retail prices and quantities of successfully negotiated drugs. The horizontal axis denotes quarters relative to the negotiation period. The vertical axis reports estimated dynamic treatment effects using Callaway and Sant'Anna (2021)'s CSDID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

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 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

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

Figure 4: Summary of Negotiations with Cancer Drugs



Note: This figure presents the negotiation 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.

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

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

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 abute 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:

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

where MS_m is the market size (number of patients diagnosed with cancer) in province m and $\mathrm{Welfare}_{im} = \mathbb{E} \max_j u_{ijm}$ 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]

Negotiation A negotiation succeeds if the government and drug company find an *admissible* price such that gains from trade are positive for both parties. In this model, the central government's relative weight β on total expenditure, which we assume is a random variable from a given distribution $\beta \sim F_\beta$, serves several purposes. First, it is a parsimonious way to reflect the government's priorities on patient welfare vs. fiscal constraints. Second, the parameter helps rationalize negotiation failures observed in our data. As β increases, the government's focus on minimizing expenditure intensifies, exerting downward pressure on the drug prices deemed acceptable. If these prices fall below a threshold where the gains from trade for pharmaceutical companies turn negative, negotiations may 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

[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.

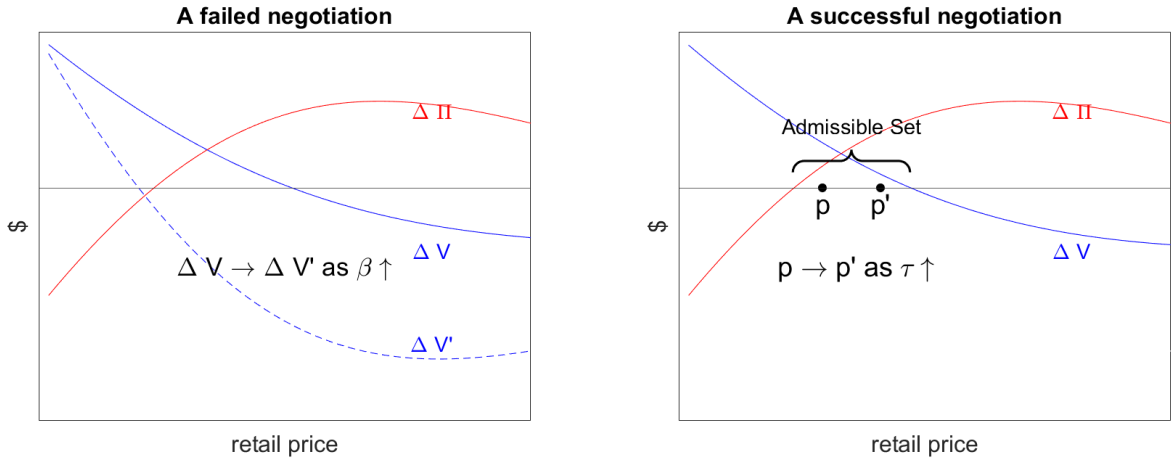
firm j's bargaining power τ_j:

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

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

$$\sum_m \underbrace{(p_j - mc_{jm})}_{\text{retail margin}} \frac{\partial q_{jm}}{\partial p_j} = -\sum_m \underbrace{\frac{q_{jm}}{\text{Coins}_m}}_{\text{expansion effect}} + \underbrace{\left(\frac{1-\tau_j}{\tau_j} \times \frac{\Delta\pi_j}{\Delta V_j}\frac{dV_j}{dp_j}\right)}_{\text{bargaining effect}}, \ \forall j \in \mathcal{G}. \tag{2}$$

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.

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. 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. 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

[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.

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 (2), the bargaining FOC. The equation is invertible with respect to β_j, leading to a closed-form solution of β as a function of negotiated price and bargaining parameter:

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

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

Step five: the joint log-likelihood function is:

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

We estimate the supply-side parameters via maximum likelihood.

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

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.

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

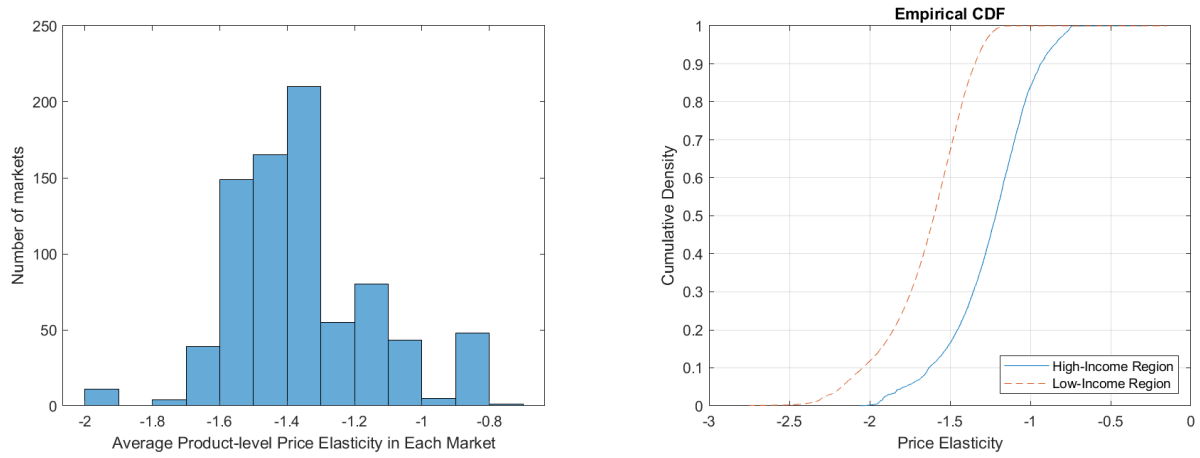
Figure 6a shows a histogram of the implied average product-level own-price elasticities across provinces, based on the demand estimates from Column (3) of Table 3. Figure 6b plots the cumulative distribution function of the estimated price elasticity for provinces with above-median incomes (blue line) 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.

4.2 Supply Estimates

Table 4 presents the estimates for β, the government's weight on drug insurance spending, and τ, the firm's bargaining power parameter. The first specification only estimates the average of the β distribution, while the second specification allows the average to depend on ΔOS, 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 β, we estimate that the government's weight on spending is lower for drugs

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.

with greater overall survival benefits. The θ parameters for the log-exponential distribution imply that β =0.78 for the average drug and β =1 for the median drug. That is, for the median drug, the government equally weights drug spending and consumer surplus, but the implied government budget constraint is relaxed for higher-quality drugs. This finding implies that the government prioritizes the inclusion of high-quality drugs in the NRDL formulary.

The bottom panel of the table indicates that the average bargaining power of firms, τ, is roughly 0.6, with the difference in bargaining power between foreign multinationals and domestic firms being small and imprecisely measured. This estimate indicates that firms generally have more bargaining power than the government, but that negotiated prices are significantly below Nash Bertrand levels in the private market.

As a robustness check, we allow the government to have preferences over equity, by reweighting the government value function using a Pareto weight for each patient: $w = \frac{income^{-\nu}}{H}$, where H is the patient's income, ν is a scalar parameter that represents the government's preference for redistribution, and H is the sum of $income^{-\nu}$ across all patients. We find that the estimates of θ_τ are robust across different νs, and that $\nu = 0$ delivers the best in-sample fit as measured by the likelihood, so we use $\nu = 0$ as our preferred specification in the remainder of the draft. However, we return to the issue of potential efficiency-equity tradeoffs involved in the NRDL Reform and various policy alternatives below.

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.

4.3 Decomposition of NRDL Reform effects

In this Section, we use simulations to explore the economic mechanisms driving the price, quantity, and welfare impacts of the NRDL Reforms, on average and across different geographies and income groups.

Each of our counterfactual scenarios considers the 2023Q2 anti-cancer drug market. The 57 drugs that were included in the NRDL formulary during our study period of 2017-2023 were negotiated on a staggered basis over time. There were 13 drugs that were negotiated but failed the negotiations and thus were not included in the NRDL formulary. We simulate outcomes in this Section allowing for counterfactual insurance and negotiation treatments for all eligible drugs in 2023. The resulting impacts of counterfactual scenarios on prices, quantities, and welfare are larger than they would have been in 2017, when a small subset of these drugs was eligible for negotiation. In our simulations, we also adjust the equilibrium prices of unsuccessful and ineligible innovative drugs, which were sold in the private market a la Nash-Bertrand, and quantities of all anti-cancer drugs.

Baseline Scenario All scenarios are compared to a baseline scenario where the NRDL Reform program did not exist—all successfully negotiated drugs are excluded from the formulary and sold in the private market at Nash-Bertrand prices. This is akin to the pre-reform world (before 2017), but includes new drugs that entered the Chinese market between 2017

and 2023.

Expansion-only In this counterfactual scenario, we assume the NHSA implements a policy in which the government covers the 57 successfully negotiated anti-cancer drugs on the NRDL formulary of the universal insurance program, implying that patients can access them at province-specific coinsurance rates. However, firms continue to set prices unilaterally a la Nash-Bertrand.

Negotiation-only In this counterfactual scenario, we assume the NHSA implements a policy to centrally negotiate prices of anti-cancer drugs. However, the government does not offer NRDL coverage for successfully negotiated drugs, and the firm can still sell on the private market when the negotiation fails. This counterfactual delivers the same results as the baseline counterfactual, since firms have no incentive to participate in negotiation.

We begin by decomposing the price and quantity impacts of the NRDL Reforms into those driven by the two key levers: insurance expansion and bargaining. Starting with the baseline world in which the focal 57 drugs are not on the formulary and are priced a la Bertrand-Nash, we first allow the Chinese government's NHSA to negotiate prices centrally with drug firms ("Negotiation only"), then we return to the Bertrand-Nash pricing world but add the focal 57 drugs to the NRDL formulary with universal insurance coverage ("Expansion only"), and finally we combine the two reforms as in the actual 2023 world ("Expansion+negotiation").

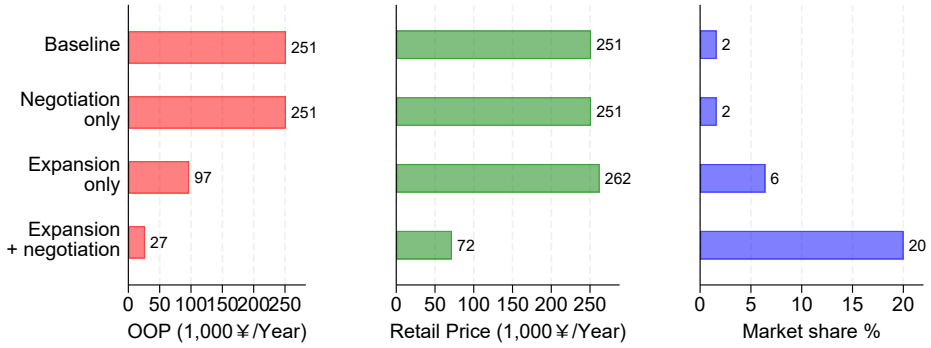
The baseline price and quantity results can be seen in the top row of Figure 7(a).[17] Absent the NRDL Reforms, both OOP and retail price would average about ¥251,000 per year (equivalent to about $35,000), and the focal innovative drug would have only a 2% quantity share of the cancer drug market.

The "Negotiation only" counterfactuals in the second row of Figure 7(a) are identical to the Baseline. This is because, without insurance expansion, the government has nothing to offer firms to induce them to participate in the negotiation. Without a promise of market expansion, firms will opt instead to sell their drugs in the private market at profit maximizing prices. In order to offer a more informative analysis of negotiation without expansion, we consider an alternative negotiation regime in Section 5.1 below in which firms must negotiate in order to have access to the Chinese drug market.

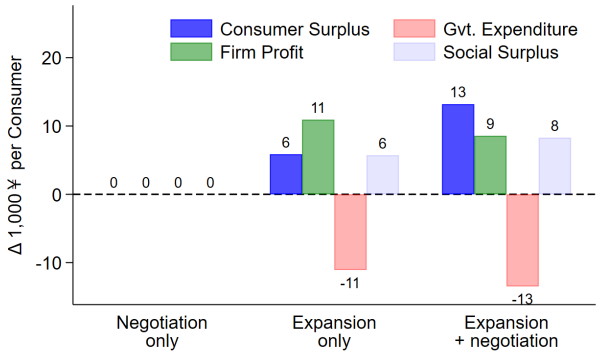
The "Expansion only" counterfactuals, presented in the third row of Figure 7(a), are more instructive. First, consider the price effects of providing insurance for the focal drugs, without

[17] See Appendix Table A2 for numbers.

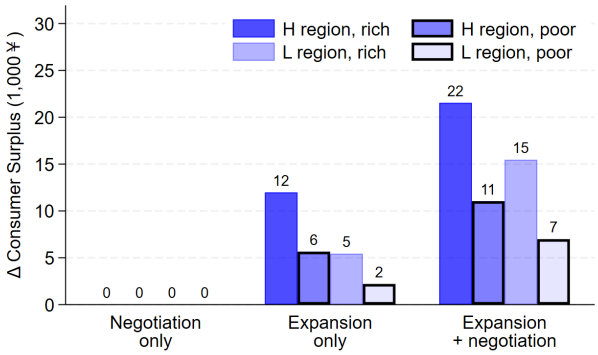
Figure 7: NRDL Reform—Decomposition Results



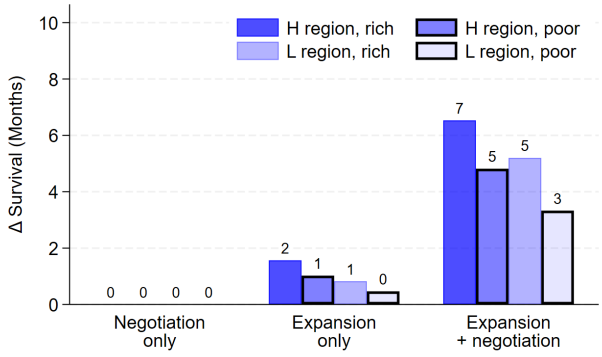
(a) Price and Market Share



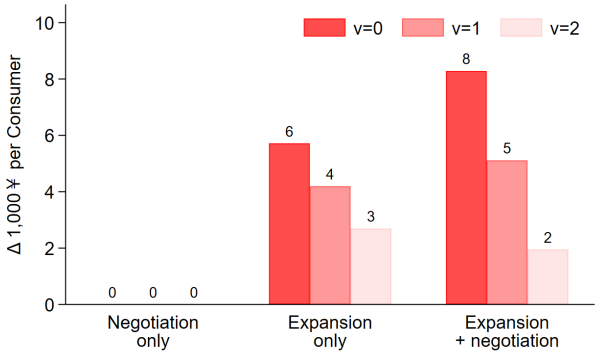
(b) Welfare Breakdown



(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.

negotiation. Adding insurance implies that, for a 100¥increase in retail price, patients pay only 20-50¥. This decreases patients' sensitivity to retail price, and firms' optimal prices increase to 262,000¥per year (4%). At the same time, patients' out-of-pocket prices decrease to 97,000¥per year (-61%) due to their insurance coverage. This substantial out-of-pocket price decrease leads to a large market expansion; the focal innovative drugs' share of the cancer drugs market increases to 6% (+200% relative to baseline).

The fourth row of Figure 7(a) shows the combined effect of the NRDL Reforms: "Expansion+negotiation." In contrast to "Expansion only," the combined reform decreases both OOP *and* retail prices, by 225,000¥per year (89%) and 182,000¥per year (72%), respectively. These larger price increases imply greater market expansions; the focal innovative drugs' total share of the cancer drug market increases by 18 ppt (+1,133% relative to baseline). This is similar to the 930% quantity expansion documented in the descriptive regression analyses in Section 2.3 above. However, the simulation results reveal that the combined effects of insurance expansion and negotiation are far more dramatic than those for insurance expansion alone, suggesting that negotiation complements insurance in this environment.

Welfare Figure 7(b) shows the impact of each simulation scenario on welfare relative to the Baseline of no NRDL Reforms. In order from left to right, each group of bars shows the change in consumer surplus, firm profit, government expenditures, and total surplus associated with moving from the Baseline to the scenario specified. To make clear that lower government expenditure is preferred, all else equal, the Figure multiplies government expenditure by -1. Consistent with this approach, Total Surplus = Consumer Surplus + Firm Profit − Government Expenditure.

Trivially, "Negotiation only" has no effect on welfare relative to Baseline. "Expansion only" increases consumer surplus by 6,000¥per patient and firm profit by 11,000¥per patient, but also increases government expenditure by 11,000¥per patient. The combined "Expansion+negotiation" reform increases consumer surplus by 13,000¥per patient, more than double the effect of "Expansion only" due to the far larger effect of the combined reform on OOP prices. The consumer surplus increase is equivalent to the increase in government expenditure, suggesting that the combined reform is far more successful at meeting the government's balanced objective. Firm profit increases by 9,000¥per patient in the combined reform, lower than "Expansion only" but far higher than Baseline.

These results indicate that negotiation alone has no impact on welfare, whereas insurance expansion alone induces an OOP price reduction and market expansion that benefit patients, as well as a large transfer from the government to firms. However, the two reform instruments

are complementary: the insurance expansion ensures broader access and makes the pie bigger, while negotiation shifts the split of the pie in favor of the government and patients. On balance, total surplus is highest under the combined reform, representing an increase of 8,000¥per patient relative to Baseline, compared to only ¥6,000 (5,000) for either expansion alone or negotiation alone.

An alternative method of valuing the welfare benefits of the market expansion under each reform scenario is to consider health outcomes. Based on the clinical evidence of drug effectiveness from the medical literature, the increased access to innovative drugs under the combined NRDL Reform would be expected to extend overall survival by 4.85 months per patient purchasing cancer drugs (1,372% relative to Baseline), a more than five-fold increase over the already-substantial survival benefits of insurance expansion alone (0.92 months, or 259% of Baseline).

Equity Considerations The aggregate welfare effects presented above mask substantial heterogeneity in impacts across patients in different parts of the income distribution. These distributional effects are shown in Figure 7(c). NRDL coinsurance is more generous for wealthy provinces, so a given reduction in retail prices leads to a larger reduction in out-of-pocket prices for patients in high-income provinces. Moreover, high-income households are less price sensitive and therefore more likely to purchase innovative drugs absent the NRDL Reform. These two factors imply that rich people living in high-income (low-coinsurance) regions have the highest dollarized welfare increases from the "Expansion only" and "Expansion+negotiation" policies (¥12,000 and 22,000, respectively). These surplus increases are far higher than those obtained by poor patients in low-income provinces (¥2,000 and ¥7,000, respectively).

A similar, though less extreme, pattern is observed when we measure patient benefits using survival increases, as shown in Figure 7(d). Rich households in high-income provinces still benefit most from the combined reform, followed by rich households in low-income provinces, then poor patients in high-income provinces, and lastly poor households in low-income provinces. But the gap is much smaller. Intuitively, survival is a quantity-based measure and therefore less sensitive to the differing levels of price-sensitivity between high-income and low-income patients.

Turning to social surplus, Figure 7(e) shows that both the "Expansion only" and "Expansion+negotiation" policies lead to increases in social surplus. However, both policies are regressive as implemented, and the ranking of the policies hinges on the social planner's preference for equity. When the social planner has a higher weight on equity ($\nu = 1$ or 2), the social surplus gain associated with each policy declines. The reason for this is that each

policy entails a higher government subsidy to high-income patients than to low-income patients, and a higher equity weight penalizes such transfers. If the social planner is utilitarian ($\nu = 0$) or has a moderate preference for equity ($\nu = 1$), then the efficiency benefits of "Expansion+negotiation" dominate and the combined reform is preferred. If the social planner has a stronger preference for equity ($\nu = 2$), then the flatter gradient in consumer surplus under "Expansion only" seen in Figure 7(c) is more desirable than the steep gradient under "Expansion+negotiation." Therefore, with sufficiently strong preferences for equity, "Expansion only" is preferred over "Expansion+negotiation."

5 Counterfactual Policy Simulations

In this Section, we compare performance of the observed NRDL Reform design to several feasible alternative designs.

5.1 Market Access Negotiation

In Section 4.3, we demonstrated that negotiation for NRDL formulary inclusion alone has no effect; negotiation must be paired with insurance expansion in order to have an effect on welfare. 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. The government can negotiate with the threat of market access *without* insurance expansion, so the formulary of covered innovative drugs is an empty set ($\mathcal{G}^{ma,ni} = \varnothing$), and suppose that the vector of negotiated prices is $\mathbf{p}^{ma,ni}$. 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 $\mathcal{G}^{ma,ni} = \varnothing$ will equal: $\Delta\pi_j(p_j^{ma,ni}; \varnothing) \equiv \pi_j(p_j^{ma,ni}; \mathbf{p}_{-j}^{ma,ni}, \varnothing) - 0$.

Given this change in firm gain from trade, the equilibrium prices and formularies will depend on whether the government expands insurance at the same time as it negotiates prices. First, consider the market access negotiation without insurance expansion. The government's objective is then to maximize consumer surplus. Government expenditure is not of concern because the government does not offer coinsurance for drugs. Therefore we can write down

the government's gains from trade as:

$$\Delta V_j^{ma,ni}\left(p_j^{ma,ni};\mathbf{p}_{-jt}^{ma,ni},\varnothing\right) \equiv CS_j\left(p_j^{ma,ni};\mathbf{p}_{-j}^{ma,ni},\varnothing\right) - CS_j\left(\infty;\mathbf{p}_{-j}^{ma,ni},\varnothing\right).$$

The Nash-in-Nash first-order condition implies,

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

Second, consider the market access negotiation *with* insurance expansion. The government can include the drug in NRDL if the negotiation is successful but deny market access if the negotiation fails. The government's objective is then to maximize consumer surplus minus expenditure. Therefore, we can write down the government's gains from trade as:

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

The Nash-in-Nash first-order condition implies,

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

The results are shown in Figure 8, with detailed calculations in Appendix Table A3. The Baseline results are identical to those shown previously in Figure 7. Figure 8(a) presents simulated prices and quantities for the alternative "Market access negotiation" regime without insurance expansion, then for the "Expansion+market access negotiation" regime, and finally, for comparison with our original results, the "Expansion+formulary access negotiation" regime (i.e., the combined NRDL Reform studied in Figure 7).

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 the 57 drugs included in the NRDL formulary is ¥148,000 (59%) 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 ¥148,000 per year. This results in a market expansion of 3 ppt, or 191% 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 shifts the price under a failed negotiation from p^{BN} to ∞. This implies higher gains from trade for both the government and firms. From the government's perspective, keeping the product in the market generates more consumer surplus, though at the cost of greater insurance subsidies. On the firm side, having the product in the market generates positive profit and is therefore strictly better than exclusion. Keeping the bargaining power fixed, whether the resulting negotiated price is higher with negotiation for market access or with negotiation for formulary access is ambiguous, and therefore an empirical question.

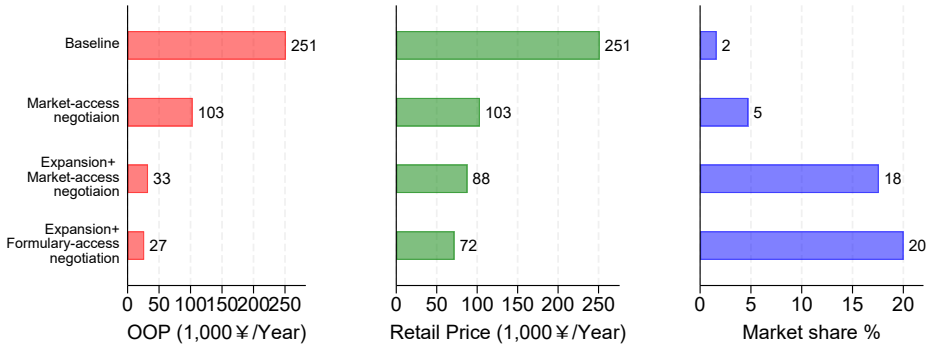
In Figure 8(a), we see that "Expansion+market access negotiation" reduces retail prices by ¥163,000 (65%), and OOP prices by ¥219,000 (87%). The resulting market expansion is 16 ppt (983%). These results, and the accompanying welfare and survival results in the remainder of Figure 8, are nearly identical to the results achieved by the "Expansion+formulary access negotiation" regime. 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.

5.2 Centralized vs. Decentralized Negotiation

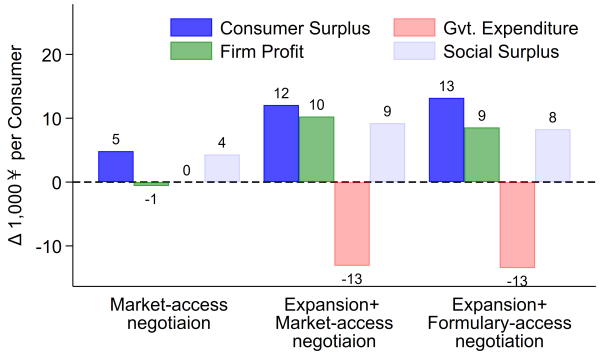
The findings in Section 4.3 on the distributional effects of the NRDL Reform motivate two sets of counterfactuals that explicitly investigate the geographic variation and regressivity of the program. Focusing first on geography, we contrast the effects of centralized national bargaining (the status quo) 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. We keep β and τ the same as we estimated (from observed centralized negotiation). We set the local coinsurance rate equal to the national average level (0.37) across all provinces.

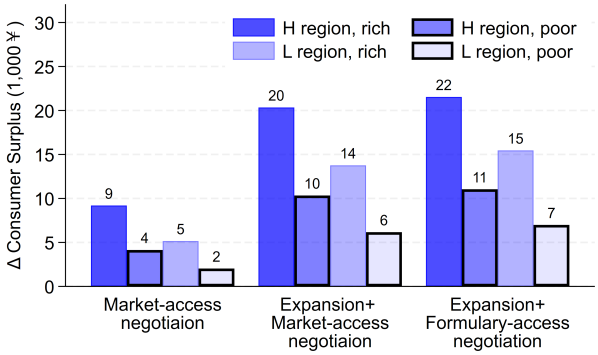
Figure 8: Counterfactual Results: Alternative Bargaining Formats



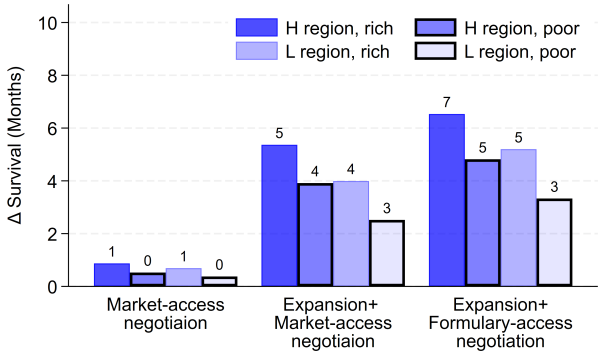
(a) Price and Market Share



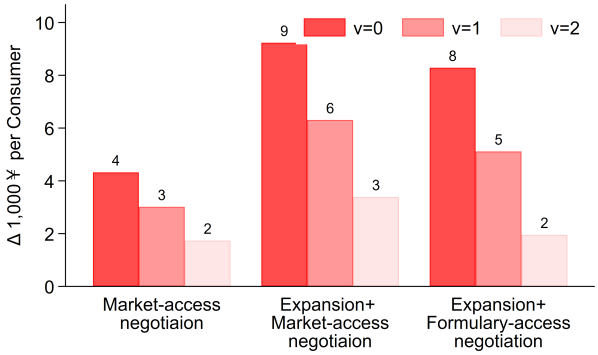
(b) Welfare Breakdown



(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. "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.

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.

There are 13 drugs in the 2023Q4 market that failed the (centralized) negotiations in the data. In the decentralized counterfactual, we allow the provincial government to negotiate with these drugs' firms. 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 main text, we assume these 13 failed negotiations always fail in the decentralized negotiations (effectively setting $\boldsymbol{\beta} = \infty$). Alternatively, as a robustness check, 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.[18]

In all the results below, we compare the counterfactual negotiated outcome and prices under centralized and decentralized negotiations.[19] Figure 9 shows the distributional impacts of centralization across provinces.

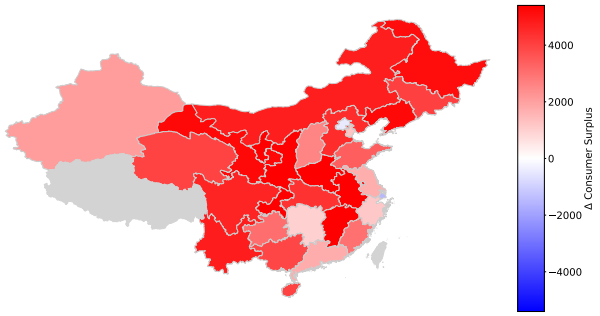
Aggregate Effects of Centralization We first document the aggregate effects on both the extensive and intensive margins as shown in Table A3. On the extensive margin, centralized bargaining would result in a 19% decrease in negotiation failures relative to decentralized bargaining. This is because, under decentralized bargaining, the market expansion effects of formulary inclusion are insufficient to justify the government's expenses in lower-income regions. On the intensive margin, our model predicts that average retail (OOP) prices would be 60% (64%) lower and the innovative drug market share would be 5.6 pt higher under centralized province-level negotiation relative to decentralized negotiation.

What makes centralized negotiation different? Theoretically, if all provinces are homogeneous, then decentralized negotiation would lead to the same price and quantity outcomes. However, because of regional heterogeneity in WTP, decentralized negotiation leads to many negotiation failures in lower-income provinces, where the consumer surplus gains associated with negotiation success are insufficient to justify the increased government costs. This can be seen in Figure 9 panels (d) and (f). As a result, pooling provincial budgets softens the

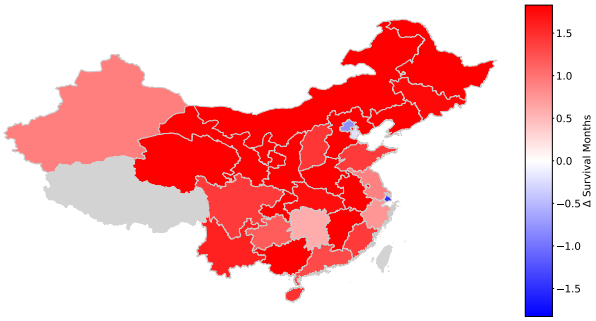
[18] Because one drug's negotiation success or failure may affect gains from trade of other negotiations, and change another negotiation's success, there may be multiplicity concerns in the counterfactual equilibrium. We impose the equilibrium selection rule that the more popular drugs (measured by quantity sold) move first.

[19] We also recalibrate the centralized negotiations because the coinsurance rate across provinces is set at the uniform level now. As a robustness check, we compare the centralized at uniform level and the centralized at the observed coinsurance level. We confirm that the aggregate welfare does not change, but not surprisingly, the provinces with lower coinsurance rates would benefit more compared to uniform rates.

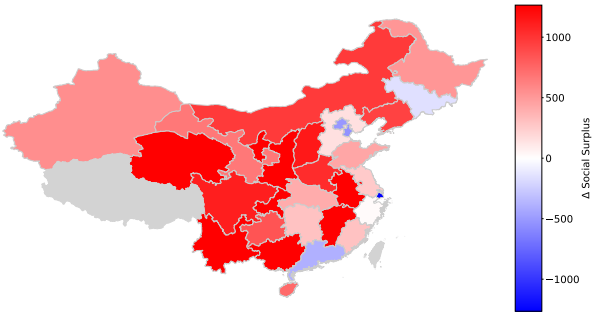
Figure 9: Effects of Centralized vs. Decentralized Negotiations



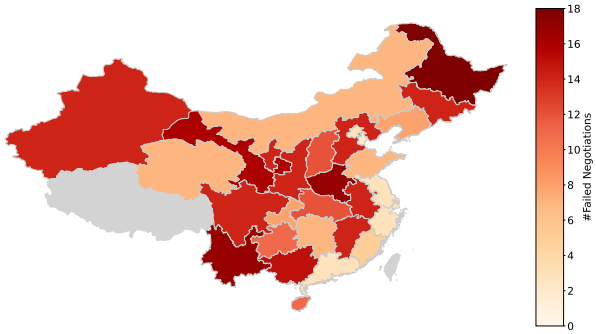
(a) Δ CS (¥/Patient)



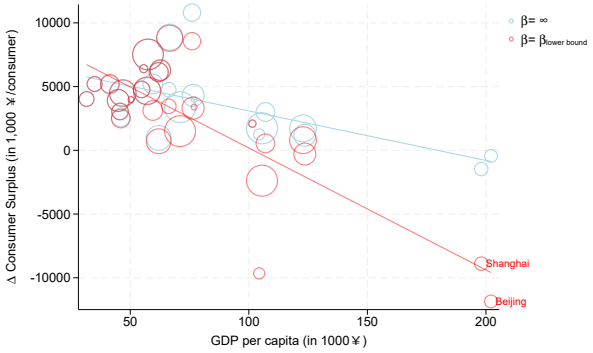
(b) Δ Survival Months (per Patient)



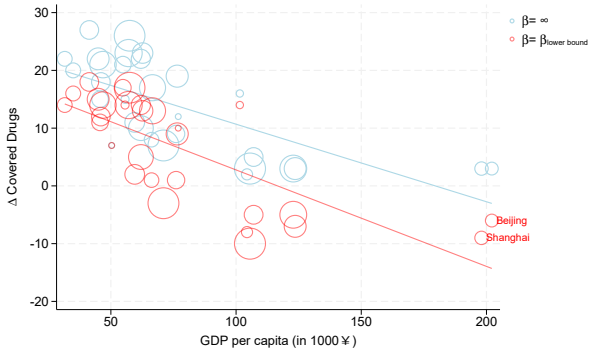
(c) Δ Social Surplus (¥/Patient)



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

government's budget constraints, so that negotiations are less likely to fail under centralization. In addition, bundling provinces together changes the relative bargaining leverage for the government and firms. Including lower-income, more price-sensitive provinces increases the central government leverage and tends to drive down average prices.

Welfare Effects of Centralization by Province Next, we break down the welfare effects of centralization across provinces. 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 most regions, especially regions in the center and west of China. Moving to centralized negotiations achieves ¥3,210 (1.8 months) gains for low-income patients in low-income regions and ¥1,410 (0.7 months) gains for high-income patients in high-income regions. See Figure 9 panel (e) for the income gradient in consumer surplus. Figure 9 panel (c) plots the change in Social Surplus in each region under centralization, calculated as $CS + Profit - Expenditure$ in that region. Four provinces (Beijing, Shanghai, Tianjin, and Guangdong) experience drops in Social Surplus under centralization because they could have negotiated a better price on their own. And Figure 9 panel (d) shows the changes in number of covered drugs—all regions cover more drugs under centralization, but the impact of centralization on formulary coverage is much smaller in rich provinces than poor provinces. For example, Beijing and Shanghai would cover only two more drugs, and both are fringe products. Figure 9 panel (f) shows the income gradient in drug coverage.

5.3 Efficiency vs. Equity in Coinsurance Design

As a last exercise, we examine the efficiency and equity implications of the NRDL Reform's current regressive coinsurance schedule, and explore the welfare effects of alternative coinsurance schedules. In our context, there are many possible income-based coinsurance schedules. For 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 rate for high-income patients 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

[20]High-income is defined as income above the national median income.

the preference weights of a utilitarian social planner, and higher values of ν reflect stronger preferences for equity and redistribution.

Thorectically, the effects of lowering coinsurance on the market outcomes are ambiguous. Holding fixed negotiation outcomes, low coinsurance rates increase government expenditure, but increase consumer surplus and expected survival.

Coinsurance rates are also expected to affect negotiation outcomes. Conditional on negotiation success, lower coinsurance rates increase firms' gains from trade, thereby increasing the government's bargaining leverage. On the other hand, lower coinsurance rates increase the likelihood of negotiation failure.

The effects of alternative coinsurance schedules are presented in Figure 10.[21] First, Figure 10(a) confirms that low coinsurance rates increase the rate of negotiation failure. For example, when coinsurance equals 20% across all patients, the model predicts that half of negotiations will fail.

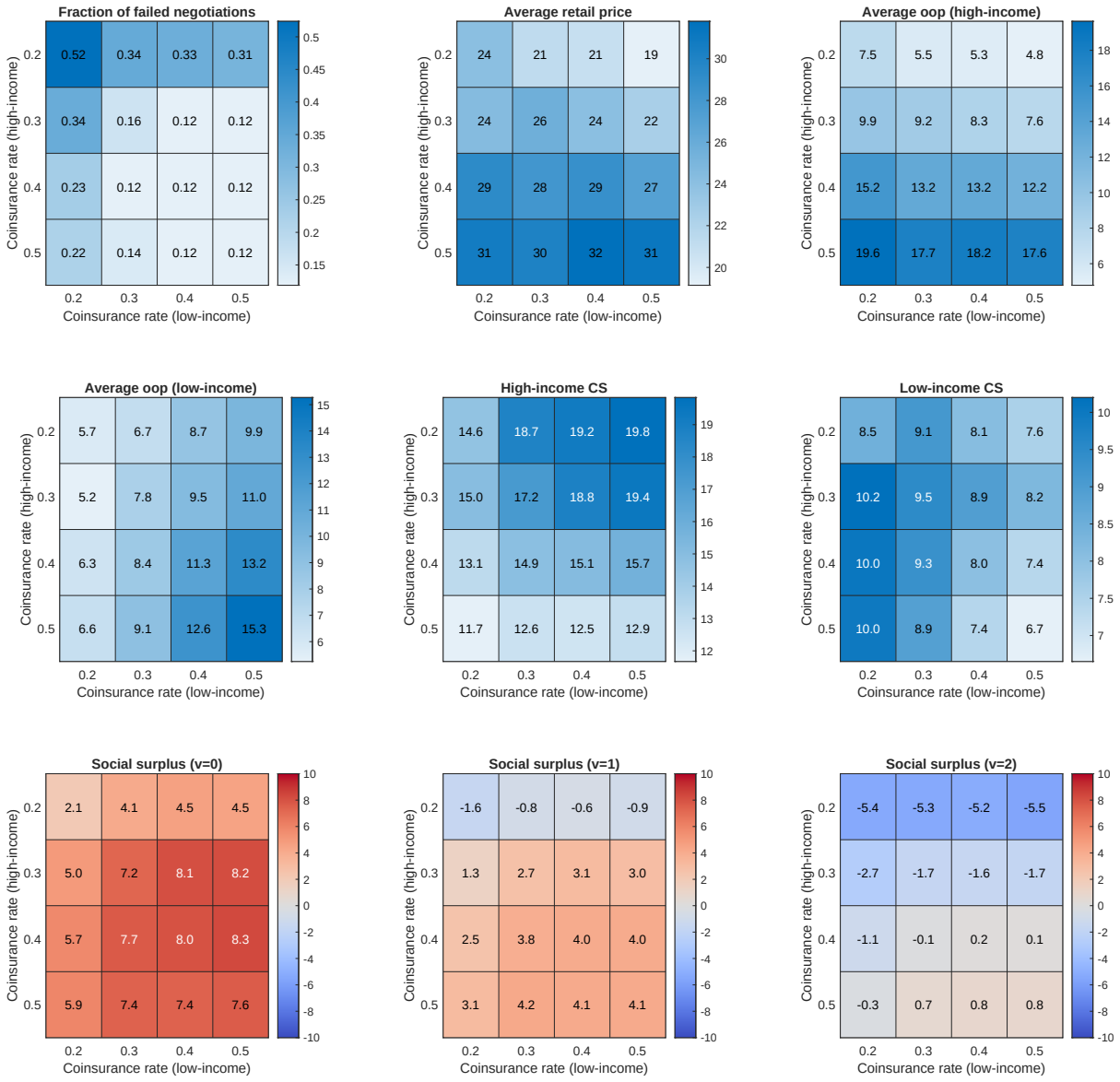
Figure 10(b) shows the average retail price of innovative cancer drugs, weighted by market shares of each drug. The diagonal terms show that lowering coinsurance rates tends to decrease the average retail price despite more negotiation failures. This is because the government gains more leverage conditional 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 consumers' 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 optimal coinsurance schedule from the high-income consumers' perspective would be (H 0.2, L 0.5).

In contrast, Figure 10(d) shows that low-income consumers' out-of-pocket price decreases as we decrease their own coinsurance rate and as we decrease the high-income coinsurance rate. Figure 10(d) implies that the optimal coinsurance schedule from the low-income consumers' perspective would be (H 0.3, L 0.2). Low-income consumers would prefer a low coinsurance

[21] Figure 10 fixes the negotiation outcomes of all negotiations that failed under the NRDL Reform as implemented. As a robustness check, we relax this restriction and present results assuming $\boldsymbol{\beta} = \underline{\boldsymbol{\beta}}$ in Appendix Figure A3. The patterns described below hold under both (extremal) assumptions.

Figure 10: Coinsurance Design



Note: This set of heatmaps presents simulated outcomes under alternative coinsurance designs. The horizontal axis shows the coinsurance rate for low-income (below median) patients, while the vertical axis shows the coinsurance rate for high-income (above median) patients. "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.

rate for high-income consumers, in order to bring down negotiated retail prices through the leverage channel. In other words, offering high-income consumers generous coinsurance rates can benefit all consumers because it increases firms' willingness to reduce retail prices. These contrasting patterns can be seen in panels (e) and (f) as well.

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 ($\nu = 1, 2$) would prefer a higher coinsurance rate, as shown in Figure 10 panels (h) and (i), particularly higher for high-income consumers. This is because lowering coinsurance rates allows marginal consumers to adopt the innovative drug and, at the same time, transfers subsidies to inframarginal consumers who would have purchased 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 from the 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

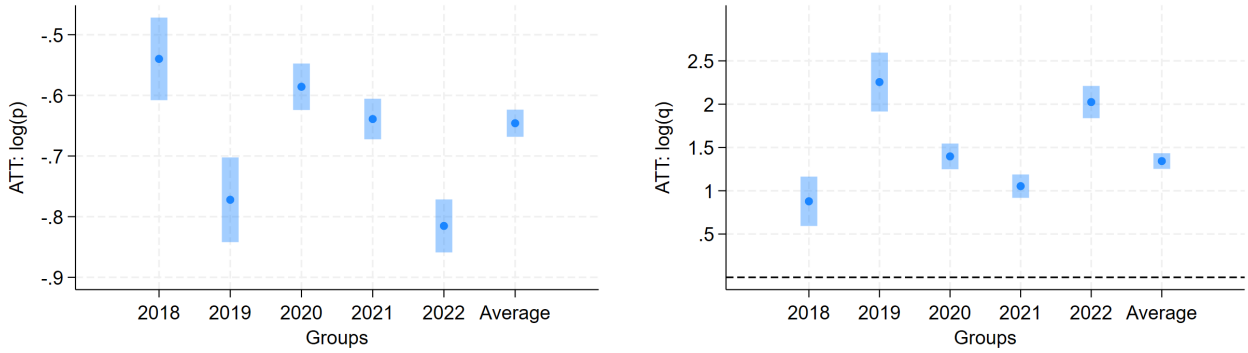
  - Lower bound of 95% confidence interval of outcome for control group if reported
  - Upper bound of 95% confidence interval of outcome for control group if reported
  - Median outcome for control group if reported

- 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 Appendix Figures

Figure A1: Cohort-Specific Effects of the Centralized Negotiation Program on Price and Quantity

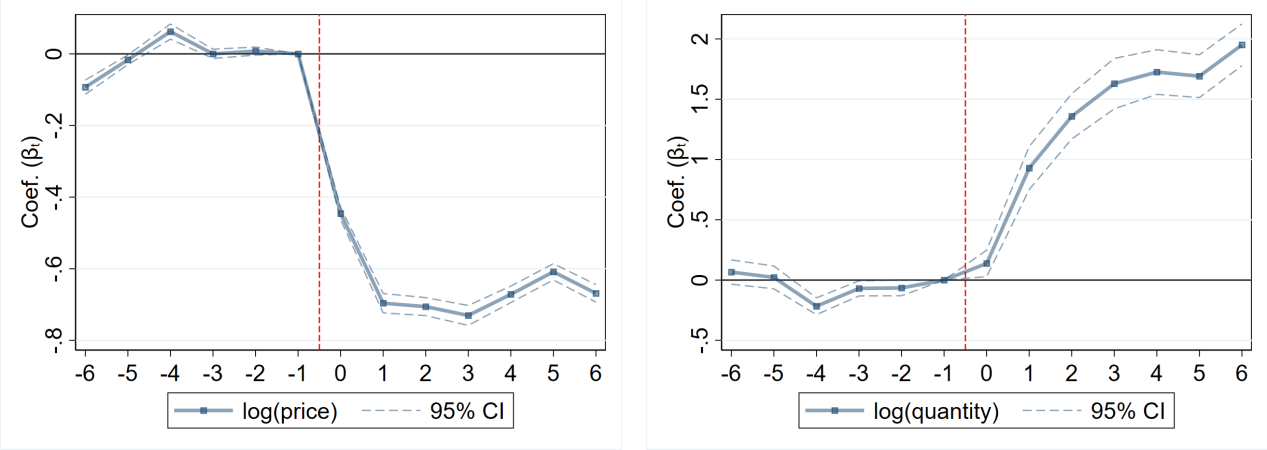


(a) Retail price: all categories

(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 A2: TWFE: Centralized Negotiation Program on Price and Quantity

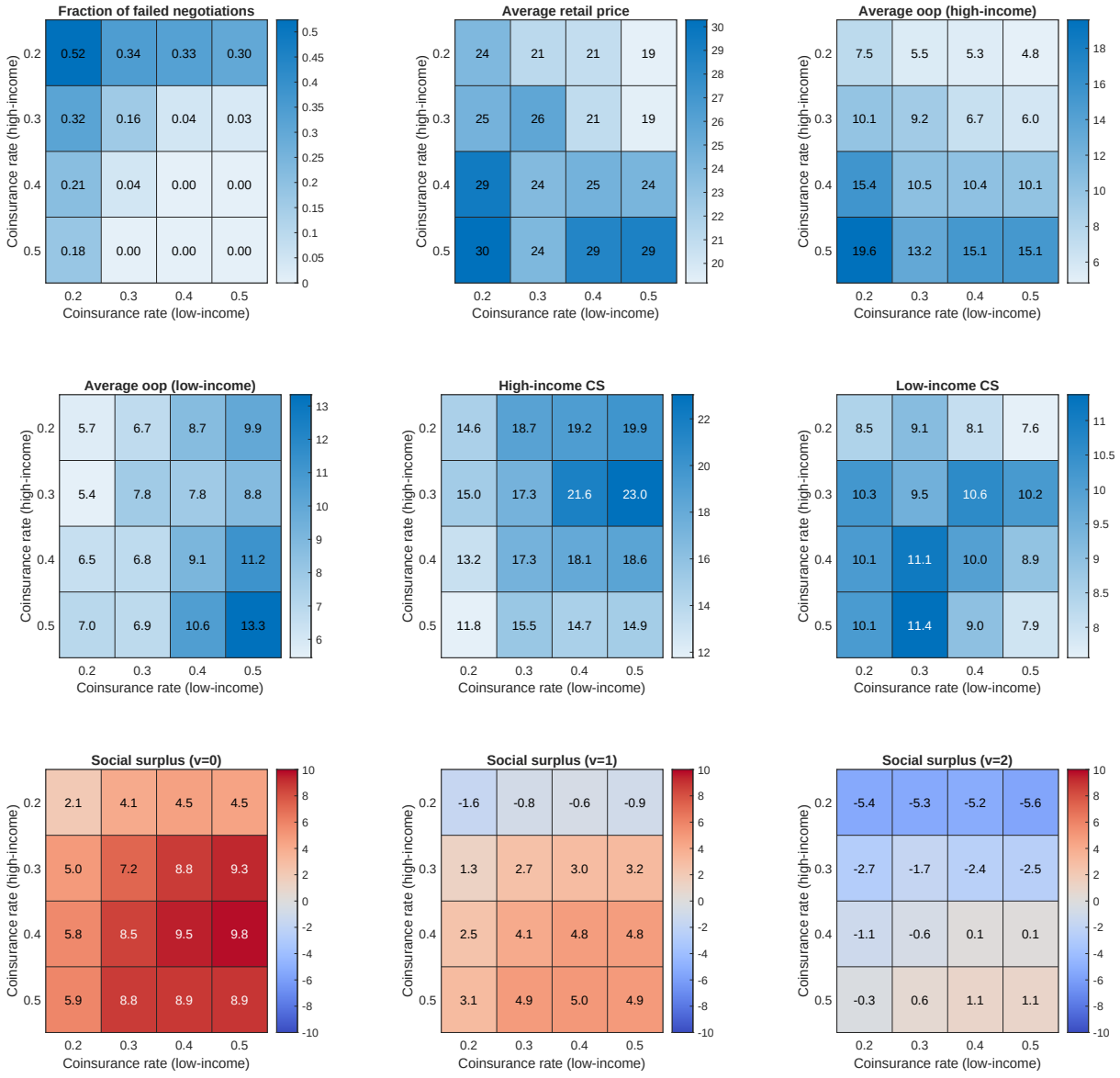


(a) Retail price: all categories

(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 A3: Optimal Coinsurance Design: $\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$, considering failed negotiations in 2023Q2



Note: This set of heatmaps shows the market outcome under different coinsurance designs. A darker color indicates bigger values. The horizontal axis shows the coinsurance rate for low-income (below median) patients, while the vertical axis shows the coinsurance rate for high-income (above median) patients. "Fraction of failed negotiations" reports the model predicted failed negotiations under each coinsurance rate design. "Average retail price" is the weighted average retail price across the 70 negotiated products (57 successful and 13 failed): $\sum_{j\in\mathcal{N}} \frac{p_j * s_j}{s_j}$. "Average OOP" is the weighted average out-of-pocket price for patients: $oop^h = \sum_{j\in\mathcal{N}} \frac{p_j \times Coins^h \times s_{j,h}}{s_{j,h}}$. "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 (with weight= income$^{-\nu}$ and $\nu = 0, 1, 2$).

C 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) + Expansion Only	(4)	(5) + Expansion &Negotiation
		y	Δy	Δy%	Δy	Δy%
Market Outcomes						
Avg. Out-of-pocket Price	Inno, Success	251.37	32.50	12.93	-181.51	-72.21
(¥1,000 per year)	Inno, Others	19.21	1.91	9.96	1.91	9.96
	Traditional	13.54	-0.02	-0.16	-0.02	-0.16
Market Share	Inno, Success	251.37	-154.24	-61.36	-224.78	-89.42
(%|inside)	Inno, Others	19.21	-0.00	-0.03	-0.00	-0.03
	Traditional	13.54	-0.02	-0.16	-0.02	-0.16
Welfare Effects in 1,000 ¥per consumer per year						
Consumer Surplus	H region, Rich	0.00	0.00	295.06	0.02	1133.28
	H region, Poor	0.03	-0.00	-4.89	-0.00	-18.76
	L region, Rich	0.07	-0.00	-4.86	-0.01	-18.68
	L region, Poor	0.00	0.01	250.55	0.02	450.48
Share-weight OS	H region, Rich	0.00	0.01	297.21	0.01	580.91
(months per consumer)	H region, Poor	0.00	0.01	144.50	0.02	411.21
	L region, Rich	0.00	0.00	170.40	0.01	539.47
	L region, Poor	0.00	0.01	206.24	0.01	465.22
Gvt. Expenditure		0.00	0.00	310.95	0.01	1271.70
Variable Profits	Inno, Success	0.00	0.00	411.56	0.01	1904.15
	Inno, Others	0.00	0.00	163.04	0.01	1012.62
	Traditional	0.00	0.00	213.74	0.00	1506.54
Welfare	$\nu = 0$	0.00	0.00	250.03	0.01	1299.00
	$\nu = 1$	0.00	0.01	774.31	0.01	942.27
	$\nu = 2$	0.00	0.01	253.87	0.01	198.95

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

		(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	19.21	-0.00	-0.03	1.91	9.96	32.13	167.30
	Traditional	13.54	-0.02	-0.16	-0.02	-0.16	22.61	166.93
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	19.21	-0.00	-0.03	-0.00	-0.03	-0.00	-0.03
	Traditional	13.54	-0.02	-0.16	-0.02	-0.16	-0.02	-0.16
Market Share	Inno, Success	1.62	2.48	152.90	14.95	920.67	12.82	789.87
(%|inside)	Inno, Others	25.05	-0.63	-2.53	-3.82	-15.24	-3.27	-13.06
	Traditional	73.32	-1.85	-2.52	-11.13	-15.18	-9.55	-13.02
Welfare Effects in 1,000 ¥per consumer per year								
Consumer Surplus	H region, Rich	4.78	8.25	172.63	19.87	415.70	18.09	378.47
	H region, Poor	1.90	3.67	193.32	10.04	528.22	9.17	482.52
	L region, Rich	3.76	4.31	114.69	13.25	352.47	8.67	230.56
	L region, Poor	1.30	1.68	129.50	5.89	454.79	4.04	311.66
	Average	2.87	4.23	147.65	11.82	412.23	9.39	327.49
Share-weight OS	H region, Rich	0.55	0.76	139.85	5.24	958.73	4.37	799.46
(months per consumer)	H region, Poor	0.27	0.45	168.96	3.80	1416.15	3.19	1190.52
	L region, Rich	0.53	0.56	103.86	3.74	700.37	2.83	530.02
	L region, Poor	0.23	0.30	129.31	2.35	1023.76	1.86	811.59
	Average	0.39	0.50	127.92	3.66	932.45	2.95	750.32
Gvt. Expenditure		1.43	-0.00	-0.10	12.99	908.01	8.68	607.13
Variable Profits	Inno, Success	4.30	-0.38	-8.90	10.47	243.27	7.28	169.22
	Inno, Others	4.77	-0.01	-0.14	-0.04	-0.88	-0.20	-4.27
	Traditional	8.53	-0.01	-0.14	-0.07	-0.83	-0.07	-0.77
Welfare	$\nu = 0$	16.20	3.83	23.66	9.19	56.71	10.56	65.16
	$\nu = 1$	16.19	2.69	16.61	6.33	39.13	7.51	46.37
	$\nu = 2$	16.18	1.57	9.70	3.49	21.58	4.49	27.72

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. Column 1 shows outcomes in the baseline (Betrand-Nash competition) without the reform. Columns 2-5 change negotiation formats. Columns 2 and 3 show a counterfactual scenario where the government negotiates with drug manufacturers for market entry but provides no insurance coverage, i.e., failed negotiation leads to market exclusion, while successful negotiation does not offer insurance coverage. Columns 4 and 5 show a counterfactual scenario where the government negotiates with drug manufacturers for both market entry and insurance coverage, i.e., failed negotiation leads to market exclusion, while successful negotiation offers insurance coverage. Columns 6 and 7 show a counterfactual provincial negotiation; the negotiation format is the same as the current program, where each provincial government negotiates with a drug company for insurance access, i.e., failed negotiation leads to insurance exclusion, while successful negotiation offers insurance coverage. In all the simulations, τ is set at 0.6 from Table 4). In each column, "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 consumer surplus between the baseline equilibrium and an alternative environment in which only the outside option is available. Share-weight OS is based on clinical evidence of improved survival months collected from Phase III trial data. Results for market outcomes report the national averages. In particular, 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. Results for welfare report aggregate outcomes across all markets.