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

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Abstract

Making innovative drugs affordable and accessible is a pressing global challenge. Centralized negotiation is an increasingly popular policy solution, but it remains understudied despite wide variation in implementation. This paper studies China's ongoing NRDL Reform, which combines centralized drug price negotiation with expanded insurance coverage. The reform reduced retail prices by 48% and out-of-pocket costs by 80%, and increased drug utilization by 350%. At the same time, the insurance design was regressive, and 25% of negotiations failed. 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 spending. We estimate that including innovative cancer drugs in the NRDL generated ¥40 billion ($5.6 billion) in annual consumer surplus gains and increased survival by 900,000 life-years among Chinese cancer patients each year. Among the counterfactual policies we examined, centralized market-access negotiation with an optimal coinsurance schedule raises social surplus by 19% relative to the observed policy and achieves 90% of the social surplus of an efficient benchmark.

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1 Introduction

Innovative drugs have the potential to generate large social benefits, but high prices place life-saving treatments out of reach for the majority of self-paying patients. Consider Verzenio, a breast cancer therapy approved by the U.S. Food and Drug Administration (FDA) in 2017. While it was shown to improve 5-year survival rates by 12%, its price is prohibitively high: $180,000 per year in the U.S. and an initial annual price of ¥66,000 ($9,430) in China. Prescription drug insurance increases access to these drugs for a wider population, but comes with substantial costs. For instance, the Medicare Part D program for the elderly in the U.S. spends 61% of its budget on the top 100 highest-priced drugs (CMS, 2024). The set of policy interventions commonly deployed to restrain prices include regulation, auctions, and negotiation. Price regulation can be difficult to implement, as it relies on potentially fraught cost and quality data rather than market signals. Successful auctions require multiple close substitutes, which are typically unavailable for innovative drugs. Negotiation is an increasingly popular solution, but it remains understudied despite wide variation in implementation (Kyle, 2025).

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 expanded universal insurance coverage to include an increasing number of innovative drugs, provided that their manufacturers negotiated price reductions with China's National Healthcare Security Administration (NHSA). Once a drug is added to the NRDL, patients can access the drug at a fraction of the negotiated price, with the government paying the balance. In our motivating example of Verzenio, inclusion in the NRDL in 2021 reduced the retail price from ¥66,000 to ¥21,000 and the average out-of-pocket (OOP) price to ¥7,400.

We use the variation generated by the NRDL Reform in China to investigate the welfare implications of observed and counterfactual drug market reforms. For motivation, note two striking features of the environment. First, 25% of negotiations fail, and higher-quality

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

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

drugs are more often successfully negotiated. Second, insurance generosity varies widely. The patient's share of the drug cost (the coinsurance rate) ranges from 20% in higher-income provinces to 45% in lower-income provinces due to provincial subsidies. We incorporate these features into a deep investigation of how key policy choices—regarding negotiating parties' outside options, centralization, and insurance generosity—impact bilateral gains from trade. In turn, gains from trade determine the extensive margin of which drugs are covered, and the intensive margin of negotiated price levels.

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

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

We present, to our knowledge, the first comprehensive evidence on the price and quantity effects of China's NRDL Reform, which are substantial. The program expanded coverage of 487 innovative drugs to over a billion people during our study period. Negotiations resulted in a 48% drop in retail prices and an 80% reduction in patients' out-of-pocket costs. Utilization of innovative drugs surged, with successful negotiations followed by a 350% increase in quantity on average. 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)).

To unpack the economic mechanisms underlying these results, we focus on cancer drugs, which accounted for two-thirds of revenues for negotiated drugs in the NRDL program. We

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

build a structural framework consisting of a demand model that features random preferences and differences in affordability across income groups, and a supply side in which the government and pharmaceutical firms negotiate prices to split surplus. The supply side incorporates centralized bargaining with heterogeneous households, bargaining breakdowns, and a government objective function that depends on patient welfare and government expenditure. We estimate several key parameters: income-varying price elasticities of demand, firms' marginal costs of producing and distributing innovative drugs, a bargaining parameter that determines the surplus split between firms and the government, and the relative weights the government places on patient surplus versus government expenditures. Our model shares features with structural work on drug markets (Atal et al., 2022; Cao and Chatterjee, 2022; Chaudhuri et al., 2006; Xia, 2025) and with the recent empirical literature on bargaining in health care markets more broadly (e.g., Gowrisankaran et al. (2015); Grennan (2013); Ho and Lee (2017); see Grennan and Swanson (2022) for a review).

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

Consistent with prior work on global drug markets (e.g., Dubois et al. 2022), price elasticities of demand for cancer drugs are low, around -1.6 for the median patient and -1.9 for patients at the 25^{th} income percentile. The supply-side analyses focus on two classes of innovative cancer drugs: monoclonal antibodies and protein kinase inhibitors. Our estimates indicate that the government assigns equal weight to consumer surplus and government expenditures for the median drug, and lower weights on expenditures for drugs with larger survival improvements in clinical trials. Finally, the estimated firm bargaining parameter is

[4] An alternative explanation for the bargaining failures observed in our setting would be incomplete information. See Ausubel et al. (2002) for a review. This is unlikely a key driver of bargaining failures in our setting, as both the government and drug manufacturers observe years of market outcomes prior to negotiations. Moreover, during the pre-negotiation stage, information is exchanged frequently between the parties.

0.68, suggesting that firms hold considerable bargaining power.

The model estimates allow us to evaluate the effectiveness of the NRDL Reform and counterfactual policies. The NRDL Reform, as implemented, combines insurance expansion and negotiation. Insurance expansion alone would reduce price sensitivity, leading to lower OOP prices but higher retail prices; see Cutler and Reber (1998), Jaffe and Shepard (2020), and Liu and Jin (2015).[5] Price negotiation alone would have no impact, as firms would receive no gains from trade from participating in the negotiation relative to firms' outside option of setting profit-maximizing prices on the private market. The combined reform allows the government to discipline prices, while patients benefit from greater drug access. Relative to no reform, the NRDL Reform increases the market share of innovative drugs among all cancer drugs by 18 ppt (1,133%), far exceeding the gains from insurance alone (5 ppt, or 295%) and negotiation alone (0 ppt). At the same time, it reduces OOP costs for successfully negotiated drugs by 89% and raises average survival by 3.2 months per cancer patient. In aggregate, the innovative drugs successfully negotiated under the NRDL reform between 2017 and 2022 generated ¥40 billion ($5.6 billion) in annual consumer surplus gains and contributed to a total survival increase of 900,000 life-years among Chinese cancer patients each year.

We next turn to counterfactual exercises to shed light on how policy choices impact economic outcomes and welfare, allowing both formularies and negotiated prices to adjust.

First, we focus on the role of outside options, contributing to recent work on bargaining with exclusion and formulary tiering (Ho and Lee, 2019, 2024; Prager and Tilipman, 2025). In contrast to the observed NRDL Reform, which employs a formulary-access negotiation with the firm's outside option being to sell drugs in the private market, we model a "market access" negotiation that is more typical in the literature. Here, the government's threat point is to exclude the drug from the Chinese market entirely. This increases the gains from trade to both the government and firms, allowing all drugs to be successfully negotiated, but with ex-ante ambiguous effects on welfare. Relative to the no-reform baseline, if firms must negotiate with the government to access the market, even without insurance expansion, retail prices would decrease by 53% at zero cost to the government, and the innovative drugs' market share would increase by 2 ppt (152%). Moreover, we continue to find that insurance expansion reinforces negotiation. In comparison with the formulary-access negotiation, the market-access negotiation with insurance results in coverage of more drugs, and increases overall welfare gains and medical benefits when the government has sufficient bargaining power.

Next, we examine the role of centralization. There is wide variation in income and price

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

sensitivity across provinces, implying that centralized negotiation may create winners and losers. To investigate this, we contrast the effects of centralized national bargaining with those in which each province negotiates its own prices and formularies. This analysis contributes to recent policy debates and academic research regarding central procurement; see, e.g., Dubois et al. (2021), Dubois and Sæthre (2020), Dubois et al. (2022), Ho and Pakes (2024), and Maini and Pammolli (2023). The driving feature of this comparison is that gains from trade are lower for both firms and the government in low-income provinces than high-income ones. Hence, the effects of centralization vary across regions: while the highest-income provinces would fare better under province-level negotiation, most provinces benefit from more successful negotiations and lower prices under centralized negotiation, making it beneficial on average.

The next set of counterfactual analyses examines the efficiency and equity implications of income-based coinsurance schedules. Public insurance programs often include subsidies tied directly to income, rather than geography. We explore two-tier structures with different coinsurance rates for households above and below the national median income. To evaluate the equity implications of more and less progressive schedules, we follow the public finance literature (e.g., Hendren 2020) and re-weight households' consumer surplus by $income^{-\nu}$. When $\nu = 0$, the measure reflects utilitarian preferences, while higher ν indicates a stronger emphasis on equity. We document a few notable results. First, 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 successfully negotiated drugs by half due to the increase in government expenditures. Second, lowering coinsurance for high-income households is more effective in expanding 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 because demand expansion from high-income households offers the government greater bargaining leverage. This in turn leads to more drug coverage and lower prices that also benefit low-income households. However, a higher preference for equity yields a nearly flat, high coinsurance schedule as the optimum. Our analyses contribute to the literature on subsidies for privately-supplied products, e.g., Polyakova and Ryan (2022) and Finkelstein et al. (2019), and on optimal coinsurance given the tradeoff between moral hazard and risk protection (Cutler and Zeckhauser, 2000; Einav et al., 2018; Gowrisankaran et al., 2015).

We conclude by recommending centralized, market-access negotiation paired with an optimal coinsurance schedule as the best policy combination within the broad "Negotiation plus Expansion" regime. This policy yields a 19% gain in social surplus over the observed policy,

achieves 90% of the social surplus of an efficient benchmark, and has favorable features in terms of efficiency, access, and equity.

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.

2 Institutional Background and Data

2.1 Institutional Features: CHS and the NRDL Reform

The Chinese healthcare system, known as CHS, provides nearly universal coverage to over 95% of Chinese citizens, making it the largest healthcare insurance program in the world (Yu, 2015). It was created in 1999 and has gone through several changes over the years. Today, it consists of two major health insurance plans: the urban employee basic medical insurance plan (UEBMI) for individuals working in (and retirees of) state-owned enterprises and private-sector businesses, and the urban and rural resident basic medical insurance plan (URRBMI) for rural residents and urban residents not covered by UEBMI. In 2023, the premium for these insurance plans was set at ¥1080, with individuals and employers contributing ¥380 and the government providing a subsidy of ¥700. A small commercial market for complementary insurance exists, accounting for less than 7% of total health expenditure (National Health Commission of the PRC, 2023).[6] Given the widespread insurance coverage in CHS, 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 (Long et al., 2022).[7,8] Historically, CHS's NRDL excluded innovative drugs due to budget considerations.[9] In recent years, CHS faced criticism

[6]Some provinces have a cap on total annual insurance coverage. Commercial insurance products offer catastrophic coverage, thereby decreasing residents' financial exposure to major health events. In our sample period, coverage caps are well above the prices of our focal drugs.

[7]Besides prescription drugs, China's health insurance program also covers inpatient care, emergency care, preventive care such as vaccines, and maternity benefits.

[8]China had various price caps and price regulations on pharmaceutical drugs during the 1980s-2000s. In 2015, China removed most price regulations and only retained price controls for anesthetics. See https://www.gov.cn/gongbao/content/2015/content_2901387.htm. The NRDL Reform we study in this paper focuses on improving access to innovative drugs beginning in 2016. The volume-based public procurement (VBP) auction policy targets drugs with generic competitors, beginning in December 2018. For academic studies on VBP policy, see Cao et al. (2022); Fang et al. (2021); Liu et al. (2024).

[9]In some cases, provincial formularies covered a few innovative drugs, but this practice was ended with the passing of the NRDL Reform in 2016, before the beginning of our dataset.

due to its lack of coverage for innovative drugs, which resulted in limited access to effective treatments and high out-of-pocket prices.

In response to public pressure, the CHS launched a drug reform in 2016, i.e., the NRDL Reform, that is ongoing today. Each year, the NHSA comes up with an "eligible list" of drugs and invites drug producers to participate in negotiations. Firms and the NHSA exchange a host of information (including drug effectiveness, sales, and prices, as well as NRDL payment procedures) during the pre-negotiation stage, which can last a few months. On the day of negotiation, government representatives engage in simultaneous and independent negotiations with delegates from each drug company for each drug. Table 1 summarizes the seven rounds of negotiations from 2016 to 2022, which had an average success rate of 76%. Negotiations occur annually, and the number of negotiations has rapidly increased since the pilot year.

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%.

The negotiation process has three notable features. First, both parties are well-informed about supply and demand conditions at the time of negotiation. Most eligible drugs have already been sold on the private market, and there is frequent information exchange during the pre-negotiation stage. As a result, the government likely has a good understanding of firms' production costs, while drug companies likely are well aware of the government's preferences.

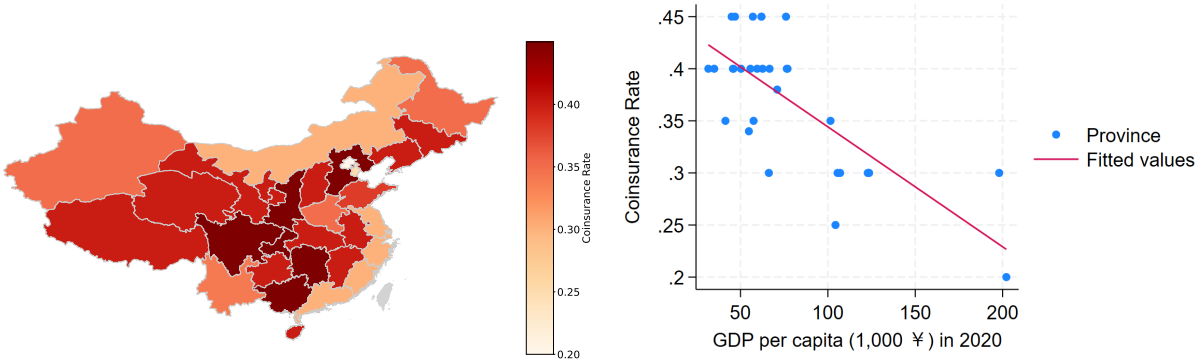
Second, the government prioritizes both social benefits and fiscal sustainability. It appoints two expert groups for each negotiation: pharmacoeconomic experts to evaluate potential patient benefits and finance experts to assess the drug's affordability for the insurance fund.

Third, each drug is negotiated independently. Separate government teams meet with company representatives for different drugs in different rooms, without communication across teams. All negotiations are completed by the end of the day. This setup minimizes strategic interactions within and across firms and limits the government's ability to play firms against each other at the time of negotiation, making it an appropriate application for the Nash-in-Nash bargaining model.

If a negotiation is successful, the drug is typically added to the NRDL within one quarter. Negotiated contracts generally last 2–3 years, after which drugs are subject to renegotiation. Contracts are almost always automatically renewed at the originally negotiated price.

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 centralized, coinsurance rates are determined at the provincial 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, which covers more than 70% of the population, requires 5 ppt higher coinsurance rates on average.[10] Within each province and plan type, coinsurance rates are uniform for all covered drugs. We use the coinsurance rate for the larger program (URRBMI) in our analysis. The left panel of Figure 1 presents a map of the URRBMI coinsurance rates across provinces; the right panel presents a scatterplot of the coinsurance rates against provincial income. Patients in wealthier provinces like Beijing and Shanghai pay 20-30% of the retail price, whereas those in poorer regions like Gansu pay up to 45%.

Figure 1: Coinsurance Rate Design



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

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

2.2 Data and Sample Description

Our primary dataset contains comprehensive coverage of drug sales in China from 2017Q1–2023Q2, sourced from SinoHealth. SinoHealth is the only health consulting firm that is publicly listed in China. It supplies data to all major international pharmaceutical companies, including Pfizer, Roche, Bayer, AZ, GSK, Merck, Eli Lilly, etc. Its price and sales data closely match the information posted on NHSA's website and published in China's Statistic Yearbooks. We

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

focus on hospital sales because nearly all innovative drugs are dispensed through hospitals. Data on hospital sales are at the province-quarter level and include total drug sales, quantities dispensed (standardized to years of 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.

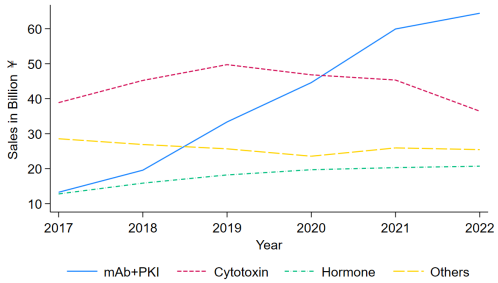
Innovative drugs that are eligible for NRDL negotiations include drugs that treat cancer, hypertension, and diabetes, among others. We focus on cancer drugs in our structural analyses for two main reasons. First, this market is significant from both health and economic perspectives. In 2020, China had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

We constructed several ancillary datasets concerning cancer drug markets. First, we obtained brand-year-level indications from the Handbook of Innovative Cancer Drugs, which details the approved usage of each cancer drug for different indications by China's National Medical Products Administration, the analog of the U.S. FDA. Second, we collected clinical evidence for all innovative cancer drugs from Phase III clinical trials on ClinicalTrials.gov. Phase III studies are large-scale, double-blind, randomized controlled trials comparing the safety and efficacy of interventions relative to control therapies. Implementing such trials, and registering them on ClinicalTrials.gov, is typically a prerequisite for FDA approval. We use the clinical trial results to measure the quality of each drug. Our preferred measure is the overall survival treatment effect (additional months lived) relative to the standard treatment for the relevant disease. Details of our data collection procedure are available in Appendix A. Third, we collected province-level demographics from each province's Statistics Yearbook, along with cancer incidence data from the National Cancer Center.

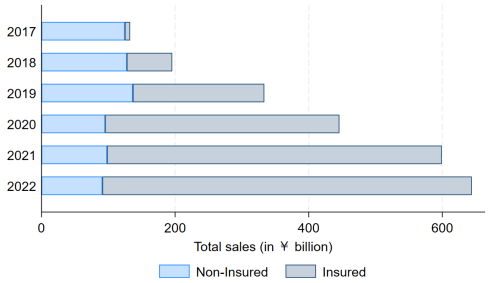
There are four major types of cancer drugs on the market: monoclonal antibodies (mAbs), protein kinase inhibitors (PKIs), cytotoxins (traditional chemotherapy), and hormone drugs. Innovative cancer drugs are typically mAbs or PKIs, and are the primary target of the NRDL Reform. Cytotoxins can be effective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

443 cancer drugs, of which 110 are branded and up to 70 are innovative.

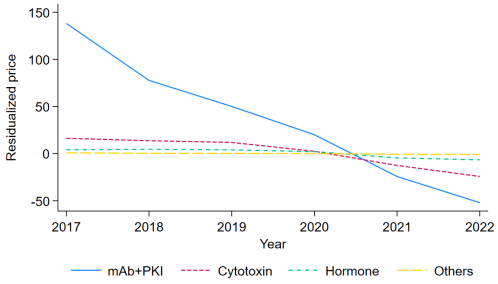
Figure 2: Overview of the Cancer Drug Market



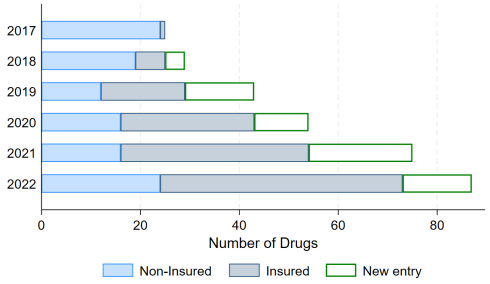
(a) Sales by Cancer Drug Category



(b) Sales for Non/Insured Innovative Drugs



(c) Residualized Retail Price



(d) Num. of Innovative Cancer Drugs in Market

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

Figure 2 presents key data patterns regarding the cancer drug market. First, the NRDL Reform led to substantial market expansion for innovative cancer drugs.[11] 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 substitution from cytotoxins to innovative treatments. Figure 2(b) decomposes the sales of innovative cancer drugs into insured and non-insured products. In 2017, the innovative cancer drug market was almost entirely uninsured, and patients had to pay the full retail price to receive treatment. By 2022, more than 80% of innovative cancer drug sales were for insured (successfully negotiated) products. Meanwhile, the average retail price of innovative cancer drugs declined substantially, as shown in the residualized price plot (Figure 2(c)), after partialing out brand fixed effects to account for price changes driven by product entry and exit.

[11] In the remainder of the text, we consider mAb and PKI drugs to be the focal innovative drug categories.

This period also saw significant market entry and a growing variety of innovative cancer drugs. The availability of innovative drugs increased sharply for the most common cancer types between 2017 and 2022, and the total number of innovative cancer drugs available in China nearly tripled over this period (Figure 2(d)). Many drugs newly introduced to the Chinese market were already available in developed countries, suggesting that insurance expansion may have raised the expected profitability of the Chinese market and made it more attractive for multinational pharmaceutical companies to launch their products there.[12]

2.3 Descriptive Patterns

In this Section, we present event study evidence on the effect of NRDL inclusion on drug prices and quantities, across all innovative drugs and for cancer drugs specifically.

Prices and Quantities Figures 3(a) and 3(b) compare outcomes for successfully negotiated innovative drugs with those of a never-treated group (drugs that appeared on the "eligible list" but were never successfully negotiated). We follow Callaway and Sant'Anna (2021) and implement difference-in-differences regressions allowing for variation in treatment timing and heterogeneous treatment effects. The NRDL program led to a 48% reduction in retail prices and a 350% increase in quantities.[13,14]

The combined effects of the documented price negotiation and insurance reduced patients' out-of-pocket prices by 80%. The price responses are immediate and persistent—retail prices adjust to the negotiated price within one quarter—while the quantity response takes slightly longer to fully materialize. There are no substantial pre-trends in prices, indicating that firms did not strategically manipulate retail prices before the negotiation. Appendix Figure A1 shows that the price and quantity treatment effects were large and significant for drugs in all negotiation cohorts, but there is some variation in magnitudes across cohorts due to composition.[15] This supports our use of the method from Callaway and Sant'Anna (2021). We also estimate the treatment effect of successful negotiation using a standard Two-Way Fixed Effects (TWFE) regression, leveraging the staggered timing of negotiation across drugs.

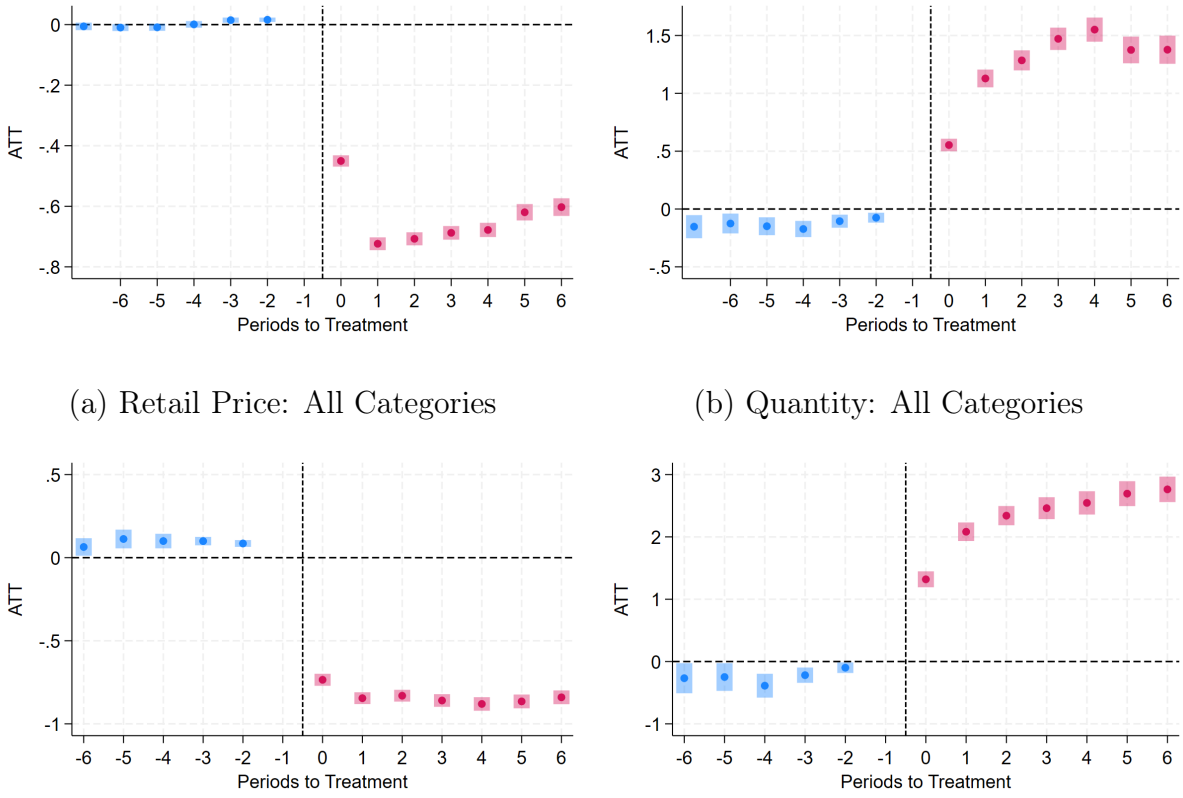
[12]The ratio of new cancer drug indication approvals in China relative to the U.S. was 0.24 between 2001-2016 and more than doubled to 0.5 during 2017-2020.

[13]For each of the reported effect sizes, we present the difference-in-differences estimate in percentage terms. E.g., 48% = 100%*(exp(-0.66)-1).

[14]A few innovative drug companies offered a "Patient Assistance Program" that provided discounts on the retail price to patients in the pre-NRDL period. We have adjusted the retail prices to reflect these discounts.

[15]Price reductions and quantity expansions were larger in 2019 and 2022, when a greater 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: Cancer Drugs

(d) Quantity: Cancer Drugs

Note: This figure reports effects of the NRDL Reform on 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 and 95% confidence intervals using the CSDID method from Callaway and Sant'Anna (2021).

The results are similar to those in Figure 3.

Figures 3(c) and 3(d) present the event study estimates of the treatment effects for successfully negotiated *innovative cancer* drugs. The control group consists of innovative cancer drugs that are eligible for negotiation but have either not yet been included or have never been included in the formulary. Given the greater potential for spillovers (business stealing) across drugs within a single class, these estimates should be interpreted as suggestive. The effect of NRDL inclusion is more pronounced: we estimate a 57% reduction in retail prices and a dramatic 930% jump in quantity. The estimated retail price reduction, combined with insurance, led to an 86% reduction in patients' out-of-pocket price.

Negotiation Successes and Failures Next, we present descriptive evidence on negotiation successes and failures, as motivation for our structural model. By 2022, a total of 89 negotiations had taken place covering 70 innovative cancer drugs, with 57 resulting in successful agreements.[16] There are a total of 37 firms, with 16 foreign and 21 domestic.

To examine the factors associated with negotiation outcomes, we regress negotiation success on drug characteristics and present the results in Table 2. Drug quality is positively correlated with success: both lagged sales and expected improvements in patient survival have significant and positive coefficients. For instance, each additional month of expected survival gain increases the likelihood of NRDL inclusion by 2–3 ppt. When all drug attributes are included, drugs that are newer and offer greater clinical benefits are the most likely to be added to the NRDL (Column 7).

Table 2: Regressions on Bargaining Outcome

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\log(\text{sales}_{-1})$	0.087***						0.089***
	(0.015)						(0.015)
Δ survival (month)		0.030***					0.022**
		(0.009)					(0.008)
$\mathbb{1}$(1st negot. of an indication)			0.225*				0.099
			(0.117)				(0.104)
log(mortality)				-0.000			-0.010
				(0.013)			(0.011)
International firm					0.008		-0.091
					(0.098)		(0.083)
#Year since entry						-0.057	-0.103**
						(0.046)	(0.041)
Constant	-1.172***	0.404***	0.471***	0.531***	0.523***	0.620***	-1.005***
	(0.290)	(0.060)	(0.054)	(0.158)	(0.076)	(0.088)	(0.300)
R^2	0.245	0.083	0.034	0.000	0.000	0.014	0.353
Independent Variable Mean	19.64	4.13	0.21	11.65	0.60	1.62	

Note: This table presents OLS regression results, regressing an indicator for negotiation success on various product features. Out of 89 negotiations, 57 resulted in success. Δ survival (months) denotes the estimated improvement in overall survival from the drug, compared to standard therapy, based on Phase III clinical trials. $\mathbb{1}$(First negot. of an indication) is an indicator for the drug being the first to be eligible for negotiation in any of its indications; log(mortality) denotes the log of the total deaths in the same year in the drug's approved indications. International firm is an indicator for firms based outside China. Years since entry denotes how long the drug had been sold on the Chinese market as of the negotiation round. $\log(\text{sales}_{-1})$ denotes the log sales of the drug in the quarter before the negotiation.

[16] While a quarter of overall negotiations fail, forty percent of negotiations involving innovative cancer drugs fail, partly because they are more expensive. Among them, 54 drugs were negotiated once, 13 drugs were negotiated twice, and three drugs were negotiated three times.

3 Model

We now present a model of China's cancer drug market that formulates how key market primitives, such as demand, cost, the government budget constraint, and bargaining power, jointly determine equilibrium outcomes. The model also serves two purposes for counterfactual analyses. First, it allows us to disentangle the impact of the NDRL reform into effects driven by insurance expansion versus 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 cancer drug j (including both innovative and non-innovative drugs) in market m (province-quarter) is assumed to take the following form:

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

where OOP_{jm} is the out-of-pocket price for drug j in market m, defined as $OOP_{jm} = p_{jm} \times [\mathbb{1}(j \in \mathcal{G}) \times \gamma_m + \mathbb{1}(j \notin \mathcal{G})]$ and γ_m is the coinsurance rate in market m. A "drug" is a brand-molecule combination. For innovative drugs, each brand corresponds to a unique molecule.[17] There may be multiple producers of non-innovative cancer molecules. The total market size is the population of cancer patients from the cancer registry, at the province-year level. The outside option is a composite good that may include Chinese traditional medicine, non-drug treatment, or no treatment.

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

We address the correlation between price and the demand unobservable ξ_{jm} with price instruments. The sets of instruments we use are: (1) a negotiation dummy (=1 if the drug is included in the NRDL in that quarter), which exogenously shifts retail and out-of-pocket

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

prices; (2) a negotiation dummy interacted with province-level median income, which allows differential responses to the price shock created by the NRDL Reform among high-income patients; (3) a negotiation dummy interacted with the 25th, 50th, and 75th percentiles of province-year income, to provide flexibility relative to (2); and (4) the number of direct rival products within the same drug class-province-year, aiming to capture the effect of local competition on prices.[18] In Section 4, we also show that our results are robust to alternative identification strategies and specifications that allow for richer substitution patterns.

3.2 Bargaining Model

We model the negotiation process between the government and pharmaceutical companies using a complete information multi-lateral Nash-in-Nash framework. Following the empirical bargaining literature for health care and other vertical markets, we assume that bargaining outcomes are binding in all contingencies, and the failure of one negotiation does not influence the outcomes of others (Crawford et al., 2018; Gowrisankaran et al., 2015; Grennan, 2013; Ho and Lee, 2017; Horn and Wolinsky, 1988). These assumptions are supported by the institutional features of the NRDL Reform, in which each group of government delegates negotiates simultaneously and independently over a specific drug with the pharmaceutical company that holds its patent (see Section 2.1). Collard-Wexler et al. (2019) provide a microfoundation for this empirical model, which maps closely to our setting.

Firm Profit Pharmaceutical companies participate in NRDL negotiations to maximize their profits in the Chinese market. While profits from a successful negotiation are standard, the threat point – firms' profits when negotiations fail – differs from those in most empirical studies of health care bargaining. Typically, negotiation breakdowns would result in the product being excluded from consumers' choice sets. However, in our context, a failed negotiation means the drug is excluded from the NRDL formulary but remains available in the private market. The key difference is the coinsurance amount: without NRDL inclusion, patients bear 100% of the retail price, compared to the 20%-45% coinsurance if the drug were included. The firm's 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 drugs in the market.

For the sake of brevity, we assume single-product firms in the following discussion, though our empirical estimation accommodates multi-product firms. With a slight abuse of notation,

[18] "Drug class" refers to the 4th-level Anatomical Therapeutic Chemical (ATC4) classification, which groups drugs into chemical subgroups. In our sample of 443 cancer drugs, there are 67 ATC4 classes.

we use j to denote the firm producing the drug. Let $\mathcal{G}$ denote all drugs included in the NRDL formulary and m denote a market (province-year-quarter).[19] Under a successful negotiation, firm j's profit at the negotiated price p_j (uniform nationally) and given the formulary $\mathcal{G}$ and marginal cost mc_{jm} is:

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

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

$$\Pi_j^{dev}(\mathbf{p}_j^{BN}; \mathbf{p}_{-j}, \mathcal{G} \setminus \{j\}) = \max_{\tilde{p}_{j1},\ldots,\tilde{p}_{jM}} \sum_m (\tilde{p}_{jm} - mc_{jm})\, q_{jm}(\tilde{p}_{jm}; \mathbf{p}_{-j}, \mathcal{G} \setminus \{j\})$$

Crucially, firm j sets different prices across provinces under negotiation failure. Its gain from a successful negotiation at the price p_j and network $\mathcal{G}$ is defined as: $\Delta\Pi_j(p_j; \mathbf{p_{-j}}, \mathcal{G}) \equiv \Pi_j(p_j; \mathbf{p}_{-j}, \mathcal{G}) - \Pi_j^{dev}(\mathbf{p}_j^{BN}; \mathbf{p}_{-j}, \mathcal{G} \setminus \{j\})$. Intuitively, the **gains from trade** come from the quantity expansion induced by the sharp reduction in OOP_{jm} when $j \in \mathcal{G}$.

Government Objective The central government cares about patient welfare but faces constraints on drug insurance spending. We consider several welfare metrics, including the standard measure of consumer surplus, but also more equitable measures, such as an inverse-income weighted consumer surplus measure drawn from the public finance literature. The discussions below focus on consumer surplus, though the analyses are similar with other welfare metrics. Let V denote the government objective function, where β captures the government's relative weight on insurance program expenditures:[20,21]

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

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

[19] The NRDL formulary varies over time, but we omit the time subscript on $\mathcal{G}$ for simplicity.

[20] The assumption that the government values patient surplus and government expenditures is consistent with the government sending pharmacoeconomic experts and health fund experts to each negotiation.

[21] Modeling the government objective as a weighted sum is a reduced form representation of potentially many underlying mechanisms that would generate similar empirical patterns. The parameter β could reflect the government's shadow cost of expenditures, or variations in how government officials perceive the impact of network inclusion on patient welfare and future spending. Another approach is to assume that $V(\mathbf{p}, \mathcal{G}) = \lambda CS(\mathbf{p}, \mathcal{G}) - TC(\mathbf{p}, \mathcal{G})$, where $\lambda = \frac{1}{\beta}$ captures the government's preference for (or belief regarding) consumer surplus. These two approaches are isomorphic.

calculate this as:

$$\Delta CS(p_j; \mathbf{p_{-j}}, \mathcal{G}) = \sum_m \text{MS}_m \cdot \int_i \int_{\gamma_m p_j}^{p_{jm}^{BN}} \underbrace{\frac{1}{\alpha_i / OOP}}_{\substack{\$ \text{ per} \\ \text{util}}} \cdot \underbrace{\frac{\partial \widetilde{EU}_{im}(OOP; \mathbf{p_{-j}}, \mathcal{G})}{\partial OOP}}_{\substack{\text{change in utils for} \\ \text{a local price change}}} dOOP \cdot dF(i|m), \quad (2)$$

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

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

The government's gain from covering drug j (i.e., the **gains from trade**) at the negotiated price p_j is $\Delta V(p_j; \mathbf{p_{-j}}, \mathcal{G}) = \Delta CS(p_j; \mathbf{p_{-j}}, \mathcal{G}) - \beta \Delta TC(p_j; \mathbf{p_{-j}}, \mathcal{G})$.[22]

Negotiation A negotiation succeeds if the government and drug company find an *admissible* price such that gains from trade are weakly positive for both parties. This is consistent with the institutional fact that the government and firms negotiate over a linear price without lump sum transfers. The government's relative weight β on expenditure, which we assume is a random variable from a distribution $\beta \sim F_\beta$, serves several purposes. First, it is a parsimonious way to reflect the government's priorities over patient welfare versus 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 the threshold where the gains from trade for pharmaceutical firms are zero, negotiations will fail and drug firms will withdraw from the bargaining table. Third, the assumption that β is a random variable helps explain the variability in bargaining outcomes across drugs with similar consumer surplus and expenditure effects. The fact that drugs with similar surplus gains sometimes, but do not always, make it 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

[22] 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. Potential dynamic incentives are an interesting question, but beyond the scope of this paper.

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, then the admissible set is empty, $\mathcal{P} = \varnothing$, and the negotiation fails.

For successful negotiations, the negotiated price maximizes the Nash product of gains from trade for both parties. The share of surplus accruing to each party is determined by firm j's bargaining power τ_j:

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

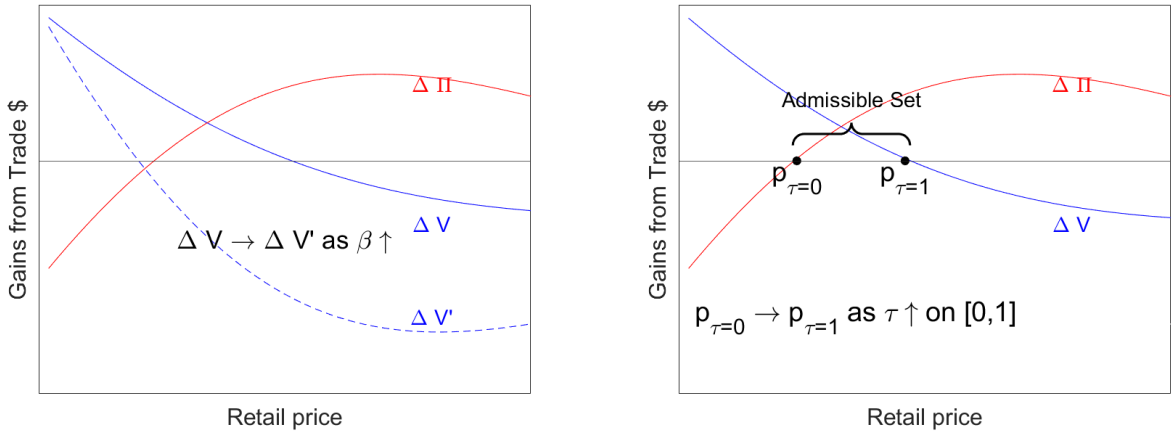
This implies the following first-order condition for successfully negotiated prices:

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

To illustrate how the government's preference β and a drug firm's bargaining power τ affect negotiation outcomes, Figure 4 plots each party's gains from trade against the negotiated retail price. The price range where both curves are positive is the admissible set. 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 (Figure 4(a)). The bargaining parameter determines the negotiated price within the admissible region (Figure 4(b)). If the pharmaceutical firm holds all the bargaining power, the negotiated price will be at the upper bound of the admissible set, holding the government to its participation constraint. If the government wields all of the bargaining power, the negotiated price will be at the lower bound, just satisfying the firm's participation constraint. In essence, a negotiation success pins down the upper bound of β, whereas the location of the negotiated price within the admissible set, together with our parametric assumptions, jointly identifies τ and β.

A key advantage of our setting is that we observe prices and quantities both *before* and *after* negotiations, allowing us to directly infer firms' gains from trade, $\Delta\Pi$, from the data, demand, and marginal cost estimates. As a result, we can recover $p_{\tau=0}$ after estimating demand. The differences between $p_{\tau=0}$ and observed negotiated prices are informative of τ.

Figure 4: An Illustration of Model Predicted Bargaining Outcomes



(a) Identification of β

(b) Identification of τ

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

Welfare and Equity Considerations We calculate total surplus as consumer surplus, plus firm profits, minus government expenditures. This approach assumes that demand patterns reveal patients' true preferences over cancer treatments. This would be inappropriate if demand patterns are distorted by behavioral frictions (Baicker et al., 2015) or liquidity constraints (Ericson et al., 2025; Nyman, 1999). An alternative approach to evaluating welfare gains is to use health outcomes, such as overall survival.[23]

The specification of the government's objective function above assumes that the government has utilitarian preferences and values consumer surplus. As a robustness check, we consider alternative specifications that allow for equity considerations, following the public finance literature (Hendren, 2020):

$$V(\mathbf{p}, \mathcal{G}) = \frac{1}{H} \int_i \text{income}_i^{-\nu} CS_i(\mathbf{p}, \mathcal{G}) dF(i) - \beta TC(\mathbf{p}, \mathcal{G}) \tag{4}$$

where $\nu \geq 0$ is a scalar and a higher ν indicates a stronger government preference for equity. $H = \int_i \text{income}_i^{-\nu} dF(i)$ is a normalization constant that integrates over all individuals. We examine three cases: $\nu = 0$ (the utilitarian preference above), $\nu = 1$, and $\nu = 2$.

[23] To do so, we multiply quantity q_{jm} by the estimated gains in overall survival from Phase III clinical trials, as well as a scaling factor $1/\phi_j$, where ϕ_j is the number of years over which patients take drug j in a standard course of treatment. The scaling factor ϕ_j, taken from the drug labels in the SinoHealth data, converts quantities in years of treatment into the number of patients with the standard course of treatment.

3.3 Estimation

Estimation proceeds through the following steps. In the first step, we recover demand parameters by estimating Equation (1). In the second step, for each successfully negotiated drug, we recover the marginal cost in each province using demand parameter estimates and the observed prices and market shares during the quarter before the negotiation. Here, we assume Bertrand-Nash competition among all firm-market pairs whose prices are not yet determined by negotiations.[24] We also assume that marginal costs for drugs under negotiation remain unchanged from their pre-negotiation levels. Note that we can separately identify marginal costs and bargaining parameters (discussed below) because we observe market outcomes in pre-negotiation periods.

In the third step, we assume the government's relative weight on insurance spending $\exp(\beta)$ follows an exponential distribution (i.e., β follows T1EV distribution): $\exp(\beta) \sim Exp(X_{\beta j}; \theta_\beta)$. We allow θ_β to be a function of drug attributes $X_{\beta j}$ such as clinical effectiveness. The drug firm's bargaining power may depend on attributes $X_{\tau j}$ such as nationality: $\tau_j = f(X_{\tau j})$.

We then construct the sample log-likelihood function for parameters $\theta = \{\beta, \tau\}$, using the observed negotiation outcomes $\{\mathcal{G}_j \in \{0,1\}, \forall j\}$ and negotiated prices $\{p_j\}$ for all successful cases $\mathcal{G}_j = 1$.[25] A negotiation fails if the government's gains from trade are negative at the lowest price acceptable to the drug company, denoted by p_j^l. By construction, p_j^l satisfies:

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

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

$$\underline{\beta_j} = \frac{\Delta CS_j(p_j^l; \mathbf{p_{-j}}, \mathcal{G})}{\Delta TC_j(p_j^l; \mathbf{p_{-j}}, \mathcal{G}).} \tag{5}$$

Any β above $\underline{\beta_j}$ results in the government's gains turning negative at p_j^l, leading to bargaining

[24] 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. There are ten negotiated drugs that could treat cancer (but are also used for other conditions), but are not mAbs or PKIs. These are included in the demand estimation but excluded from the supply estimation and counterfactual simulations.

[25] Each first-order condition takes as given the prices of non-negotiated drugs, whose prices are set using the Bertrand Nash first-order condition in the same period, and of drugs whose prices are fixed under contracts negotiated in previous periods. Both the government and firms use demand conditions from one quarter before the negotiation to evaluate gains from successful negotiations in future periods.

failure. Intuitively, this condition implies that the government is unwilling to include the drug in the formulary, even at the firm's lowest acceptable price. The likelihood of observing a negotiation failure for drug j is thus $Pr_j(\beta > \underline{\beta_j}) = 1 - F_\beta(\underline{\beta_j}; \theta_\beta)$.

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

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

where $\vartheta = -\frac{\tau_j}{1-\tau_j}\frac{\partial \Pi_j}{\partial p_j}$. Given the distributional assumption on β, the likelihood of observed price p_j is $\frac{\partial \beta_j}{\partial p_j} f_\beta(\beta_j(p_j; \tau_j); \theta_\beta)$. Putting things together, the joint log-likelihood function is:

$$log\mathcal{L}(\theta_\beta, \tau) = \sum_j \underbrace{\mathbb{1}(\mathcal{G}_j = 1) \log\left(\frac{\partial \beta_j}{\partial p_j} f_\beta(\beta_j(p_j; \tau_j); \theta_\beta)\right)}_{\text{successful negotiations}} + \underbrace{\mathbb{1}(\mathcal{G}_j = 0) \log\left(1 - F_\beta(\underline{\beta_j}; \theta_\beta))\right)}_{\text{failed negotiations}}.$$

We estimate the supply-side parameters via maximum likelihood, using all (successful and failed) negotiations.

4 Results

4.1 Demand Estimates

Table 3 reports OLS demand estimates in Column (1) and IV estimates in Columns (2)-(5). Columns (3) and (4) allow price sensitivity to vary with patient income. Column (5) adds a random coefficient on prices. The set of instruments expands across columns: Column (2) uses the negotiation dummy; Column (3) adds its interaction with province-year median income; Column (4) further includes interactions with the 25th and 75th income percentiles; and Column (5) additionally incorporates the number of rivals within an ATC4-province-year.

Instrumenting for the out-of-pocket price OOP has the anticipated effect of increasing the magnitude of the estimated price elasticity. Products with large positive demand shocks tend to have both higher prices and higher demand, biasing the price coefficient downward. In Column (2), which instruments 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

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	112,019	112,019	112,019	112,019	112,019
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-year-quarter FE	Yes	Yes	Yes	Yes	Yes

Note: The table presents demand estimates, with all specifications controlling for product and province-by-year-quarter fixed effects. Column (1) reports OLS estimates, while Columns (2)-(5) present IV estimates using different sets of instruments. Column (2) uses the negotiation dummy as an instrument. Column (3) adds its interaction with province-year median income. Column (4) further includes interactions with the 25th, 50th, and 75th percentiles of province-year income as additional IVs. Column (5) builds on Column (3) by also including the count of rival products in the same ATC4-province-year as an instrument. The reported median elasticity is the median of individual-level elasticities across products, defined as $\frac{ds_{ij}/s_{ij}}{dp_j/p_j}$.

(3)-(5), the interaction between income and price is statistically and economically significant, indicating that higher-income individuals are less price-sensitive. The results in Columns (3) and (4) are very similar. In our preferred specification, Column (4), the median own-price elasticity is -1.56, with an inter-quartile range of [-1.89, -1.28]. The difference in price sensitivity between high- and low-income households underscores the importance of distributional considerations, especially since the highest-income provinces in our setting have the lowest coinsurance rates.

The random coefficient specification in Column (5) yields parameter estimates similar to

those in Column (4), but the median own-price elasticity increases to –2.35. This would imply lower pre-NRDL profit margins than those suggested by industry reports, and that 75% of successfully negotiated drugs have negative profits post-negotiation.[26] For these reasons, we do not use Column (5) as our preferred specification. Appendix Figure A2 shows the distribution of implied average product-level own-price elasticities under the preferred specification.

Robustness The demand specifications above control for drug and province-by-year-quarter fixed effects and exploit variation in sales before and after negotiations to recover price sensitivity and drug substitution patterns. Appendix Table A1 presents robustness checks. Column (1) replaces drug fixed effects with drug-year-quarter fixed effects (while retaining province-year-quarter fixed effects). This identification strategy relies on variation in OOP price changes *within* a given drug-year-quarter and *across* provinces, akin to a shift-share design where the shift is negotiation and the share is the provincial coinsurance rate. Column (2) limits the sample to innovative drugs. Columns (3)-(5) estimate alternative nested logit specifications using drug class information: a single nest for innovative drugs, a separate nest by ATC3 group, and a separate nest by ATC4 group. The median own-price elasticities resulting from these specifications are broadly consistent, ranging from -1.20 to -1.60.

4.2 Supply Estimates

Table 4 presents the estimates for β, the government's weight on drug insurance spending, and τ, firms' bargaining power parameter. Column (1) estimates one β and τ for all drugs, while Column (2) allows β to vary with the life-years saved per treatment course and permits domestic and foreign firms to have different bargaining parameters.

Regarding the government's weight on drug spending (i.e., the shadow cost of the budget constraint), the θ_β parameter from the log-exponential distribution implies that β is 0.87 for the average drug and 1.08 for the median drug. The negative coefficient on survival in Column (2) indicates that β is lower for drugs with greater survival benefits. Specifically, a one standard deviation increase in overall survival (6 months) reduces β by approximately 0.13. This implies that, while the government values consumer surplus and drug spending equally for the median drug, it places relatively more weight on consumer surplus for higher-

[26] Accounting estimates of biologic drug marginal costs in the U.S. vary widely; one review article reports a range of 5–19% of price (Chen et al., 2025). Given that pre-reform cancer drug prices in China were lower than those in the U.S.—one study reports a median price ratio of 0.36 (Goldstein et al., 2016)—this would suggest marginal costs ranging from 14–53% of the price in our sample, a range that encompasses our estimate of approximately 25%.

quality drugs, effectively relaxing the budget constraint for these drugs. This finding suggests a policy preference for including high-quality drugs in the NRDL formulary. Our β estimates appear sensible given the estimates in the public finance literature where the social cost of government funds is often assumed to be 1.3 (Ballard et al., 1985).

Table 4: Supply-side Estimation

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

Note: This table presents the supply side estimates. The government's weight on drug spending, β, is assumed to follow a T1EV distribution with the inverse scale parameter determined by θ_β. The mean and median of β are 0.87 and 1.08, respectively. Firms' bargaining power parameter is estimated to be 0.68 and similar across domestic and foreign firms.

The bottom panel of the table indicates that firms' bargaining power, τ, is estimated to be 0.68, and is similar for both domestic and foreign (multinational) firms. While firms possess more bargaining power than the government, the government still has enough bargaining power to negotiate prices well below those that would prevail in the private market (i.e., under Bertrand-Nash pricing).

Robustness The baseline estimations assume the government follows a utilitarian objective. As a robustness check, we estimate the supply-side parameters assuming the government cares about equity (Equation (4), with $\nu > 0$). The β and τ estimates are robust across ν's, but the utilitarian case with $\nu = 0$ delivers the best in-sample fit as measured by the likelihood (Appendix Table A2). We use $\nu = 0$ as our preferred specification for the main analyses, while also reporting welfare results for $\nu = 1$ and $\nu = 2$ to explore equity considerations. We tried alternative distributional assumptions of β (such as χ^2), and the results are similar.

4.3 Evaluation of the NRDL Reform

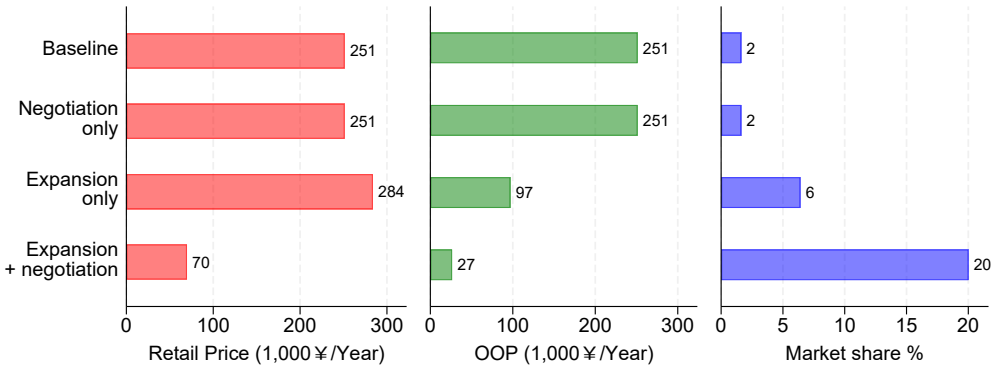
The NRDL Reform consists of two policy instruments: (1) insurance expansion, which adds previously uninsured innovative drugs to the NRDL formulary, and (2) central negotiation, where the government and pharmaceutical firms bargain to determine a mutually agreeable price. We first decompose the effects of the NRDL Reform on prices, quantities, and welfare into impacts driven by insurance expansion and those driven by central negotiation. We then explore how these welfare implications vary across provinces and income groups.

During our study period (2017Q1–2023Q2), 57 drugs were included in the NRDL formulary. The analyses here focus on these drugs with successful negotiation outcomes. We revisit the 13 drugs that failed NRDL negotiations and the issue of bargaining failure in Section 5, where we examine alternative policy designs. We conduct simulations using the second quarter of 2023 as our reference period, holding patient income, preferences, and production costs at their 2023Q2 levels. In each counterfactual simulation, we compute negotiated prices for these 57 drugs, solve for the equilibrium prices for drugs excluded from the formulary and sold in the private market, and then determine the equilibrium quantities for all cancer drugs.

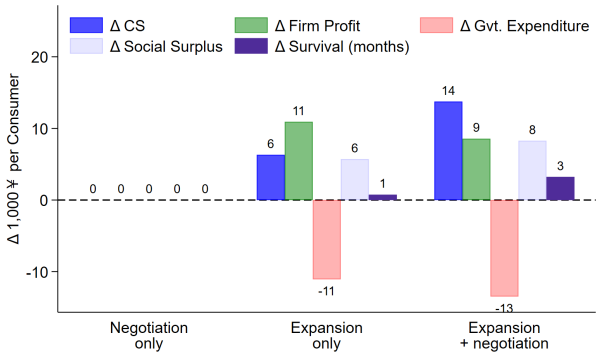
We consider four scenarios. In the **Baseline** scenario, we assume that the NRDL Reform did not occur. There was no insurance expansion, and all 57 successfully negotiated drugs would instead be sold only in the private market. This scenario mirrors the pre-reform conditions in 2016 but accounts for new drugs that entered the market between 2017 and 2023. In the **Negotiation-only** counterfactual, the government negotiates prices with drug firms but does not provide insurance coverage for the negotiated drugs. Firms retain the option to sell in the private market if negotiations fail. In the **Expansion-only** scenario, the government includes the 57 cancer drugs in the NRDL formulary, allowing patients to purchase them at province-specific coinsurance rates, but does not engage in central price negotiations. Pharmaceutical firms continue to set prices via Bertrand-Nash competition. Finally, we consider **Negotiation+expansion**, which represents the full NRDL reform as implemented in the data but assumes that all negotiations take place in the 2nd quarter of 2023.

Prices and Quantities The top row of Figure 5(a) reports baseline prices and quantities. Absent the NRDL Reform, both OOP and the retail prices for an annual dosage would average about ¥251,000 per year (equivalent to $35,900), with the focal innovative drugs capturing only 2% of the cancer drug market. Results for the Negotiation-only scenario in the second row of Figure 5(a) are identical to the Baseline. Without insurance, there is no promise of a demand expansion. Thus, the government has no leverage to incentivize firms to participate

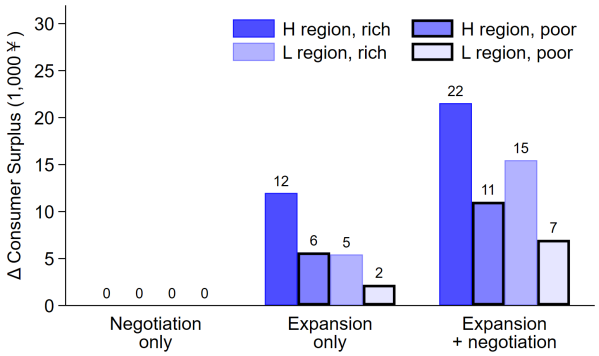
Figure 5: Effect of NRDL Reform—Decomposition



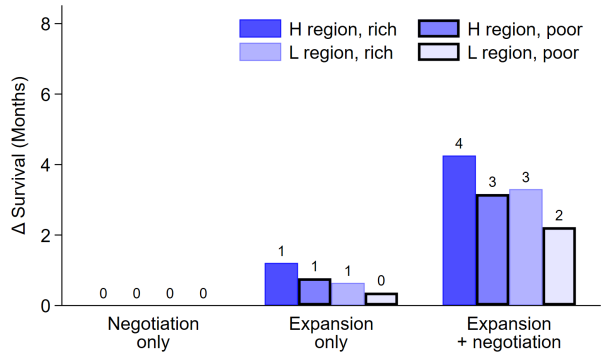
(a) Price and Market Share of Innovative Cancer Drugs



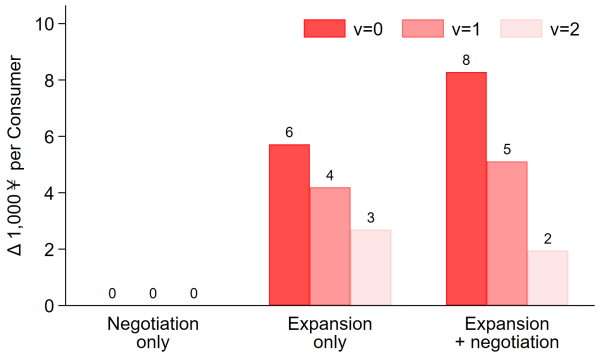
(b) Welfare Effects



(c) Δ Consumer Surplus by Income Group



(d) Δ Survival by Income Group



(e) Alternative Social Surplus Measures

Note: This figure summarizes counterfactual outcomes for the 57 cancer drugs successfully negotiated as of 2023. Panel (a) compares four scenarios. "Baseline" denotes Bertrand-Nash pricing with no insurance coverage. "Negotiation only" assumes the government negotiates lower prices with firms but does not provide insurance coverage. "Expansion only" assumes the government offers insurance coverage without engaging in price negotiations. "Expansion+negotiation" represents the NRDL reform, where the government provides insurance coverage and negotiates prices. Panels (b)-(e) show differences in each scenario relative to the "Baseline" in terms of changes in welfare, consumer surplus by income group, overall survival gains by income group, and alternative social surplus measures that incorporate equity. Appendix Table A3 provides more details.

in negotiations, and firms prefer to sell drugs in the private market at profit-maximizing prices rather than accepting negotiated terms.

The third row of Figure 5(a) presents results for the Expansion-only scenario. Insurance lowers patients' out-of-pocket costs, increases demand, and allows firms to raise their retail prices given the reduced price sensitivity. Specifically, for every ¥100 increase in the retail price, patients pay only ¥20–¥45 after insurance. This leads to a 13% increase in the average retail price to ¥284,000 per year, while patients' OOP spending decreases to ¥97,000 per year (a 61% reduction). Demand surges: the focal innovative drugs' market share increases from 2% to 6% (a 295% expansion).

The fourth row of Figure 5(a) illustrates the combined effect of the full NRDL Reform, with both insurance expansion and central negotiation. Unlike the Expansion-only scenario, the combined reform significantly lowers both retail prices *and* OOP: the average retail price per annual dose decreases by ¥182,000 (a 72% reduction), and OOP spending drops by ¥225,000 (an 89% reduction). These price reductions drive a 1,133% spike in market share, with the focal innovative drugs capturing 20% of the cancer drug market, a result comparable to the 930% quantity expansion documented in Section 2.3.

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

Welfare Figure 5(b) illustrates the welfare effects of each scenario relative to the Baseline. Each group of bars represents changes in consumer surplus (CS), firm profit (PS), government spending (GS), total surplus (CS + PS − GS), and overall survival. To emphasize that higher government spending reduces surplus, we plot government expenditures as negative values.

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

These results highlight that negotiation alone does not affect welfare, while insurance expansion benefits patients but entails relatively high government spending. In the NRDL

Reform, negotiation and insurance expansion are complements: insurance expansion ensures broader access to drugs, while negotiation shifts part of the financial burden from the government to pharmaceutical firms (through lower drug prices), benefiting both the government and patients. Overall, total social surplus is highest under the combined reform, increasing by ¥8,000 per patient-year relative to the Baseline, compared to ¥6,000 under Expansion-only.

An alternative approach to evaluating welfare is to use health outcomes. Enhanced access to innovative cancer drugs under the combined NRDL Reform extends overall survival by 3.16 months per patient, a *1,084%* increase relative to the survival improvements due to innovative drugs at Baseline. This effect is far larger than the survival benefit of insurance expansion alone, which increases survival by 0.71 months (243% of the Baseline). Note the contrast between CS and survival in Figure 5(b): while gains in CS under the combined NRDL Reform are more than twice those in the Expansion-only scenario, the survival benefits are nearly fivefold larger. This discrepancy arises because poorer patients contribute less to CS due to their lower willingness to pay, but they experience substantial health benefits.

In aggregate, the innovative drugs successfully negotiated under the NRDL Reform between 2017 and 2022 generated nearly ¥40 billion ($5.6 billion) in annual consumer surplus gains and contributed a total survival increase of 900,000 life-years among Chinese cancer patients each year.

Innovation While we abstract away from dynamic considerations such as R&D, our results suggest that the NRDL reform increases firm profits through market expansion, which could spur firm pharmaceutical innovation in the long run and reinforce the short-run welfare gains. This is in contrast to programs that negotiate prices without stimulating demand, as may occur in markets with generous insurance for innovative drugs (Garthwaite, 2025).

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

These distributional effects are illustrated in Figure 5(c). Wealthier regions offer lower coinsurance rates; hence, a given reduction in retail drug prices leads to a larger decrease in OOP expenses. In addition, high-income households are less price-sensitive and more likely

to purchase innovative drugs. As a result, rich individuals in high-income (low-coinsurance) regions experience the largest dollarized welfare gains under both Expansion-only and Negotiation+expansion, at ¥12,000 and ¥22,000, respectively. In contrast, the welfare gains for poor patients in low-income provinces are significantly lower, at ¥2,000 and ¥7,000, respectively.

A similar, though less extreme, pattern emerges when we measure patient benefits using increases in months survived, as shown in Figure 5(d). While wealthy households in high-income provinces still benefit the most, the disparities in survival gains are much smaller than those in CS gains. This is because survival is a quantity-based measure and is therefore less sensitive to the differences in price sensitivity across income groups. Echoing the discussions above, all income groups experience three to sixfold increases in survival benefits under the combined reform relative to Expansion-only.

Turning to social surplus, both Expansion-only and Negotiation+expansion lead to increases in social surplus compared to the Baseline (Figure 5(e)). However, both scenarios are regressive because wealthier patients benefit more than poorer ones in terms of both CS and survival improvements. The relative ranking of these two policies depends on the government's preference for equity. As the government's weight on equity increases (ν, defined in Equation (4), increases from 0 to 1 or 2), the social surplus gains associated with each policy decline. This is because both policies entail greater government subsidies for high-income patients than for low-income patients, and a stronger preference for equity penalizes such transfers.

If the government is utilitarian ($\nu = 0$) or has a moderate preference for equity ($\nu = 1$), the efficiency considerations (gains in CS) dominate, making the combined reform the preferred policy. However, if the government has a very strong preference for equity ($\nu = 2$), then the flatter gradient in consumer surplus under Expansion-only becomes more desirable than the steep gradient under Negotiation+expansion.

5 Counterfactual Policy Simulations

In this section, we compare the observed NRDL Reform with several alternative policy designs to evaluate how policy choices impact firms' and governments' gains from trade and, ultimately, the welfare effects of drug market reforms. Section 5.1 examines market access negotiation, Section 5.2 compares centralized negotiation (as in NRDL Reform) with decentralized negotiation, and Section 5.3 investigates optimal coinsurance designs. Each of these scenarios represents a feasible alternative: bundled negotiation for market access and reimbursement occurs in Canada and other high-income countries (Dubois et al., 2022); the US,

EU, and Latin America each have decentralized regimes that are adopting (or proposing to adopt) greater centralization (Duggan and Scott Morton, 2010; Ho and Pakes, 2024; PAHO Executive Committee, 2024); and means-tested coinsurance is the norm in many public insurance models, including several in the US (Commonwealth Fund, 2020).

We discuss both extensive and intensive margins for all alternative policy designs. On the extensive margin, different policy frameworks alter the range of prices that are mutually acceptable to firms and the government, thereby influencing the number of successful negotiations. On the intensive margin, policy variations affect the government's and firms' surplus, which in turn changes negotiated prices, realized quantities, and welfare, conditional on negotiation success. Throughout this Section, we refer to Figure 6 for graphical intuition regarding how policy affects gains from trade and bargaining outcomes.

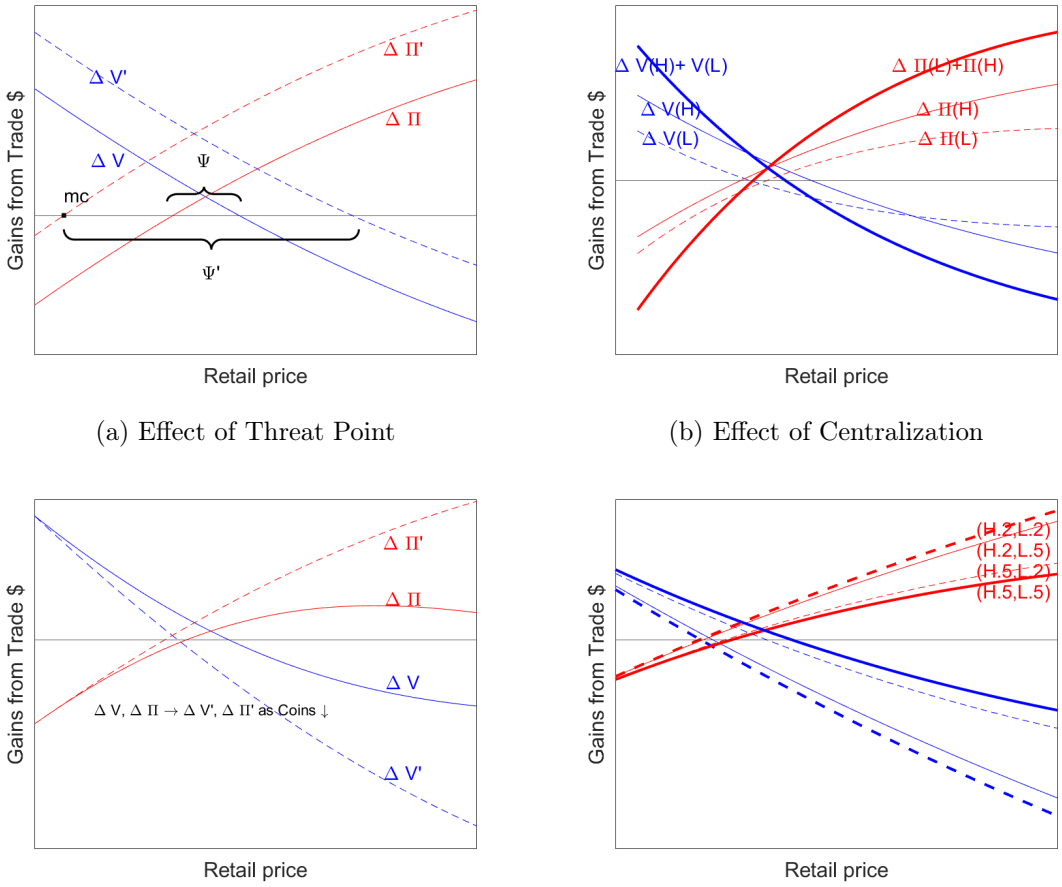
Our simulations consider all 70 drugs in the 2023Q2 market, including the 13 drugs that failed NRDL negotiations. Since we do not observe the negotiated prices for these drugs, we cannot recover their $\boldsymbol{\beta}$ values. However, we observe the lower-bound thresholds $\underline{\boldsymbol{\beta}}$ (Equation (5)) such that the government's gains from trade equal zero at the price that makes the drug company's gains from trade equal zero. That is, a slight reduction in β would have resulted in negotiation success. In the counterfactual simulations presented in the main text, we set $\boldsymbol{\beta} = \underline{\boldsymbol{\beta}}$ for these 13 drugs. In Appendix Section C, we report results under an alternative extreme assumption that these 13 negotiations would always fail ($\boldsymbol{\beta} = \boldsymbol{\infty}$).[27]

Since the success or failure of one drug's negotiation can influence the gains from trade in other negotiations, there could theoretically be multiple equilibria in counterfactual simulations. We detail our algorithm for addressing these concerns in Appendix B.1.[28] Briefly, we use an algorithm similar to the bounding approach in Sabal (2025): in each iteration, we identify drugs that must be in the formulary as those whose narrowest possible admissible price set is nonempty, and drugs that must not be in the formulary as those whose widest possible admissible price set is empty.

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

[28] In our setting, we do not find evidence of multiple equilibria, as these innovative cancer drugs are sufficiently differentiated from each other. As discussed in Appendix B.1, there is no significant spillover effect of a successful negotiation on other drugs in the same indication.

Figure 6: Effects of Policy Designs on Gains from Trade



(a) Effect of Threat Point

(b) Effect of Centralization

(c) Effect of Coinsurance

(d) Effect of Income-Based Coinsurance

Note: This figure illustrates the effects of policy designs on gains from trade for both firms and the government. Panel (a) compares gains from trade under NRDL (FA-I) ($\Delta\Pi$, ΔV, and range of admissible prices Ψ) with those under the counterfactual MA-I scenario ($\Delta\Pi'$, $\Delta V'$, range of admissible prices Ψ'). Panel (b) contrasts gains from trade in a high-income province $(\Delta\Pi(H), \Delta V(H))$ vs. a low-income province $(\Delta\Pi(L), \Delta V(L))$; the bold line shows $(\Delta\Pi(H) + \Delta\Pi(L), \Delta V(H) + \Delta V(L))$ to illustrate the benefits of centralization. Panel (c) compares gains from trade under insurance expansions with high $(\Delta\Pi, \Delta V)$ vs. low coinsurance rates $(\Delta\Pi', \Delta V')$. Panel (d) plots gains from trade under different income-based coinsurance schedules (γ_H, γ_L), where γ_H and γ_L denote coinsurance rates for high- and low-income patients, respectively. The thick dashed lines represent a uniform coinsurance rate of $(0.2, 0.2)$, thin solid lines represent $(0.2, 0.5)$, thin dashed lines represent $(0.5, 0.2)$, and thick solid lines represent $(0.5, 0.5)$.

5.1 Market Access Negotiation

In Section 4.3, we noted that negotiation has no bite unless paired with insurance expansion. In this section, we model a "market-access" negotiation, where formulary inclusion is bundled with drug entry. Under this policy, a failed negotiation results in the drug being entirely

excluded from the Chinese market. This market-exclusion threat point is commonly used in empirical health economics studies, e.g., Dubois et al. (2022); Gowrisankaran et al. (2015); Grennan (2013); Ho and Lee (2017). We analyze two scenarios: market-access negotiation without insurance expansion (MA-N) and with insurance expansion (MA-I). Additionally, we use the abbreviation FA-N for formulary-access negotiation without insurance and FA-I for formulary-access negotiation with insurance (i.e., the NRDL Reform).

Consider first the MA-N scenario, where government expenditure is always zero regardless of the negotiation outcome, and the government's sole objective is to maximize consumer surplus. Unlike the ineffective Negotiation-only case in Section 4.3, the price in the event of bargaining failure is ∞, as the product is removed from the patients' choice set. In contrast, under FA-N, the disagreement price is p^{BN}. The higher disagreement price—the harsher threat point—under MA-N increases the gains from trade for both the government and firms. This, in turn, expands the range of admissible prices to be any price between the marginal costs of producing innovative drugs and patients' willingness to pay. Consequently, negotiations always succeed, and the government *does* have leverage in this setting, as shown below.

Now consider MA-I. This policy differs from FA-I (the NRDL Reform) in several key ways. Similar to the discussion above, the price in the event of bargaining failure under MA-I equals ∞, whereas under FA-I, it is p^{BN}. The more severe disagreement payoff expands the set of admissible prices. Firms are willing to accept any price above marginal cost, while the government is willing to pay any price where consumer surplus exceeds government expenditure weighted by β. Thus, switching from FA-I to MA-I increases the likelihood of successful agreements.[29] Figure 6(a) illustrates how the gains from trade for both the government (ΔV) and the drug company ($\Delta\Pi$) shift upward under MA-I compared to the NRDL Reform, thereby widening the admissible set of prices (Ψ).

That said, the effect of switching from FA-I to MA-I on negotiated prices is ambiguous, depending upon the relative magnitudes of the changes in ΔV and $\Delta\Pi$, as well as the bargaining parameter τ. To see this, note that prices are at the bounds of the admissible set Ψ under extreme values of τ. If $\tau = 1$, then $p^{MA-I} > p^{FA-I}$ because the upper bound of the admissible set is higher under MA-I; if $\tau = 0$, then $p^{MA-I} < p^{FA-I}$ because the lower bound of the admissible set is lower under MA-I. Intuitively, if the firm has all the bargaining power, it obtains all of the government's increase in surplus in a move from FA-I to MA-I, and vice versa. Appendix B.2 presents the more nuanced finding for cases where each negotiated price is in the interior of the admissible set: $p^{MA-I} < p^{FA-I}$ if and only if the ratio of the

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

government's inclusion payoff (payoff received upon successful negotiation, which is identical under both MA-I and FA-I) to its deviation payoff under FA-I exceeds the corresponding ratio for the firm. This is more likely to hold when τ is small.

Negotiation Success, Prices, and Quantities Figure 7(a) compares simulated OOPs, retail prices, and quantities under four scenarios (FA-N is discussed in Section 4.3): (1) the Bertrand-Nash Baseline (no negotiation or insurance expansion), (2) MA-N, (3) MA-I, and (4) FA-I (i.e., the existing NRDL Reform). We report the counterfactual results separately for the 13 drugs that failed the NRDL negotiations and the 57 successfully included drugs.

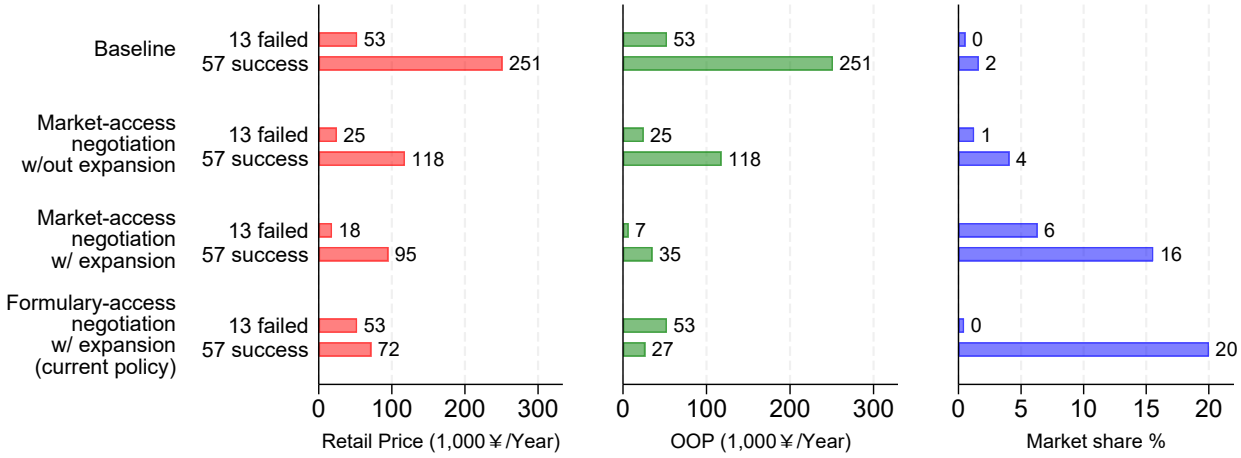
Compared to the baseline, both MA-N and MA-I ensure successful negotiations for all drugs, driving significant market expansion. Under MA-N, the government achieves substantial price reductions by leveraging the threat of market exclusion, even without insurance expansion. The average negotiated price drops by 53% for both "failed" and "successful" drugs. The OOP prices are the same as negotiated prices. Market shares increase by 0.7 ppt (125%) for the 13 failed drugs and by 2.5 ppt (151%) for the 57 successful drugs. With insurance expansion (MA-I), negotiated and OOP prices decline even further. For failed drugs, retail prices decrease by ¥30,000 (57%), OOPs drop by ¥46,000 (87%), and market share expands by 5.8 ppt (1,035%). For successful drugs, retail prices fall by ¥155,000 (62%), OOPs decline by ¥216,000 (86%), and market share grows by 14.0 ppt (859%).

As in the NRDL Reform, insurance complements negotiation: MA-I achieves significantly larger price reductions and quantity expansions for both failed drugs and successful drugs than MA-N. However, the price reductions for successful drugs are slightly smaller than those under NRDL Reform, shown in the bottom row. As a result, market expansion for successful drugs is also smaller (14 ppt vs. 18 ppt; 859% vs. 1,133%). This is because the more severe threat point in MA-I disproportionately impacts the government's gains from trade. However, the result of a smaller price discount depends on firms having high bargaining power. In alternative simulations with $\tau = 0.32$ (where the government holds more bargaining power), we find that MA-I performs as well as NRDL even for the 57 successful drugs.[30]

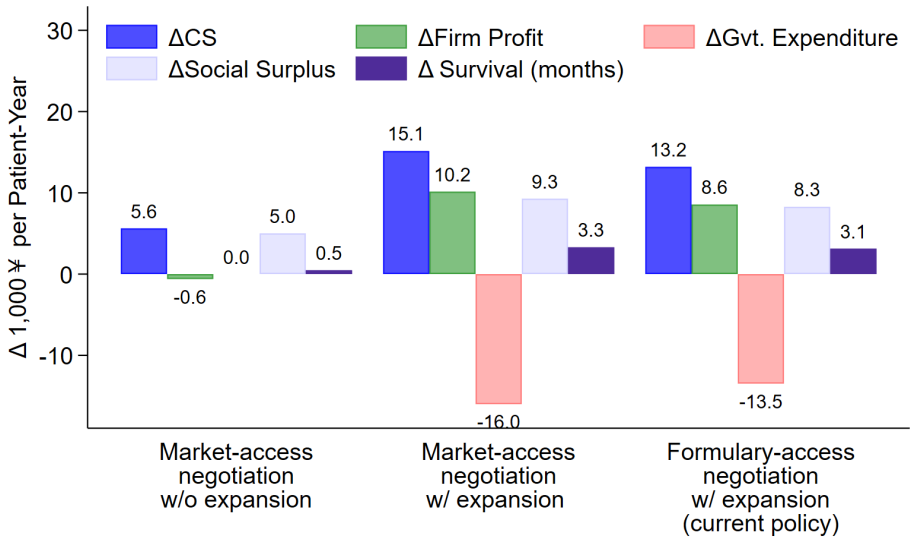
Welfare and Survival Implications Figure 7(b) illustrates changes in welfare in ¥1,000s per cancer patient-year and gains in survival months for the three policy designs relative to the baseline. MA-I generates significantly higher consumer surplus and firm profits than FA-I, but it also increases government expenditure because more drugs (70 vs. 57) are included in

[30]Results are available upon request.

Figure 7: Counterfactual Results under Alternative Bargaining Formats ($\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$)



(a) Price and Market Share



(b) Welfare Effects

Note: This figure presents results for all 70 innovative cancer drugs from alternative negotiation scenarios, assuming $\boldsymbol{\beta}_{\text{failed}} = \underline{\boldsymbol{\beta}}$ for drugs that failed the NRDL negotiations. For successfully negotiated drugs, β are fixed at their estimated values. Panel (a) compares four scenarios, with results shown separately for the 57 drugs that succeeded in the NRDL reform and the 13 that failed. "Baseline" denotes Bertrand-Nash pricing without insurance coverage. "Market-access negotiation" assumes that drugs are excluded from the Chinese market if negotiations fail. "Market-access negotiation w/ expansion" builds on this by adding insurance coverage at observed provincial coinsurance rates. Finally, "Formulary-access negotiation w/ expansion" corresponds to the NRDL reform. Panel (b) reports changes in welfare relative to the baseline scenario. See Appendix Figure A3 for results with $\boldsymbol{\beta}_{failed} = \infty$.

the formulary. Nevertheless, MA-I generates a higher total surplus on net. MA-I also achieves greater gains in average survival months.

These analyses highlight three key takeaways. First, in the absence of insurance expansion, market access negotiation is (infinitely) more effective than formulary access negotiation. Second, insurance expansion amplifies the effects of negotiation, making the two policy tools highly complementary. Third, MA-I delivers greater overall welfare gains (higher consumer, firm, and social surplus) and medical benefits than FA-I.

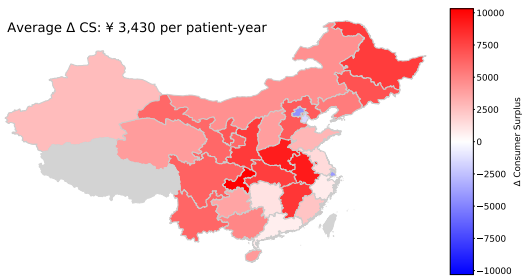
5.2 Centralized vs. Decentralized Negotiation

The findings in Section 4.3 on the distributional effects of the NRDL Reform motivate two sets of counterfactual analyses: one examining geographic variations, and the other investigating equity and regressivity. This section addresses the former (with Section 5.3 covering the latter) by comparing centralized national bargaining (the status quo) with a counterfactual scenario in which each province negotiates its own prices. These analyses contribute to ongoing policy debates and academic discussions 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).

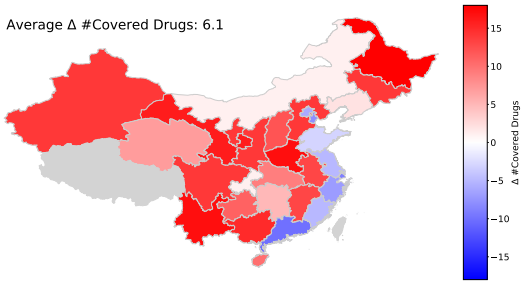
In the decentralized negotiation setting, each provincial government independently manages its formulary and negotiates drug prices, with the threat point being exclusion from the provincial formulary rather than from the national list. To ensure comparability, we impose a uniform coinsurance rate across provinces—set at the national average of 0.37—for both decentralized and centralized negotiations. Holding coinsurance rates constant across provinces allows us to isolate the distributional effects of centralized negotiation, separate from those driven by variations in coinsurance rates, which we analyze in Section 5.3.

Variation in Effects of Centralized Negotiation Figure 8 illustrates the distributional consequences of centralized negotiation. Centralization increases the leverage of lower-income provinces at the expense of wealthier ones, with implications on both the intensive and extensive margins. Figure 8(a) and 8(b) plot changes in consumer surplus and number of drugs covered in each province when shifting from decentralized to centralized negotiation. Most regions benefit along both dimensions, especially provinces in central and western China with lower income levels. Provinces that experience larger gains in consumer surplus also tend to see greater increases in drug coverage. To put a finer point on this, Figure 8(c) reveals a fairly steep income gradient in the consumer surplus gains, while Figure 8(d) shows a similar

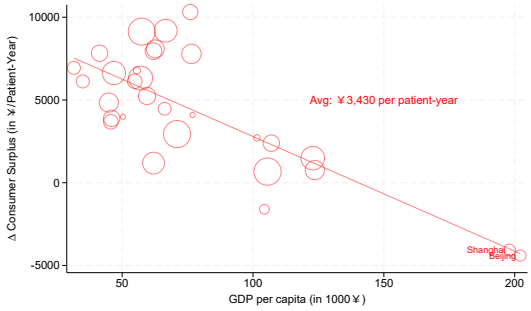
Figure 8: Changes in CS and Drug Coverage from Decentralized to Centralized Negotiation



(a) Δ CS per Patient-year



(b) Δ Number of Covered Drugs



(c) Δ CS vs. Income

(d) Δ Number of Covered Drugs vs. Income

Note: Panels (a)-(b) show the geographic distributions of changes in consumer surplus per patient-year and the number of covered drugs across provinces when moving from decentralized negotiation with insurance expansion to centralized negotiation with insurance expansion. Panels (c)-(d) present bubble plots of the same outcomes, with GDP per capita on the x-axis. Each bubble indicates one province, and bubble size scales with the province's population. All the results are based on simulations with $\boldsymbol{\beta} = \underline{\boldsymbol{\beta}}$ for failed negotiations. See Appendix Figure A4 for results with $\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$.

gradient in drug coverage. The wealthiest provinces benefit less or even incur losses under centralized negotiation. For example, Beijing and Shanghai would cover six to nine *fewer* drugs under centralization compared to the decentralized scenario.

Negotiation Success, Prices, and Quantities On average, centralized bargaining results in 6.1 additional negotiation successes (an 11% increase) per province compared to decentralized bargaining. Among the 57 drugs included in the actual NRDL formulary, average retail prices would be 26% lower, and the market shares of innovative drugs would rise by 4.2 ppt (a 32% increase). These effects reinforce one another, leading to a net gain in aggregate social surplus of ¥660 (2%) per patient-year and an increase in consumer surplus of ¥3,430 (18%) per patient-year under centralized bargaining relative to decentralized negotiations.

Mechanisms Prior research has shown that centralization can lead to lower prices when suppliers' cost functions depend on quantities (Chipty and Snyder, 1999; Inderst and Wey, 2007), when there is mutual dependency between buyers and sellers (Inderst and Montez, 2019), or when buyers compete (Ho and Lee, 2017). These mechanisms do not apply in our setting. Instead, centralization changes equilibrium outcomes through its impact on bargaining failures and regional heterogeneity in willingness-to-pay, as illustrated in Figure 6(b). Intuitively, firms' gains from trade, $\Delta\Pi$, are consistently higher in high-income than low-income provinces. In the price range where firms are willing to negotiate, the government's gains from trade, ΔV, are also higher in high-income provinces because the benefits from market expansion outweigh government costs.[31] By aggregating gains from trade across all provinces, centralized bargaining leads to more negotiation successes and lower prices on average.[32]

5.3 Coinsurance Schedule Design

China's existing provincial coinsurance schedule is regressive and ranges between 0.2 and 0.45 (Figure 1). This section explores the welfare implications of more and less progressive income-based coinsurance schedules. For simplicity, we consider a two-tier structure where households with income above and below the national median face different coinsurance rates. We simulate equilibrium outcomes while varying coinsurance rates for high- and low-income patients between 20% and 50%, a range consistent with the data. To incorporate the social planner's equity preferences, we weigh consumer surplus by $income^{-\nu}$ as in Section 3.2. The case of $\nu = 0$ corresponds to a utilitarian social planner, while higher values of ν reflect stronger preferences for equity.

We first discuss the implications of different levels of coinsurance rates. The effect of higher coinsurance rates on negotiation outcomes is theoretically ambiguous.[33] Holding prices and formularies constant, lower (i.e., more generous) coinsurance rates unambiguously raise consumer demand, consumer surplus, and firms' gains from trade. However, the effect on the government's gains from trade is less clear because lower coinsurance also increases government expenditures. Figure 6(c) presents a case in which the government's gains from trade

[31] This no longer holds at higher prices, where higher demand in high-income provinces becomes prohibitively expensive.

[32] For low-income provinces, centralization expands the admissible set and, conditional on a successful negotiation, results in higher negotiated prices. For high-income provinces, it shrinks the admissible set and leads to lower negotiated prices. On net, the extensive margin gains in low-income regions and the intensive margin savings in high-income regions dominate, resulting in more negotiation success and lower overall prices.

[33] See Appendix B.3 for details.

are lower under a lower coinsurance rate.[34] In such cases, lower coinsurance rates tend to reduce the likelihood of negotiation success, but also tend to reduce retail and OOP prices for drugs that are successfully negotiated. Intuitively, conditional on successful negotiation, lower coinsurance rates increase firms' gains from trade, which in turn strengthens the government's bargaining leverage and makes firms more willing to accept lower negotiated prices.

Importantly, the magnitude and direction of these effects depend on *who* is subject to coinsurance increases. Figure 6(d) extends the example from Figure 6(c), comparing gains from trade under four income-based coinsurance schedules, where high- and low-income patients face either 20% or 50% coinsurance. In this example, as in our empirical exercise, increasing the coinsurance rate for high-income patients has a much larger impact on gains from trade for both parties than increasing it for low-income patients. Note also that a given income group's coinsurance rate has *spillover* effects on the other income group via retail prices and negotiation success, which apply to all patients regardless of income.

Negotiation Success and Prices The effects of alternative coinsurance schedules across all eligible drugs are presented in Figure 9.[35] Figure 9(a) confirms that lowering coinsurance rates increases negotiation failure, particularly when they apply to high-income patients. For example, when coinsurance equals 20% across all patients, half of all negotiations fail.

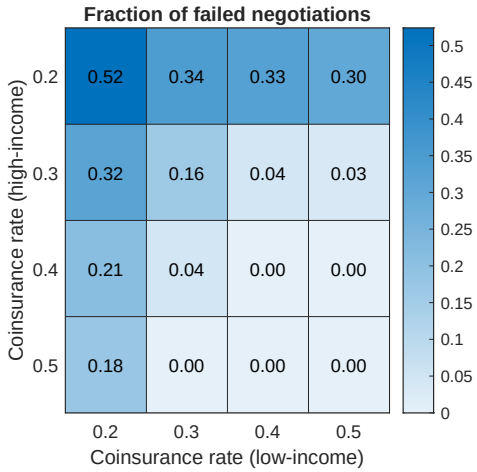
Figure 9(b) shows the average retail price of innovative cancer drugs, restricted to the 33 drugs that are always successfully negotiated to isolate effects on the intensive margin. The diagonal terms confirm that lowering coinsurance reduces average retail prices. These price reductions are driven by changes in the coinsurance rate for high-income patients, as seen when moving across rows while holding the low-income rate constant. In contrast, reducing the coinsurance rate for low-income patients (moving across columns) sometimes increases retail prices.[36]

[34] For a given price, the government's gains from trade are always increasing in the coinsurance rate when $\beta \geq 1$. However, if $\beta < 1$, the effect on ΔV can be positive or negative.

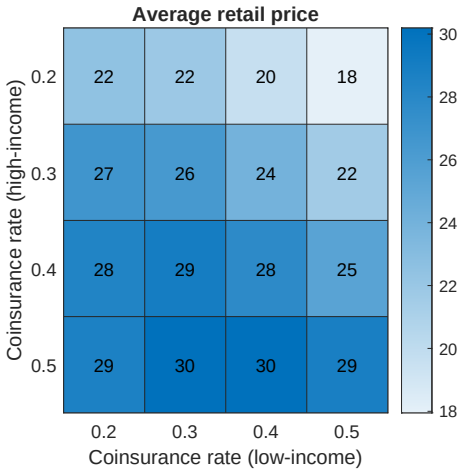
[35] Appendix Figure A5 sets $\boldsymbol{\beta} = \boldsymbol{\infty}$ for drugs that failed to reach agreement under the NRDL Reform, i.e., negotiations for these drugs would always fail regardless of policy designs. The patterns described below hold under both (extremal) assumptions.

[36] This asymmetry arises because the market expansion effect from lowering coinsurance rates is much larger for high-income patients, which increases firms' gains from trade and strengthens the government's bargaining position. Generally, coinsurance rates affect both the levels and slopes of the gains from trade curves, and lowering coinsurance rates can lead to higher prices. See Appendix B.3 for details.

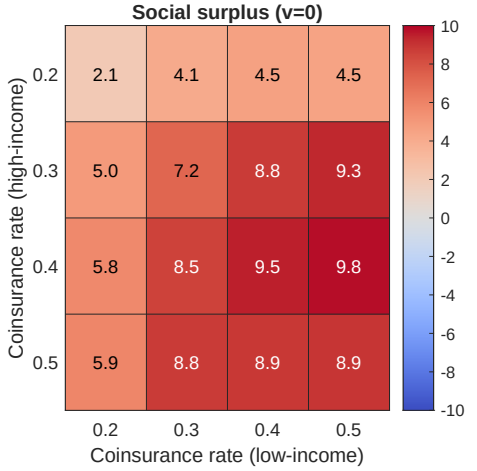
Figure 9: Counterfactual Results under Alternative Coinsurance Schedules



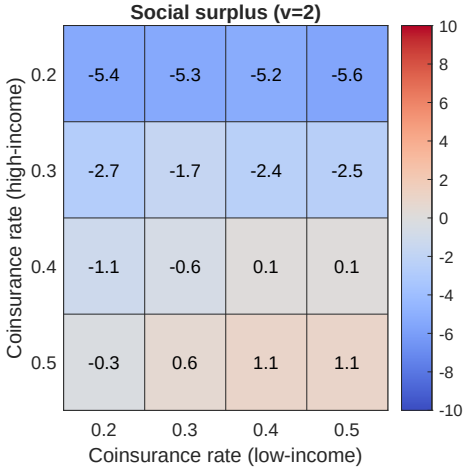
(a) Market Sales



(b) Average Retail Prices



(c) Social Surplus ($\nu = 0$)



(d) Social Surplus ($\nu = 2$)

Note: The heatmaps present simulated outcomes under income-based coinsurance schedules for all 70 eligible drugs (where $\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$ for drugs that failed NRDL negotiations). The horizontal axis and the vertical axis represent the coinsurance rate for low-income (below median) patients and high-income (above median) patients, respectively. "Fraction of failed negotiations" reports the model-predicted percentage of failed negotiations under each coinsurance design. "Average retail price" is the quantity-weighted average retail price across the 33 always successfully negotiated drugs. The bottom panel reports social surplus for a utilitarian ($\nu = 0$) vs. a Rawlsian ($\nu = 2$) government, where surplus is measured relative to the baseline with no insurance. See Appendix Figure A5 for results with $\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$.

Welfare The differential impact of coinsurance changes on high- versus low-income patients generates spillover effects across income groups, shaping the optimal policy design.[37] Figures 9(c)-(d) examine the optimal coinsurance rate under different social welfare criteria. If the social planner's goal is to maximize total social surplus as in panel (c), welfare is maximized at the schedule (H 0.36, L 0.5)—a moderately regressive structure that resembles the geographic regressivity seen in practice.

However, a more Rawlsian objective ($\nu = 2$), as shown in Figure 9(d), favors higher coinsurance rates for all patients with an optimal rate of (H 0.5, L 0.46). While lowering coinsurance expands drug adoption among marginal patients, it also results in subsidies to inframarginal patients who would have purchased the drug regardless. A Rawlsian social welfare function penalizes such expenditures, making it harder to justify low coinsurance rates for high-income consumers when equity concerns are high. Ultimately, an optimal coinsurance schedule must strike a balance between these competing objectives—ensuring equitable access, managing government expenditures, and preserving effective negotiation leverage.

5.4 Toward Optimal Policy Design

To summarize our findings, we consider the welfare implications of policies within the broad "Negotiation plus Expansion" regime. We maintain centralized negotiation, as it has a positive impact on the vast majority of regions and patients. Figure 10 presents the welfare effects of each policy combination, with survival effects on the horizontal axis and total social surplus effects on the vertical axis. Each is relative to the pre-reform Baseline with no insurance or negotiation, and the "$\times$" symbol in the far upper-right defines an ex post efficient benchmark with $OOP = MC$ for each drug.

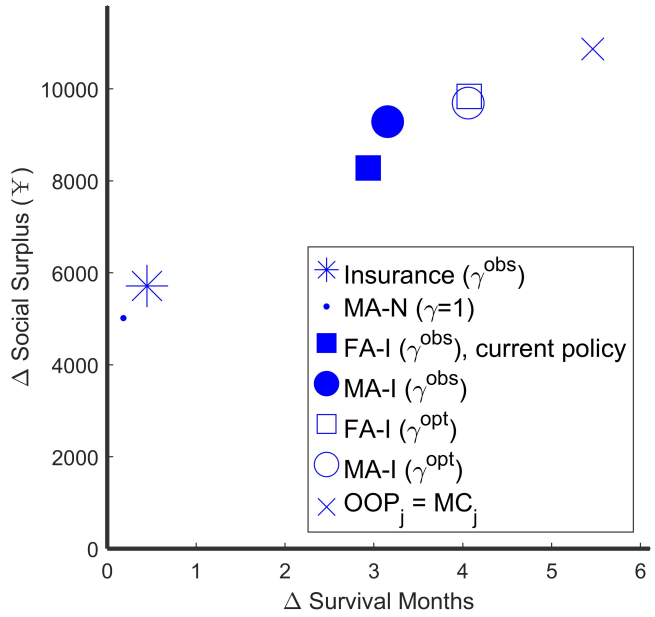
We make three observations. First, all policies that combine insurance and negotiation are to the upper right of the Baseline, Insurance-only, and Negotiation-only (MA-N) scenarios. Second, at the observed provincial coinsurance schedule γ^{obs}, market-access negotiation improves surplus and survival relative to the NRDL (formulary-access) policy. Third, with optimal income-based coinsurance schedules γ^{opt}, market-access and formulary-access are roughly equivalent; however, the optimal coinsurance schedule for FA-I is (H 0.36, L 0.5), whereas it is both lower and less regressive for MA-I (H 0.34, L 0.42).

Taken together, we argue that a combined policy of centralization, market access negotia-

[37] We focus on *ex post* optimality, i.e., what coinsurance schedule maximizes social surplus, holding fixed all parameters and ignoring the risk protective value of social insurance? The latter is a key ingredient in optimal insurance design, but requires information about consumers' risk preferences, which we do not have.

tion, and an optimal income-based coinsurance schedule strikes the best balance in terms of efficiency, access, and equity. First, MA-I allows for lower coinsurance for low-income patients, which improves equity relative to FA-I. Second, MA-I's advantage over FA-I is even greater in cases where the drug firms have less bargaining power; see Appendix B.2. Third, it allows for more generous coinsurance for all patients than FA-I, which reduces financial risk to patients. Lastly, it is worth noting that MA-I may be less demanding in terms of political economy: if it is difficult to deviate from province-based coinsurance subsidies, then MA-I is preferred to FA-I under current coinsurance schedules. Our preferred policy tool of market-access negotiation with the optimal coinsurance schedule would yield a 19% gain in social surplus over the observed NRDL, and would achieve 90% of the social surplus and 71% of the survival gains of the short-run efficient benchmark with OOP=MC.

Figure 10: Welfare Comparison of Different Policies



Note: This graph compares the social surplus and extended overall survival per patient due to innovative drugs under seven different policy scenarios. The baseline is without insurance or negotiation. For each scenario, we use the parameter γ to denote the coinsurance rate, which can be the provincial schedule observed in the NRDL Reform (γ^{obs}), the income-based schedule that maximizes social surplus in the relevant bargaining regime (γ^{opt}), or no insurance at all ($\gamma = 1$). See Appendix Figure A6 for details regarding optimal coinsurance with MA-I bargaining.

6 Conclusion

Pharmaceuticals accounted for 35% of the increase in U.S. life expectancy from 1990 to 2015 (Buxbaum et al., 2020). Yet many promising treatments remain inaccessible due to high prices, placing heavy burdens on both patients and insurers (CMS, 2024). Against this backdrop, global momentum has grown for centralized drug procurement and similar policy interventions aimed toward expanding access while constraining expenditures. Recent initiatives include the U.S. Inflation Reduction Act of 2022, which authorized Medicare to negotiate prices for selected drugs (The White House, 2023), the European Parliament's 2024 proposal for centralized pharmaceutical pricing (Ho and Pakes, 2024), and joint efforts led by the Pan-American Health Organization (PAHO Executive Committee, 2024).

This paper evaluates the effects of China's NRDL Reform. We estimate that the innovative drugs successfully negotiated under the NRDL Reform between 2017 and 2022 generated annual consumer surplus gains of nearly ¥40 billion ($5.6 billion) and increased total survival by 900,000 life-years among Chinese cancer patients. Counterfactual simulations show that there are substantial health and welfare gains from centralization, that bargaining failures are a consequence of "soft" threat points, and that ignoring bargaining failures would lead us to underestimate the benefits of centralization and the tradeoffs inherent in expanding insurance generosity.

We offer new evidence on the cost, access, health, and welfare consequences of national drug reforms; the distinction between formulary and market-access negotiations; the comparisons between centralized and decentralized negotiation; and optimal coinsurance design. Our framework has broad applicability for evaluating similar reforms across diverse settings. One limitation of our work is that we abstract from dynamic incentives—such as the impact of NRDL inclusion on pharmaceutical innovation—which remains a promising direction for future research.

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Online Appendix

A Data Construction

In our 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. 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 inclusion details, if specified (this might specify an age range for patients, or a requirement that certain treatments 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
- Time units in which outcomes are evaluated; i.e., weeks or months
- For each of the following outcomes (overall survival (OS); overall survival rate (OSR); and progression-free survival (PFS)):
  - Time frame for evaluation; e.g., "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 Phase III trials with results reported on ClinicalTrials.gov, 0 otherwise)
- NCTID
- Pub Med ID (PMID)
- Indicator for the control therapy being another innovator drug in our sample

Using these data, we create an overall survival treatment effect for each innovator drug by subtracting the control group median from the treatment group median. We use overall survival directly if reported, then overall survival rate, then progression-free survival. For some more recent trials, the median survival time for the treatment or control could not be estimated as too few participants had died by the end of the study. In such cases, we use the study time frame as an informative lower bound on median survival. We do, however, require that an estimate of median survival time be reported for *either* treatment or control therapy.

For all sample innovator drugs missing survival data after following the above process using NCTs, we search for trial results reported in medical journal articles and on trial sponsors' websites. If necessary, we then augment the dataset using the clinical result report that the drug company submitted to the NHSA.

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 that were highlighted in the package the drug company submitted to the NHSA, with the most preferred outcome available. Failing that, 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 obtained in the package submitted to the NHSA or found on the web as described above, with the most preferred outcome available.

If the above prioritization process results in multiple trial results for a given innovative drug, we take a simple average of survival treatment effects across studies. See Appendix Table A4 for an overview of key milestones for the top 20 innovative cancer drugs in China, and Appendix Table A5 for a summary table of clinical effects for all cancer drugs eligible for negotiation in our sample.

B Details on Counterfactual Simulations

B.1 Solution Algorithm

This section describes our algorithm to solve for equilibrium formularies and prices in the counterfactual analyses. We apply an iterative Gauss-Seidel method to solve the new equilibrium prices. We assume that negotiated drugs and non-negotiated drugs set prices simultaneously. The contract equilibrium is such that, given the prices, no drug firms have incentives to renegotiate (or change) the retail prices unilaterally.

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

2. **Inner loop:** Denote the full set of drugs eligible for negotiation as $\mathcal{J}$. Denote the set of drugs that *must* be included in the formulary at iteration r as $\underline{\mathcal{G}}^r$, initialized as $\underline{\mathcal{G}}^0 \equiv \varnothing$. Denote the set of drugs that *must not* be included in the formulary at iteration r as $\underline{\mathcal{H}}^r$, initialized as $\underline{\mathcal{H}}^0 \equiv \varnothing$. For each iteration $r \geq 1$, let $\underline{\mathcal{G}}^r = \underline{\mathcal{G}}^{r-1}$ and $\underline{\mathcal{H}}^r = \underline{\mathcal{H}}^{r-1}$, then for each $j \in \mathcal{J} \setminus (\underline{\mathcal{G}}^r \cup \underline{\mathcal{H}}^r)$:

   (a) Identify the admissible price set $\underline{\mathcal{P}}_j^r \equiv \{p_j : \Delta V_j\left(p_j; \mathbf{p}_{-\mathbf{j}}^{\mathbf{s}}, \mathcal{J} \setminus \underline{\mathcal{H}}^{r-1}\right) \geq 0$ and $\Delta\Pi_j\left(p_j; \mathbf{p}_{-\mathbf{j}}^{\mathbf{s}}, \mathcal{J} \setminus \underline{\mathcal{H}}^{r-1}\right) \geq 0\}$. If $\underline{\mathcal{P}}_j^r \neq \varnothing$, update $\underline{\mathcal{G}}^r = \underline{\mathcal{G}}^r \cup \{j\}$.

   (b) If $j \notin \underline{\mathcal{G}}^r$, identify the admissible price set $\overline{\mathcal{P}}_j^r \equiv \{p_j : \Delta V_j\left(p_j; \mathbf{p}_{-\mathbf{j}}^{\mathbf{s}}, \underline{\mathcal{G}}^{r-1}\right) \geq 0$ and $\Delta\Pi_j\left(p_j; \mathbf{p}_{-\mathbf{j}}^{\mathbf{s}}, \underline{\mathcal{G}}^{r-1}\right) \geq 0\}$. If $\overline{\mathcal{P}}_j^r = \varnothing$, update $\underline{\mathcal{H}}^r = \underline{\mathcal{H}}^r \cup \{j\}$.

   Iterate until $\underline{\mathcal{H}}^{r*} \cup \underline{\mathcal{G}}^{r*} = \mathcal{J}$. Update $\mathcal{G}^s = \underline{\mathcal{G}}^{r*}$ and return to the outer loop.

3. Solve for the negotiated and non-negotiated prices $\mathbf{p}^s$ given $\mathcal{G}^s$, using the Nash-in-Nash FOC in Equation (3) for $j \in \mathcal{G}^s$ and the Bertrand-Nash FOC for $j \notin \mathcal{G}^s$.

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

Intuitively, the algorithm rests on the submodularity of gains from trade in our model. When drugs are substitutes, the lowest gain from trade a drug can provide to either firm or government is when the formulary contains all other possible drugs, generating the narrowest admissible set possible for that drug. If the admissible set is nevertheless nonempty, the drug *must* be included in the equilibrium formulary (Step 2a). Conversely, the highest gain from trade a drug can provide to either firm or government is when the formulary excludes all other

possible drugs, generating the widest admissible set possible for that drug. If the admissible set is nevertheless empty, the drug *must not* be included in the equilibrium formulary (Step 2b). This approach is similar to the algorithm used for the automobile entry game modeled in Sabal (2025).

Generally speaking, there is no theoretical guarantee that the inner loop condition $\underline{\mathcal{H}}^{r*} \cup \underline{\mathcal{G}}^{r*} = \mathcal{J}$ would ever be met, in which case we would have multiple equilibria. In such a case, we would follow Ho and Lee (2019) in evaluating all possible equilibrium formularies and presenting results for formularies that maximize particular objectives, such as consumer surplus and total surplus. In practice, the condition is always met in our counterfactual analyses because the innovative cancer drugs that are eligible for negotiation in our setting are quite differentiated from one another (though they do have non-innovative, and therefore non-negotiated, substitutes that are included in the demand estimation). Indeed, we find that there is no significant spillover effect of a successful negotiation for a drug in a particular indication on the prices or quantities of non-negotiated drugs in the same indication; see Appendix Figure A7.

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

For simplicity of notation, suppose a single-product firm produces product j. On the extensive margin, MA-I (market access negotiation with insurance expansion)[38] always leads to more bargaining success than FA-I (formulary access negotiation with insurance expansion, or the NRDL). This is because the admissible set is expanded:

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

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

On the intensive margin, the negotiated price may be higher or lower under MA-I. To see this, assume that j is the only product eligible for negotiation, so we can ignore the prices and formulary status of other drugs and omit j subscripts. For brevity, use F for formulary access and M for market access. In this case, the following proposition holds.

Proposition: The negotiated price under formulary access (p^F) is lower (equal to) [higher]

[38] Under this policy, a failed negotiation results in the drug being entirely excluded from the Chinese market, while a successful negotiation leads to both market and formulary inclusion with insurance.

than the price under market access (p^M) if and only if:

$$\frac{V(\mathbf{p}^{BN})}{V(p^M)} > (=)[<] \frac{\Pi(\mathbf{p}^{BN})}{\Pi(p^M)}. \tag{6}$$

Proof: The equilibrium price under either (F/M) negotiation satisfies the first-order condition:

$$\tau \frac{d\Delta\Pi}{dp}\frac{1}{\Delta\Pi} + (1-\tau)\frac{d\Delta V}{dp}\frac{1}{\Delta V} = 0. \tag{7}$$

Rearranging,

$$\frac{\Delta V}{\Delta\Pi} = -\frac{1-\tau}{\tau}\frac{\Delta V'}{\Delta\Pi'}. \tag{8}$$

Suppose price p^M is the negotiated price under MA-I. Then:

$$\begin{aligned}
\Delta\Pi_M &= \Pi(p^M) - 0, \\
\Delta V_M &= V(p^M) - 0, \\
\frac{\Delta V_M}{\Delta\Pi_M} &= -\frac{1-\tau}{\tau}\frac{V'(p^M)}{\Pi'(p^M)}.
\end{aligned}$$

We next plug p^M into the formulary access FOC, to see whether the FOC is satisfied at p^M, and if not, whether we need a bigger or smaller p^F:

$$\begin{aligned}
\Delta\Pi_F(p^M) &= \Pi(p^M) - \Pi(\mathbf{p}^{BN}), \\
\Delta V_F(p^M) &= V(p^M) - V(\mathbf{p}^{BN}) \\
\frac{\Delta V_F(p^M)}{\Delta\Pi_F(p^M)} &\stackrel{?}{=} -\frac{1-\tau}{\tau}\frac{V'(p^M)}{\Pi'(p^M)}.
\end{aligned}$$

Note that the key differentiating factor across the MA-I and FA-I scenarios is their threat points, which do not directly depend on the price under negotiation. This implies that $V_F(p^M) = V_M(p^M) = V(p^M)$ and $\Delta V'_F = d\Delta V'_M$, and similarly for profits. Therefore, the FOC for FA-I will hold at p^M if and only if:

$$\frac{\Delta V_F(p^M)}{\Delta\Pi_F(p^M)} \equiv \frac{V(p^M) - V(\mathbf{p}^{BN})}{\Pi(p^M) - \Pi(\mathbf{p}^{BN})} = \frac{V(p^M)}{\Pi(p^M)}.$$

Rearranging, the condition simplifies to:

$$\frac{V(\mathbf{p}^{BN})}{\Pi(\mathbf{p}^{BN})} = \frac{V(p^M)}{\Pi(p^M)}.$$

If LHS $>$ RHS, then $p^F < p^M$ and vice-versa.[39] Note also that the RHS is a decreasing function of firm bargaining power, while the LHS is independent of bargaining power. Therefore, when the firm holds more bargaining power, or when the value of the product on the private market is relatively higher for the government than the firm, $p^{FA-I} < p^{MA-I}$ is more likely to hold. Intuitively, the government may prefer FA-I when the product is relatively accessible on the private market, the profit for the product on the private market is relatively low, and when the firm holds more bargaining power.

□

B.3 Effects of Coinsurance Rates on Negotiated Prices

The effects of higher coinsurance on negotiation outcomes are theoretically ambiguous. They depend on how coinsurance affects the levels of gains from trade (GFT), as well as the curvature of the two GFT curves. To see this, recall the bargaining first-order condition, and for simplicity, assume that j is the only product eligible for negotiation, so we can ignore the prices and formulary status of other drugs and omit j subscripts:

$$\max_p \left(\Delta\Pi\left(p\right)\right)^{\tau}\left(\Delta V\left(p\right)\right)^{1-\tau} \quad \Rightarrow \quad \{g(p(\gamma),\gamma) = \frac{\tau}{\Delta\Pi\left(p\right)}\frac{\partial\Pi\left(p\right)}{\partial p} + \frac{1-\tau}{\Delta V\left(p\right)}\frac{\partial V\left(p\right)}{\partial p} = 0\}$$

Now apply the implicit function theorem:

$$\begin{aligned} p'(\gamma) &= -\frac{\partial g}{\partial \gamma}/\frac{\partial g}{\partial p} \\ &= -\frac{\tau\left(-\frac{\partial\Delta\Pi/\partial\gamma}{\Delta\Pi^2} * \frac{\partial\Pi}{\partial p} + \frac{1}{\Delta\Pi} * \frac{\partial^2\Pi}{\partial p\partial\gamma}\right) + (1-\tau)\left(-\frac{\partial\Delta V/\partial\gamma}{\Delta V^2} * \frac{\partial V}{\partial p} + \frac{1}{\Delta V} * \frac{\partial^2 V}{\partial p\partial\gamma}\right)}{\tau\left(-\frac{\partial\Delta\Pi/\partial p}{\Delta\Pi^2} * \frac{\partial\Pi}{\partial p} + \frac{1}{\Delta\Pi} * \frac{\partial^2\Pi}{\partial p^2}\right) + (1-\tau)\left(-\frac{\partial\Delta V/\partial p}{\Delta V^2} * \frac{\partial V}{\partial p} + \frac{1}{\Delta V} * \frac{\partial^2 V}{\partial p^2}\right)} \end{aligned} \tag{9}$$

First, focus on how the coinsurance rate γ affects GFT: $\partial\Delta V/\partial\gamma$ and $\partial\Delta\Pi/\partial\gamma$. Higher coinsurance unambiguously decreases firms' gains from trade because it increases patients' out-of-pocket prices and reduces demand: $\frac{\partial\Delta\Pi}{\partial\gamma} = \frac{\partial q}{\partial\gamma}(p - mc) < 0$. However, the government's perspective is more nuanced. High coinsurance rates decrease government expenditure, but also decrease consumer surplus and expected survival. When $\beta \geq 1$, conditioning on the negotiated price p, the government's gains from trade increase with the coinsurance rate γ.

[39] We make the weak assumption that $V(p)$ is decreasing in p and $\Pi(p)$ is increasing in p.

This is because:[40]

$$\Delta V = \Delta CS - \beta \Delta TC = \int_{\gamma p}^{p^{BN}} q(OOP) dOOP - \beta(1-\gamma) p q(\gamma p)$$

$$\frac{\partial \Delta V}{\partial \gamma} = \frac{\partial \Delta CS}{\partial \gamma} - \beta \frac{\partial TC}{\partial \gamma} = -q(\gamma p)p - \beta(-q(\gamma p)p + (1-\gamma)p^2 \frac{\partial q}{\partial OOP})$$

$$= \underbrace{(\beta - 1) q(\gamma p) p}_{\geq 0} - \underbrace{\beta(1-\gamma)p^2 \frac{\partial q}{\partial OOP}}_{<0} \quad > 0 \quad \text{if } \beta \geq 1.$$

That is, a higher coinsurance rate shifts the government's gains-from-trade curve upward when the shadow cost of government expenditures is high ($\beta \geq 1$). If the shadow cost is low ($\beta < 1$), it may be the case that $\frac{\partial \Delta V}{\partial \gamma} < 0$.

Returning to the bargaining first-order condition, we see that $p'(\gamma)$ depends on both leverage effects (compare $\frac{\partial V}{\partial \gamma}$ and $\frac{\partial \Pi}{\partial \gamma}$) and also curvature effects (compare $\frac{\partial^2 \Pi}{\partial p \partial \gamma}$ and $\frac{\partial^2 \Pi}{\partial p^2}$ vs. $\frac{\partial^2 V}{\partial p \partial \gamma}$ and $\frac{\partial^2 V}{\partial p^2}$). Intuitively, when γ is small, consumer demand is less elastic, so firms have a particularly strong desire to increase prices, and the government has a particularly strong desire to decrease prices. Ultimately, depending on the magnitude of β, the government's and firm's curvature terms may counteract or reinforce one another, and the leverage terms may counteract or reinforce one another. This makes the sign of $p'(\gamma)$ ambiguous:

$$p'(\gamma) = -\frac{\tau \left(\underbrace{-\frac{\partial \Delta \Pi / \partial \gamma}{\Delta \Pi^2}}_{>0} \cdot \underbrace{\frac{\partial \Pi}{\partial p}}_{>0} + \underbrace{\frac{1}{\Delta \Pi}}_{>0} \cdot \underbrace{\frac{\partial^2 \Pi}{\partial p \partial \gamma}}_{<0} \right) + (1-\tau) \left(\underbrace{-\frac{\partial \Delta V / \partial \gamma}{\Delta V^2}}_{\gtrless 0} \cdot \underbrace{\frac{\partial V}{\partial p}}_{<0} + \underbrace{\frac{1}{\Delta V}}_{>0} \cdot \underbrace{\frac{\partial^2 V}{\partial p \partial \gamma}}_{\gtrless 0} \right)}{\tau \left(\underbrace{-\frac{\partial \Delta \Pi / \partial p}{\Delta \Pi^2}}_{<0} \cdot \underbrace{\frac{\partial \Pi}{\partial p}}_{>0} + \underbrace{\frac{1}{\Delta \Pi}}_{>0} \cdot \underbrace{\frac{\partial^2 \Pi}{\partial p^2}}_{<0} \right) + (1-\tau) \left(\underbrace{-\frac{\partial \Delta V / \partial p}{\Delta V^2}}_{>0} \cdot \underbrace{\frac{\partial V}{\partial p}}_{<0} + \underbrace{\frac{1}{\Delta V}}_{>0} \cdot \underbrace{\frac{\partial^2 V}{\partial p^2}}_{>0} \right)}$$

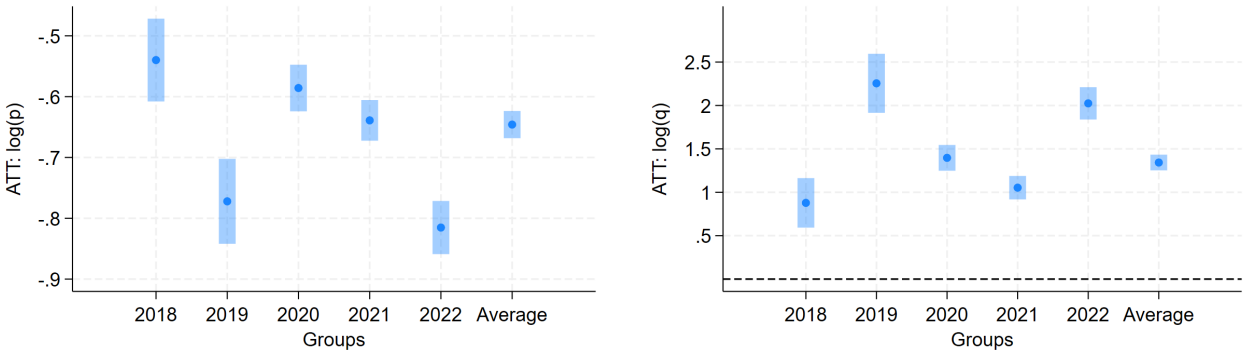
Figure 6(c) illustrates a case with $\beta \geq 1$, where lower coinsurance leads to a smaller admissible set and a lower negotiated price, conditional on negotiation success.

In our empirical application, we find that $p'(\gamma) > 0$ for coinsurance rates of high-income patients, but not always for low-income patients.

[40] Consumer Surplus is defined as the integral under the demand curve between the agreement and disagreement out-of-pocket price, and becomes Equation (2) in the main text under logit demand.

C Appendix Figures

Figure A1: Cohort-Specific Effects of the NRDL Reform on Price and Quantity

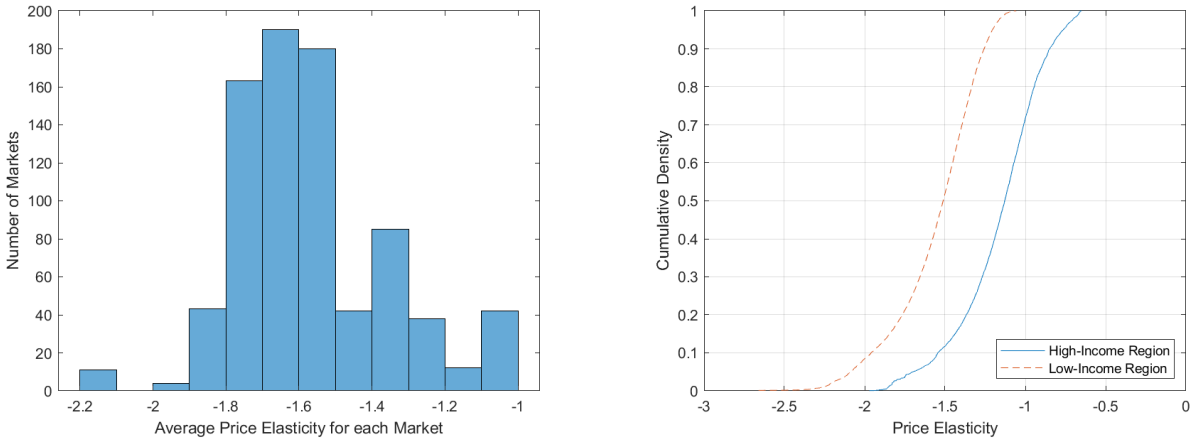


(a) Retail Price: All Categories

(b) Quantity: All Categories

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

Figure A2: Estimated Income Elasticity across Different Income Levels

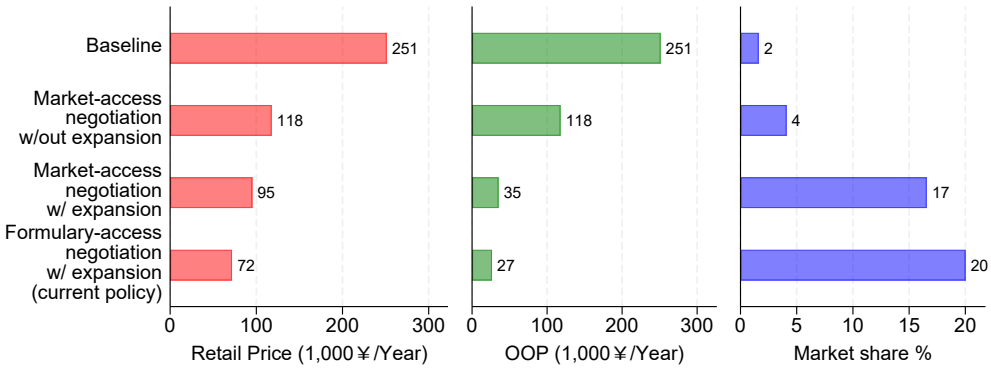


(a) Histogram of Price Elasticity

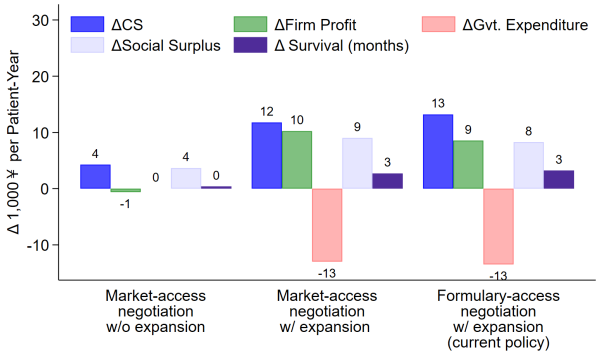
(b) CDF of Price Elasticity

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 (4) 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.

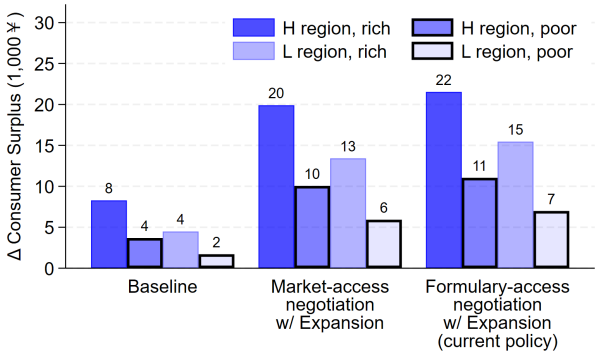
Figure A3: Counterfactual Results: Alternative Bargaining Formats ($\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$)



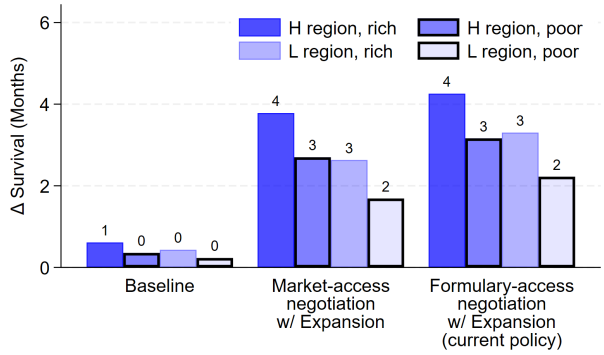
(a) Price and Market Share of Innovative Cancer Drugs



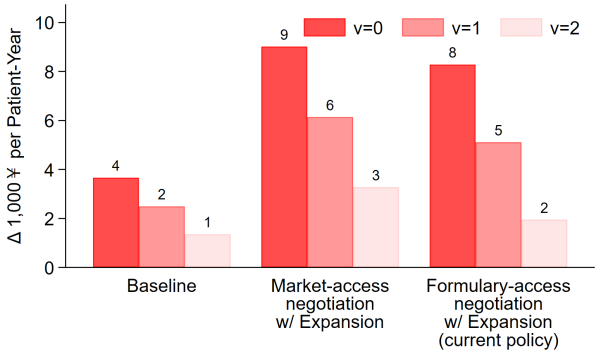
(b) Welfare Effects



(c) Δ Consumer Surplus by Income Group



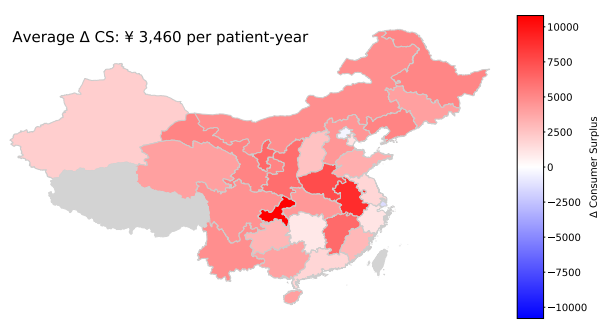
(d) Δ Survival by Income Group



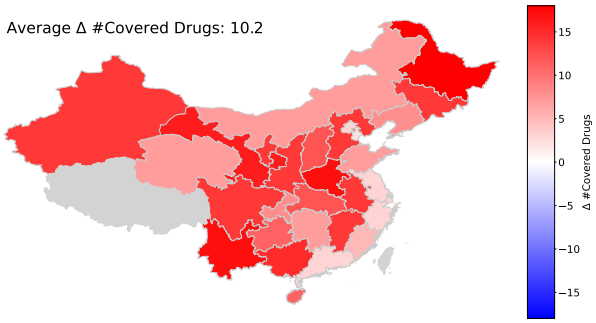
(e) Alternative Social Surplus Measures

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

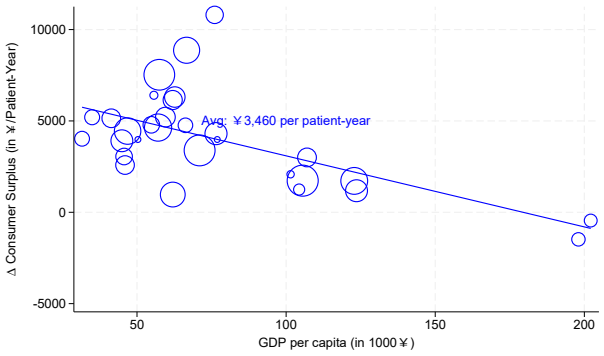
Figure A4: Changes in CS and Drug Coverage from Decentralized to Centralized Negotiation ($\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$)



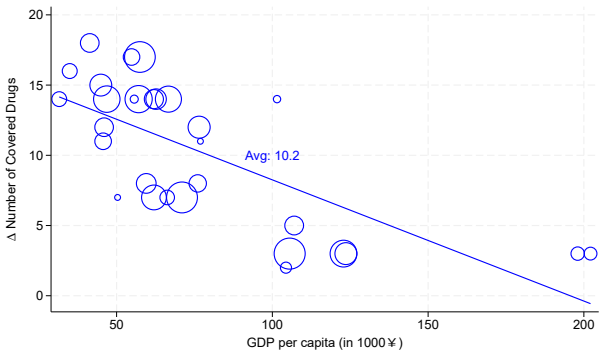
(a) Δ CS (¥/Patient)



(b) Δ Number of Covered Drugs



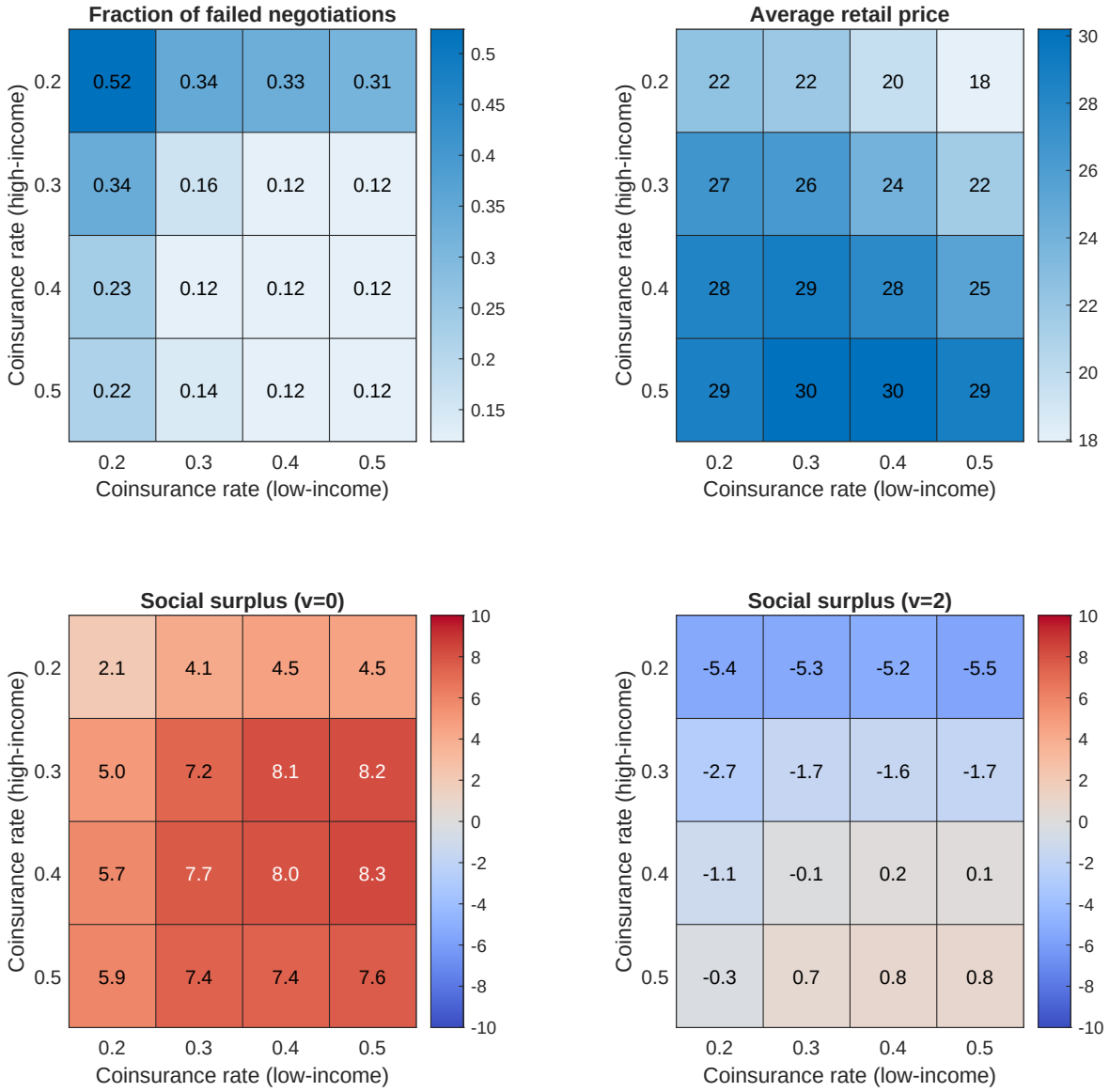
(c) Δ CS vs. Income



(d) Δ Number of Covered Drugs vs. Income

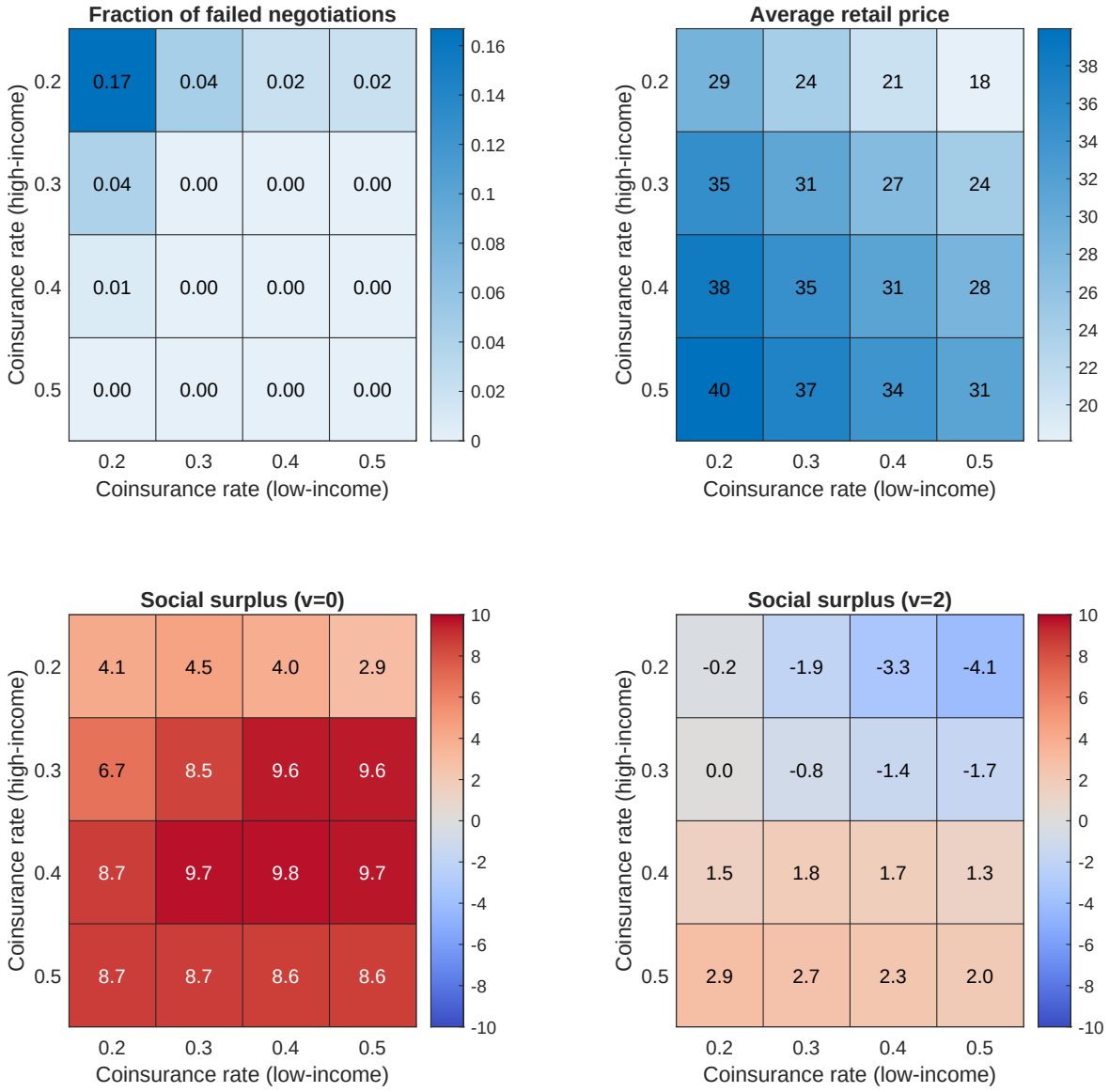
Note: Panels (a)-(b) show the geographic distributions of changes in consumer surplus per patient-year and the number of covered drugs across provinces when moving from decentralized negotiation with insurance expansion to centralized negotiation with insurance expansion. Panels (c)-(d) present bubble plots of the same outcomes, with GDP per capita on the x-axis. Each bubble indicates one province, and bubble size scales with the province's population. All the results are based on simulations that set $\boldsymbol{\beta} = \boldsymbol{\infty}$ for failed negotiations, so these drugs will always be excluded from the formulary.

Figure A5: Counterfactual Results under Alternative Coinsurance Schedules ($\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$)



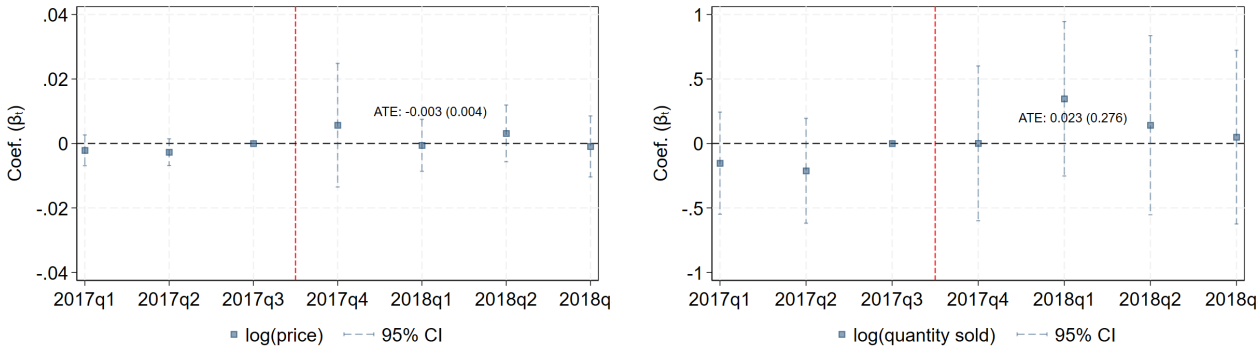
Note: These heatmaps present simulated outcomes under income-based coinsurance schedules. Simulations allow negotiation for 57 innovative cancer drugs and assume $\boldsymbol{\beta}_{failed} = \boldsymbol{\infty}$ for drugs that failed the NRDL negotiations. The horizontal axis and the vertical axis represent the coinsurance rate for low-income (below median) patients and high-income (above median) patients, respectively. "Fraction of failed negotiations" reports the model-predicted percentage of failed negotiations under each coinsurance design. "Average retail price" is the quantity-weighted average retail price across the 33 always successfully negotiated drugs defined in Figure 9. The bottom panel reports social surplus for a utilitarian ($\nu = 0$) vs. a Rawlsian ($\nu = 2$) government, where surplus is measured relative to the baseline without insurance.

Figure A6: Counterfactual Coinsurance Design for Market-access Negotiation with Insurance Expansion ($\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$)



Note: These heatmaps present simulated outcomes under income-based coinsurance schedules for all 70 eligible drugs (where $\boldsymbol{\beta}_{failed} = \underline{\boldsymbol{\beta}}$ for drugs that failed NRDL negotiations), in the MA-I scenario. The horizontal axis and the vertical axis represent the coinsurance rate for low-income (below median) patients and high-income (above median) patients, respectively. "Fraction of failed negotiations" reports the model-predicted percentage of failed negotiations under each coinsurance design. "Average retail price" is the quantity-weighted average retail price across the 33 always successfully negotiated drugs defined in Figure 9. The bottom panel reports social surplus for a utilitarian ($\nu = 0$) vs. a Rawlsian ($\nu = 2$) government, where surplus is measured relative to the baseline without insurance.

Figure A7: Spillover Effects of the Negotiation on Competing Drugs



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

Note: This event study examines the potential spillover effects of negotiation on closely competing drugs. All non-included drugs which have at least one same indication as any included drugs in the 2017 negotiation cohort are treated groups (15 drugs in *lung, liver, breast, kidney, stomach, ovarian* categories), and other non-included drugs that have zero overlapping indications as control groups (27 drugs). We compare the prices and quantities of treated drugs between 2016 and 2018. After 2018, nearly all drugs are treated.

D Appendix Tables

Table A1: Demand Estimates: Robustness

	Logit		Nested Logit		
	(1)	(2)	(3)	(4)	(5)
log(OOP)	-1.196***	-1.346***	-0.858***	-1.262***	-1.235***
	(0.081)	(0.020)	(0.034)	(0.028)	(0.025)
λ (nesting para.)			0.535***	0.981***	0.861***
			(0.033)	(0.022)	(0.023)
Indication					
Lung cancer		0.468***	0.313***	0.276***	0.439***
		(0.050)	(0.032)	(0.054)	(0.045)
Breast cancer		0.343***	0.211***	0.025	0.314***
		(0.096)	(0.063)	(0.107)	(0.086)
Colon cancer		0.771***	0.247***	0.662***	0.740***
		(0.075)	(0.057)	(0.085)	(0.067)
Stomach cancer		0.430***	0.135**	0.524***	0.468***
		(0.076)	(0.057)	(0.087)	(0.068)
Nesting level			1(mAb/PKI)	ATC3	ATC4
Median elasticity	-1.20	-1.35	-1.60	-1.57	-1.40
Product FE		Yes	Yes	Yes	Yes
Product*YearQuarterFE	Yes				
Province*YearQuarterFE	Yes	Yes	Yes	Yes	Yes

Note: The table presents the demand estimates for alternative specifications. The sample size is 112,019 for Columns (1) and (3)-(5), and 34,867 for Column (2). All columns instrument for prices. Column (1) reports logit with product-by-year-quarter FEs and uses the negotiation dummy $\times$ local coinsurance rate as instruments. Column (2) restricts the sample to innovative drugs (mAb/pKI) only. Columns (3)-(5) report nested logit estimates with different nesting structures: Column (3) uses a single nest for innovative drugs (mAb/pKI), Column (4) uses the ATC3 to define nests (20 classes), and Column (5) uses the ATC4 to define nests (67 classes). λ denotes the nesting parameter, with $\lambda \to 0$ indicating perfect substitutes within a nest and $\lambda \to 1$ indicating plain logit. Instruments in Columns (2)-(5) are: negotiation dummy and number of products in the nest. The median elasticity reported in this table is the median individual-level elasticity ($\frac{ds_{ij}/s_{ij}}{dp_j/p_j}$) across products.

Table A2: Robustness Check: Estimation with Alternative Assumptions on ν

	$\nu = 0$	$\nu = 1$	$\nu = 2$
θ_β	4.27	4.04	3.87
S.E.	0.48	0.61	1.46
τ	0.68	0.66	0.64
S.E.	0.02	0.05	0.00
Log-likelihood	-262.16	-270.61	-279.37

Note: The table shows the supply estimates for alternative specifications. β is assumed to follow a T1EV distribution with inverse scale parameter determined by θ_β, and τ is the firm bargaining power parameter. Columns (1)-(3) assume the government objective function has different equity considerations $\nu = 0, 1$, or 2.

Table A3: Decomposition of the Effects of Expansion & Negotiation

		(1) Baseline	(2)	(3)	(4)	(5)
			+ Expansion Only		+ Expansion & Negotiation	
		y	Δy	Δy%	Δy	Δy%
Market Outcomes						
Avg. Retail Price	Inno, Success	251.37	32.50	12.93	-181.51	-72.21
(¥1,000 per year)	Inno, Others	52.60	-0.09	-0.17	-0.09	-0.17
	Traditional	13.54	-0.02	-0.14	-0.02	-0.14
Avg. Out-of-pocket Price	Inno, Success	251.37	-154.24	-61.36	-224.78	-89.42
(¥1,000 per year)	Inno, Others	52.60	-0.09	-0.17	-0.09	-0.17
	Traditional	12.96	-0.02	-0.12	-0.02	-0.12
Market Share	Inno, Success	1.62	4.79	295.06	18.40	1133.28
(%|inside)	Inno, Others	0.56	-0.03	-5.01	-0.11	-19.10
	Traditional	97.82	-4.76	-4.87	-18.29	-18.70
Welfare Effects in 1,000 ¥per consumer per year						
Consumer Surplus	H region, Rich	4.78	11.98	250.55	21.53	450.48
	H region, Poor	1.90	5.65	297.21	11.04	580.91
	L region, Rich	3.76	5.43	144.50	15.46	411.21
	L region, Poor	1.30	2.21	170.40	6.99	539.47
	Average	2.87	5.91	206.24	13.34	465.22
Share-weight OS	H region, Rich	0.41	1.21	296.80	4.26	1045.38
(months per consumer)	H region, Poor	0.20	0.77	388.71	3.16	1589.39
	L region, Rich	0.39	0.64	162.96	3.30	837.02
	L region, Poor	0.17	0.37	213.57	2.22	1298.61
	Average	0.29	0.71	242.77	3.16	1083.96
Gvt. Expenditure		0.00	11.08	-	13.48	-
Variable Profits	Inno, Success	4.30	10.93	253.87	8.56	198.95
	Inno, Others	0.89	-0.00	-0.44	-0.01	-1.51
	Traditional	12.40	-0.03	-0.27	-0.13	-1.01
Welfare	$\nu = 0$	19.04	5.72	30.03	8.28	43.50
	$\nu = 1$	18.19	4.19	23.06	5.11	28.10
	$\nu = 2$	17.39	2.69	15.46	1.95	11.22

Note: This table decomposes the effect of all rounds of policy reform (as of the year 2023) into its two main channels. The baseline scenario excluded all 57 cancer drugs that were included in the program. We report consumer surplus in four groups: "H region, Rich" denotes high-income patients (above median) in high-income (above median) provinces. Total welfare is reported according to different weights on households, as a function of income: $income^{-\nu}$ where $\nu = 0$ is utilitarian and $\nu \to \infty$ is Rawlsian. To compute baseline patient welfare, we calculate the change in consumer surplus between the baseline equilibrium and an alternative equilibrium in which only outside option treatments (i.e., no cancer drugs) are available. Share-weighted overall survival (OS) is based on clinical evidence of increased months of survival collected from Phase III trial data. Results for the 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 A4: Overview of Top 20 Innovative Cancer Drugs in China

Drug	Success in	Eligible since	Global Entry Time	Local Entry Time	Company	Sales (b ¥)	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	2019	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	2019	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. Companies with asterisks are domestic firms.

Table A5: Overview of Clinical Effects of Innovative Cancer Drugs

Drug Name	Year entering NRDL	Eligible for negotiation	Effects on survival (months)	Data Source	Type
Dasatinib	N/A	No	0.3	Phase III- OSR	PKI
Gilteritinib	N/A	No	4.3	Phase III- OS	PKI
Ivosidenib	N/A	No	2.8	Phase III- OS	PKI
Pemigatinib	N/A	No	5.8	Phase III- OS	PKI
Zimberelimab	N/A	No	7.3	Phase III- OS	PKI
Avapritinib	N/A	Yes	1.8	Phase III- OS	PKI
Axicabtagene	N/A	Yes	11.0	Phase III- PFS	PKI
Entrectinib	N/A	Yes	8.6	Phase III- PFS	PKI
Pralsetinib	N/A	Yes	1.4	Phase III- PFS	PKI
Relma-cel	N/A	Yes	3.3	Phase III- PFS	PKI
Atezolizumab	N/A	Yes	2.7	Phase III- OS	mAb
Blinatumomab	N/A	Yes	2.6	Phase III- OS	mAb
Cadonilimab	N/A	Yes	3.8	Phase III- PFS	mAb
Dinutuximab beta	N/A	Yes	4.2	Phase III- OSR	mAb
Durvalumab	N/A	Yes	2.9	Phase III- PFS	mAb
Envafolimab	N/A	Yes	0.6	Phase III- PFS	mAb
Inotuzumab	N/A	Yes	1.3	Phase III- OSR	mAb
Ipilimumab	N/A	Yes	1.6	Phase III- OS	mAb
Nivolumab	N/A	Yes	3.3	Phase III- PFS	mAb
Pembrolizumab	N/A	Yes	3.0	Phase III- OS	mAb
Ramucirumab	N/A	Yes	1.9	Phase III- OS	mAb
Rituximab	N/A	Yes	4.3	Phase III- OSR	mAb
Serplulimab	N/A	Yes	4.6	Phase III- OS	mAb
Sugemalimab	N/A	Yes	3.5	Phase III- PFS	mAb
Gefitinib	2016	Yes	2.0	Phase III- OS	PKI
Erlotinib	2017	Yes	0.7	Phase III- OS	PKI
Sorafenib	2017	Yes	1.5	Phase III- PFS	PKI
Nimotuzumab	2017	Yes	2.4	Phase III- OS	mAb
Trastuzumab	2017	Yes	4.6	Phase III- OSR	mAb
Afatinib	2018	Yes	2.1	Phase III- PFS	PKI
Anlotinib	2018	Yes	2.2	Phase III- OS	PKI
Axitinib	2018	Yes	2.2	Phase III- OS	PKI
Crizotinib	2018	Yes	3.1	Phase III- PFS	PKI
Ensartinib	2018	Yes	8.5	Phase III- PFS	PKI
Ibrutinib	2018	Yes	11.0	Phase III- OSR	PKI
Nilotinib	2018	Yes	1.0	Phase III- OS	PKI
Osimertinib	2018	Yes	3.1	Phase III- OSR	PKI
Pazopanib	2018	Yes	2.2	Phase III- OS	PKI
Regorafenib	2018	Yes	1.6	Phase III- OS	PKI
Sunitinib	2018	Yes	2.0	Phase III- PFS	PKI
Vemurafenib	2018	Yes	0.5	Phase III- OSR	PKI
Cetuximab	2018	Yes	1.0	Phase III- OS	mAb
Alectinib	2019	Yes	9.5	Phase III- PFS	PKI
Apatinib	2019	Yes	2.8	Phase III- OS	PKI
Fruquintinib	2019	Yes	2.6	Phase III- OS	PKI
Pyrotinib	2019	Yes	8.1	Phase III- PFS	PKI
Bevacizumab	2019	Yes	0.6	Phase III- OS	mAb
Pertuzumab	2019	Yes	5.9	Phase III- OS	mAb
Almonertinib	2020	Yes	9.4	Phase III- PFS	PKI
Dabrafenib	2020	Yes	2.4	Phase III- OSR	PKI
Denosumab	2020	Yes	0.6	Phase III- OS	PKI
Flumatinib	2020	Yes	3.1	Phase III- OS	PKI
Lenvatinib	2020	Yes	4.1	Phase III- OS	PKI
Ruxolitinib	2020	Yes	0.5	Phase III- PFS	PKI
Trametinib	2020	Yes	6.3	Phase III- OS	PKI
Zanubrutinib	2020	Yes	9.3	Phase III- PFS	PKI
Camrelizumab	2020	Yes	4.5	Phase III- OS	mAb
Daratumumab	2020	Yes	9.9	Phase III- OS	mAb
Inetetamab	2020	Yes	3.7	Phase III- PFS	mAb
Sintilimab	2020	Yes	3.9	Phase III- PFS	mAb
Tislelizumab	2020	Yes	5.2	Phase III- OS	mAb
Toripalimab	2020	Yes	4.8	Phase III- OS	mAb
Abemaciclib	2021	Yes	7.4	Phase III- OS	PKI
Dacomitinib	2021	Yes	2.6	Phase III- OS	PKI
Donafenib	2021	Yes	4.2	Phase III- OS	PKI
Ensartinib	2021	Yes	13.1	Phase III- PFS	PKI
Furmonertinib	2021	Yes	9.7	Phase III- PFS	PKI
Icotinib	2021	Yes	1.2	Phase III- PFS	PKI
Neratinib	2021	Yes	1.0	Phase III- OSR	PKI
Orelabrutinib	2021	Yes	21.8	Phase III- PFS	PKI
Pamiparib	2021	Yes	1.6	Phase III- PFS	PKI
Surufatinib	2021	Yes	6.3	Phase III- PFS	PKI
Disitamab vedotin	2021	Yes	0.7	Phase III- OS	mAb
Obinutuzumab	2021	Yes	18.6	Phase III- PFS	mAb
Brigatinib	2022	Yes	12.9	Phase III- PFS	PKI
Lorlatinib	2022	Yes	23.7	Phase III- PFS	PKI
Olverembatinib	2022	Yes	18.4	Phase III- PFS	PKI
Palbociclib	2022	Yes	3.3	Phase III- OSR	PKI
Ripretinib	2022	Yes	6.9	Phase III- OS	PKI
Savolitinib	2022	Yes	1.4	Phase III- PFS	PKI
Venetoclax	2022	Yes	18.2	Phase III- OS	PKI
Ado-trastuzumab	2022	Yes	2.2	Phase III- OSR	mAb
Brentuximab	2022	Yes	16.0	Phase III- PFS	mAb

Note: This table lists all innovative cancer drugs (mAb and PKI) and their overall survival effects collected from published clinical trials. Data Source denotes the efficacy outcome reported in the Phase III trial, from which we inferred an impact on Overall Survival as described in Appendix A.1.