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Abstract

This study investigated the impact of China's centralized drug procurement (CDP) on drug prices, utilization, and expenditure in China. Employing the event study method, we estimated the impacts for both contract-awarded (hereafter, "approved") drug products and unawarded (hereafter, "unapproved") products in the same molecule-dosage forms. The results show that the CDP decreased the prices of the approved drug products by 66.7% on average. Moreover, unintendedly, the CDP also pushed the prices of the unapproved products down by 25.9%. After the inception of the CDP, the quantities sold of the approved and unapproved products rose by four times and fell by 75.4%, respectively. With these estimates, we concluded that the CDP saves 252.2 billion yuan (equivalent to 38.8 billion US dollars) annually in drug expenditure.

1 Introduction

Given its large population and growing income level, China has become the second largest pharmaceutical market in the world. In 2020, its drug sales were 2.1 trillion Chinese yuan, which converts to approximately 300 billion US dollars.[1] Notably, this significant market sector has been criticized because of its high drug prices and lack of innovation. In the Chinese pharmaceutical market, a large majority of the drugs are generic; by early 2018, more than 95% of around 170,000 drug approvals issued by the National Medical Products Administration were generic.[2] Meanwhile, these generic drugs are sold at much higher prices compared to international levels, sometimes at even more than twice the price.[3] In 2019, drug expenditure amounted to 33.3% of the total health expenditure in China, which is more than twice the average level (15.3%) in OECD countries.[1,4]

Expensive drugs induce low drug consumption, adverse health outcomes, and future high medical costs.[5–8] With 1.36 billion people covered by the social health insurance system and the rapidly aging population in China,[9] the high drug prices put great pressure on fiscal expenditure in the present and even greater pressure in the future. Moreover, the high prices of generic drugs also guarantee exceptional profitability that the pharmaceutical firms enjoy and leave them no motivation to innovate. The government drug procurement policies are crucial for not only health and fiscal expenditures, but also drug innovation.[10–13]

To resolve such a predicament, the Chinese government has been centralizing drug procurement nationwide since 2018. It opened a bidding competition for the provision of 50% to 70% of specific drug prescriptions in all the public hospitals. In China, hospitals are the major venue of drug sales, accounting for approximately 62% of the total drug sales during 2020[1]; additionally, the majority of the hospitals are public, having 71.4% of the beds and 84.0% of

visits in the same year.[14] Only the producers of brand names or the generic drugs that passed the Generic Consistency Evaluation were invited to the bidding competition to ensure acceptable drug quality. With the high purchasing volumes and only a few selected bidders (less than six), the government intended to squeeze the drug prices to the lowest level through the competitive bidding process. This consolidation of drug procurement is called the centralized drug procurement (CDP); notably, it is also referred to as volume-based purchasing or bulk-buying.

The CDP has undoubtedly achieved acclaim for success. It was initiated specifically for 25 drugs (defined as chemical molecule-dosage-forms in this study) in 11 pilot cities in 2018, and it quickly expanded to more drugs all over the country. Until June 2022, China had launched five rounds of CDP procedures and covered 235 drugs (hereafter, CDP drugs). The government claimed that drug prices were reduced by 53% on average and that the accumulative saving in drug expenditure reached 232.3 billion Chinese yuan ($34.2 billion) from 2019 to 2021.[15,16]

Nonetheless, the economic influences of the CPD on drug expenditure were far more complicated than this government-claimed number for a number of reasons. First, the significant reduction in the drug prices after the procurement released the suppressed drug demand owing to previous high user costs. Hence, the quantities sold of the CDP contract-awarded (hereafter, "approved") products in the market were found to be greater than the quantities arranged in the procurement contracts. Second, the government only purchases the drugs with specific strengths and packaging that are produced by the winning firms (hereafter, "drug products") for part of prescriptions in public hospitals. Other products in the same molecule-dosage forms existed that either had different strengths or packaging or the same strengths and packaging but were produced by other firms. The prices and quantities sold of these unawarded drug products (hereafter, "unapproved") experienced changes after the CDP because these unapproved

products and the approved products were largely substitutes for each other. As such, their prices were likely to be pulled down and their market shares were likely to be squeezed.

Third, drug sales constituted a major source of hospital revenue in China, standing at approximately 30.6% between 2016 and 2020.[14,17] Given this underlying monetary incentive, the physicians may have dodged prescribing the approved drug products and chosen the unapproved products that had similar therapeutic effects and higher prices. Finally, patients may have been reluctant to use the approved products if they were under the impression that low prices imply low quality. These last two possibilities could offset the potential cost-saving impacts that the CDP could exert. Therefore, a deep and vigorous investigation is needed to evaluate the impacts of this new government procurement scheme on drug expenditure.

So far, several studies on the CDP have focused on the first pilot round of 25 drugs in 11 cities in early 2019.[18-20] However, the impacts of the pilot could be very different from those of the large-scale and nationwide procurement in the five follow-up rounds in later months. First, the estimated impact of the pilot on drug utilization might be overestimated because patients in the neighboring areas were found to visit the hospitals in the pilot cities for the low-price CDP-approved products. Second, in the pilot period, the pharmaceutical firms might not have been fully aware of the shock of the CDP policy and kept their sales and production strategies intact. Therefore, it took time for the CDP's impacts on drug prices and utilization to materialize as all the related parties——the government, firms, physicians, and patients—went through the process of awareness, learning, analyzing, and making appropriate decisions. Thus, by using the nationwide hospital sales data of the drug products from Q1 2016 to Q3 2021, we offer a complete examination of the CDP impact on the prices and quantities sold of the approved and unapproved drug products in the same molecule-dosage forms that were called out in the five

rounds of the CDP. Consequently, the impact of the CDP on drug expenditure can be estimated more accurately.

2 Study Data and Method

2.1 Data

We used drug sales data in sample hospitals nationwide from Wind Information Co., Ltd. during the period of Q1 2016 to Q3 2021. The sample hospitals included 564 tertiary hospitals and 112 secondary hospitals in 24 provinces, which is approximately 49% and 2.6% of total hospitals at each level in China, respectively. The chemical drug sales in the sample hospitals accounted for 15.2% of the total drug sales between 2016 and 2020 on average.[21] Each record includes the following information: China Approved Drug Name, which largely coincides with the international nonproprietary name given to the active molecule; dosage form; strength; package; production firm; sale time (in quarters); sale location (province); total sales; and total quantity sold. This information allowed us to calculate the price of each drug product and identify the approved drug products, which constitutes the panel data of prices and quantities sold at the drug product level in each province and each quarter. In this study, we mainly limited our work to the sample of drug products in the same molecule-dosage forms called out in the five CDP rounds. The sample included 6,209 products in 230 molecule-dosage forms (out of 235 in the call-outs of procurement) produced by 1,139 firms, for a total of 347,408 observations.

This drug sales data may not represent the drug sales in the whole market for the following two reasons. First, the data was oversampled in the tertiary hospitals, especially the grade-A tertiary hospitals (representing 72.49% of the grade-A tertiary hospitals in the country). The drug prescriptions in the tertiary hospitals might be different from those in the secondary and primary

hospitals. Second, the data does not cover the sales in retail pharmacies. However, such a discrepancy may not hurt the validity of our estimates because the tertiary hospitals accounted for 72.2% of the drug sales in all the hospitals between 2016 and 2020, and this percentage for the secondary and primary hospitals was 26.1% and 1.2%, respectively. Furthermore, unlike public hospitals, the retail pharmacies did not mandatorily join the government procurement program despite some individual pharmacies that were reported to have voluntarily done so in certain provinces later. More importantly, 223 out of 235 drugs in the procurement list are prescription drugs. In China, the majority of prescription drug sales occur in the hospitals; for example, retail pharmacies only sold 12% and 15% of prescription drugs in 2018 and 2020, respectively.[22] Hence, the impacts that our analysis obtained are believed to largely describe the changes in the whole market.

2.2 Statistical Analysis

Taking advantage of the relatively high frequency of the drug sales data, we employed the event study method to estimate the impacts of the CDP on the prices and quantities sold of the drug products in the same molecule-dosage forms called out in the five CDP rounds. In this study, we estimated the impacts for the approved and unapproved products separately because the mechanisms of the CDP's effects are different for them. The changes in the prices and quantities sold of the approved products were mainly determined by the negotiation results of the procurement bidding process. Discordantly, the prices and quantities sold of the unapproved products change owing to the great level of substitution between them and the approved drug. Hence, the impacts for these two types of products could go in different directions. Therefore, an understanding of these two differential impacts helps us evaluate the transformation of the whole drug market more completely.

The event study estimation method focused on the comparisons between the prices/quantities sold before and after the CDP. Because the CDP has been rolled out across the drugs at different times, the econometric model assembled the difference-in-differences estimation. Considering that the approved firms are only allowed to provide the drugs in certain provinces, the regression model included the (drug product)× province fixed effects to account for the fixed and unobservable characteristics of a drug product in a specific province. Moreover, the regression also controlled for the province×(14 Anatomical Therapeutic Chemical (ATC) classes)× time fixed effects. With such a regression specification, our analysis was able to exclude the influences of the changing disease patterns and provincial policies on the drug usage. Finally, to account for the correlations of drug prices and quantities sold within the ATC classes in each round of procurement, we clustered the standard errors at the level of (ATC classes)×(procurement rounds).

2.3 Limitations

This study had several limitations. The first one was the limitation that the data oversampled the tertiary hospitals. Nonetheless, as we have discussed, most of the sales of prescription drugs are in hospitals and mostly in tertiary hospitals (over 70%). Given this, our analytical results were considered to be the valid estimates of the CDP impacted drug prices and quantities sold. Second, we only had the aggregate sales data for all the drugs in the sample hospitals and lacked the detailed data of the drugs in molecule-dosage forms outside of the procurement call-outs. Therefore, we could not examine the substitution effects of the CDP on other drugs with similar therapeutic effects. Finally, the event study estimates may have involved influences of the trends in drug usage as well as other unobservable aspects. To ensure that the econometric model excluded these influences to a great extent, we examined the estimated coefficients of the lagged

terms of the CDP and found that they were not only small in magnitude, but also statistically insignificant.

3 Study Results

The five rounds of procurement took effect in Q1 2019 (expanded in Q4 2019), Q1 2020, Q4 2020, Q2 2021, and Q3 2021 as the following quarters of the announcement of the bidding results.[23] There were 235 drugs (chemical molecule-dosage forms) in the procurement call-outs, among which our data included 230 drugs that existed both before and after the government procurement. Exhibit 1 presents the average annual sales and numbers of the called-out drugs and those of total drugs in each ATC class in the drug sales of the sample hospitals data between 2016 and 2017 —— two years before the CDP starting time.[24] The three highest drug sales classes were the alimentary tract and metabolism (Code A) with 678 drugs and total sales of 42.8 billion yuan; antineoplastic and immunomodulating agents (Code L) with 277 drugs and total sales of 37.6 billion yuan; and antiinfectives for systemic use (Code J) with 561 drugs and total sales of 36.4 billion yuan. They amounted to 19.2%, 16.8%, and 16.2% of the total drug expenses, respectively. The number of the CDP call-out drugs only accounted for 5.7% of all the drugs in the market, but their sales accounted for 23.2% of total drug sales. This suggests that the government chose the drugs that are mostly prevalent in usage in the procurement. Such a selection is expected to generate significant impacts on drug expenditure in China.

Next, we calculated the drug utilization in each quarter by aggregating the numbers of doses or grams of active ingredients sold of all the products in that quarter. Exhibit 2 graphically presents the changes in the quarterly utilization and the average price for each drug and at the molecule-dosage-form level. The circle size presents the average quarterly sales during 2016 and

2017. The five largest sold molecules were clopidogrel (a blood clot inhibitor), atorvastatin (a statin medication which lowers cholesterol and triglyceride [fats] levels in the blood), lansoprazole (a medication which reduces stomach acid), pemetrexed disodium (an anticancer drug), and docetaxel (another anticancer drug). These particular drugs amounted to approximately 4.8%, 3.8%, 3.2%, 2.8%, and 2.8% of the total sales of the call-out drugs, respectively. After the CDP, their average prices were reduced by 50.3%, 37.5%, 48.6%, 40%, and 23.3%, respectively. The average price of the call-out drugs decreased by 32.4%, and their average price weighted by the drugs' initial quarterly sales during 2016 and 2017 decreased by 36.1%. It is noted there are 21 drugs whose average prices rose after the government procurement. This is because the CDP only awarded the contracts to brand-name or generic drugs that had passed the Generic Consistency Evaluation, which only started in 2016. To pass the consistency evaluation, the companies need to invest money not only in the biosimilar tests but also sometimes in the improvement of the pharmaceutical formulations, which lifts up the drug production costs. Hence, the approved drugs could be purchased at a higher price in the procurement than the average price before the CDP. When the prices drop, not surprisingly, the drug utilization increases; in fact, the average utilization weighted by the average initial quarterly sales increased by 137.9%.

Next, we used the event study method to separately estimate the dynamic effects of the CDP on the prices and quantities sold for the approved and unapproved drug products. Here period 0 was defined as the starting quarter of each round of procurement. Exhibit 3 plots the estimated coefficients of the lead and lag variables of the CDP policy and their 95% confidence intervals for price on the left panel and quantity sold on the right panel. The quarter immediately before period 0, period -1, was set as the default period. The coefficients of the lags were relatively

small and not statistically significant for both the approved drugs (in red line) and unapproved drugs (in grey line). This implies that with controlling for all the fixed effects in the regressions, the influences of the trends and other unobservable factors in drug prices and quantities sold were well eliminated.

Then, after the government procurement, the prices of the approved drug products dropped significantly owing to the bidding competition process. The coefficients of the CDP variables started to decrease in period 0 and stayed at approximately the same magnitude since period 1, with a 1% level statistical significance. The reason why the coefficient in period 0 was smaller than those in the periods afterwards was that period 0 was set as the quarter after the announcement of the procurement bidding results. Yet, in reality, it took a longer time for the purchased products to be sold in the hospitals. Hence, the average price in period 0 was a mixed price before and after the CDP. The coefficients from periods 1 and 4 were quite stable, revealing the price differences of the drug products before and after the procurement. The average of the coefficients from period 1 to 4 was -1.1, suggesting a price reduction of 66.7%,[25] which mostly coincided with the 53% price reduction claimed by the government.

More interestingly, we observed that the prices of the unapproved drug products also decreased along with the CDP implementation. The average coefficient during periods 1 and 4 was -0.3, which implied a 25.9% average reduction in the prices; notably, such a spillover effect was consistent with our previous conjecture. The drug products in the same molecule-dosage forms were substitutes to a great extent. As their approved counterparts featured lowered prices by entering the government procurement list, the prices of the unapproved products were forced to be cut in order to make themselves appealing in the market.

The right panel of Exhibit 3 shows the estimated impacts of the CDP on the quantities sold of the approved and unapproved products. As stipulated by the CDP schemes, the approved products were granted with a large volume of drug sales in public hospitals. The average of the coefficients from periods 1 to 4 was 1.6, equivalent to a four times increase in the quantities sold. In contrast, despite their prices being lower, the unapproved products experienced significant losses in the market shares. The average of their coefficients between periods 1 and 4 was -1.4, which implied a 75.4% reduction in their quantities sold.

With the estimated coefficients in Exhibit 3, we then calculated the change in the drug expenditure caused by the centralized drug procurement, as shown in Exhibit 4. The sales of the approved products decreased by $1-(1-66.7\%)\times(4+1)=-66.5\%$, equivalent to a 66.5% increase. Similarly, the sales of the unapproved products decreased by $1-(1-25.9\%)\times(1-75.4\%)=81.8\%$. The average annual total sales of the approved products were 2.5 billion and those of unapproved products were 48.9 billion during 2016 and 2017 in our sample. As our sample constituted approximately 15.2% of the total drug expenditure in hospitals, the total saving in annual drug expenditure can be calculated by $\frac{-66.5\%\times2.5+81.8\%\times48.9}{15.2\%}=252.2$ billion yuan. This number was much higher than the accumulative number of 232.3 billion yuan in three years that the government claimed.

4 Conclusion and Discussion

Our study estimated the impacts of the CDP on the drug prices, utilization, and expenditure in China. The results showed that the centralized procurement caused the prices of the approved drug products to drop by 66.7%, and their quantities sold increased four times. Moreover, unintendedly, the procurement also pushed the prices of the unapproved products in the same

molecule-dosage forms down by 25.9% on average. The quantities sold of the unapproved products in the market shrunk dramatically by 75.4%. Therefore, with these estimates, the CDP saved 252.2 billion yuan (38.8 billion US dollars) annually in drug expenditure.[26]

Although we acknowledge the significant impact of the CDP on saving on drug expenditure, it is worth noting that such an impact is more likely a static one. In the long run, the impact might be different in a few ways. First, here we ignored the differential utilization trends across drugs. Demographic change leads to changes in the disease patterns and, consequently, drug usage over time, which would affect the estimated impact on drug expenditure. Second, the CDP bidding process squeezes the markups in the drug prices that firms can charge and considerably reduces firms' profits from producing generic drugs. This, as the government intended to do, may incentivize firms to invest in drug innovation to pursue monopolistic profits. The emergence of new drugs would contribute substantially to the quality of life and longevity of people.[27] Such an influence is not counted in our estimates. Finally, with regard to the big picture, studies have shown that reducing the user costs of drugs can reduce other medical spending because it promotes adherence to drug therapy.[28-32] Specifically, the CDP decreased the drug prices and facilitated drug usage, which could mitigate overall healthcare spending in society.

Notes

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16. The government claimed that the total saving is 260 billion, among which the savings on heart stents and artificial hips and knees are 11.7 and 16 billion, respectively. The exchange rate is the average one during 2019 and 2021: 1 US dollar = 6.8 Chinese Yuan.

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21. The denominator is total drug sales from China Health Statistical Yearbooks (2017)—(2022). Here the total drug sales include the sales of small-molecule chemical drugs and biopharmaceuticals, but do not include the sales of traditional Chinese medicines. Because the national aggregate sales of chemical drugs are not published separately, we use . The number of total drug sales in 2021 has not been published.

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24. There are 215 CDP call-out drugs in the sample from 2016 to 2017.

25. The economic meaning of the average of estimated coefficients is obtained from $e^{-1.1} - 1 = -0.667$.

26. The exchange rate is set as the one in 2021: 1 US dollar= 6.5 Chinese yuan.

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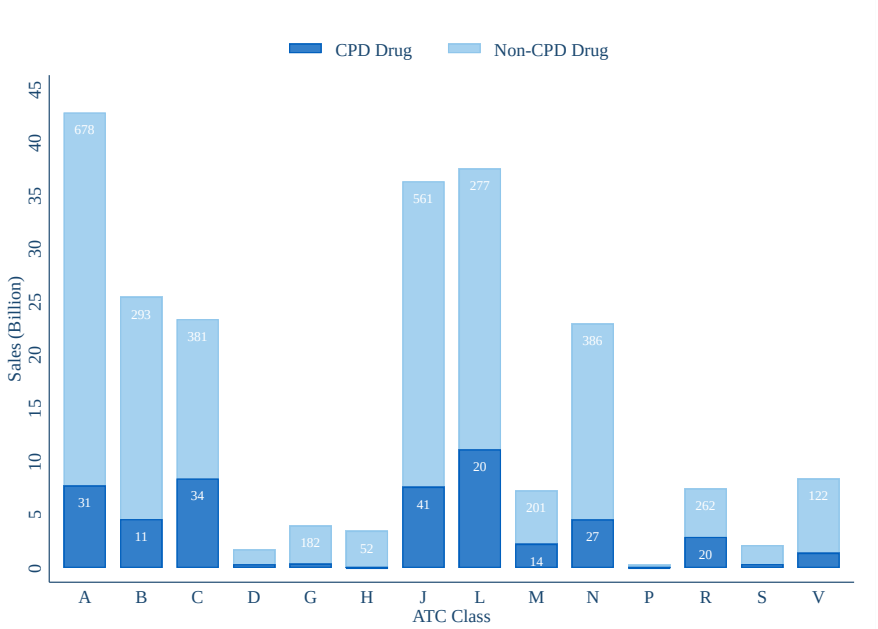
EXHIBIT 1 (figure)

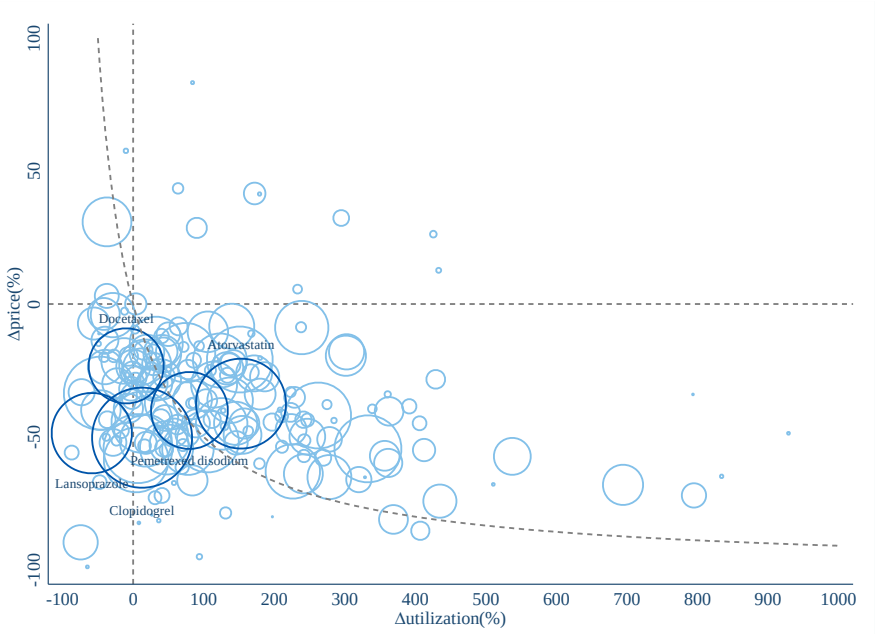
Caption: [Numbers of the drugs in the market]



Notes: This graph presents the numbers and total annual sales of all the drugs and CDP call-out drugs in the sample hospitals from 2016 to 2017. There are 219 call-out drugs and 7,484 drugs in total. The numbers on each bar are the numbers of CDP drugs and total number of drugs in that ATC class. The height of the bar refers to the sales of the CDP drugs and total sales in that ATC class. The drug numbers that are not able to be marked on the bars are: 2 for CDP drugs and 186 for the total drugs in class D; 8 and 1 for the CDP drugs in classes G and H, respectively; 1 for CDP drugs and 20 for the total drugs in class P; 3 for CDP drugs and 141 for the total drugs in class S; and 1 for CDP drugs in class V.
Source: The drug sales of the sample hospitals from Wind Information Co., Ltd.

EXHIBIT 2 (figure)

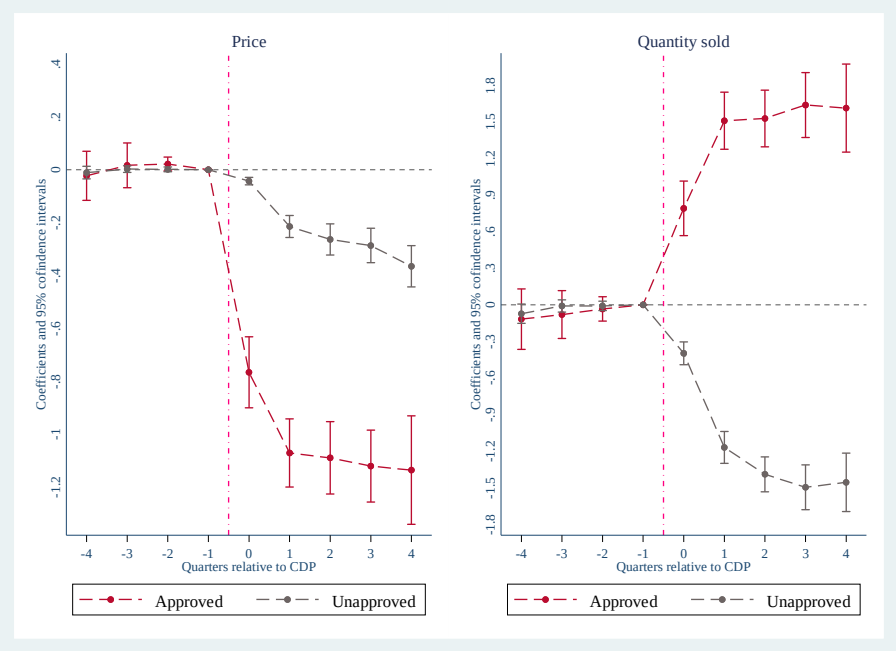
Caption: [Changes in prices and utilization after the CPD]



Notes: This graph portrays the changes in the average prices and quarterly utilization of the CDP call-out drugs from 2016 to 2017 and the time of the CDP implementation. There are 219 call-out drugs. The drugs whose prices increase over 100% or whose changes in utilization of 10 times are dropped from the graph to allow for better presentation.
Source: The drug sales of the sample hospitals from Wind Information Co., Ltd.

EXHIBIT 3 (figure)

Caption: [Dynamic effects of the CDP on drug prices and quantities sold]



Notes: This graph plots the estimated coefficients of the lead and lag variables of the CDP policy and their 95% confidence intervals for price on the left panel and quantity sold on the right panel. If the time distance is greater than four quarters, we code the lags and leads as -4 or 4 depending on whether that time is before or after the procurement was launched.
Source: The drug sales of the sample hospitals from Wind Information Co., Ltd.

EXHIBIT 4 (table)

Caption: [Calculation of drug expenditure savings of the CDP policy]

Lines	Description	Estimates/numbers	Sources
1	Average decrease in the prices of approved products	66.7%	Exhibit 3
2	Average increase in the quantities sold of approved products	400%	Exhibit 3
3	Cost saving of approved products	−66.5%	$1-(1-line1)\times(line2+1)$
4	Annual total sales of approved products during 2016 and 2017	2.5 billion	Sample mean
5	Average decrease in the prices of unapproved products	25.9%	Exhibit 3
6	Average decrease in the quantities sold of unapproved products	75.4%	Exhibit 3
7	Cost saving of unapproved products	81.8%	$1-(1-line5)\times(1-line6)$
8	Annual total sales of unapproved products during 2016 and 2017	48.9 billion	Sample mean
9	Annual cost saving of the CDP	252.2 billion	$\frac{line3\times line4+line7\times line8}{15.2\%}$