How the Chinese national centralized drug procurement affects the revenues of pharmaceutical companies: a quasi-natural experiment based in China

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Abstract

Background: As China's band purchasing policy affects firms’ revenues, this study aims to investigate how the revenues of firms entering the policy change in the context of the normalization of the policy, with the goal of providing suggestions for its improvement.

Methods: We selected two time points, December 2018 and March 2019, to investigate the impact of the policy on firms’ revenues by means of a difference-in-differences model using data from 265 pharmaceutical companies in China.

Results: We found that the policy has a negative effect on firms’ net income, which is significant at the 1% level when controlling for internal and external variables. We also demonstrated the reliability of the regression results through parallel trend, placebo, and randomness tests.

Conclusions: Our research shows that although firms are able to gain a larger market share by entering centralized purchasing, the low prices result in lower revenues due to the market dynamics. These results also reflect the policy’s bias in favor of drug purchasers and users, as well as the nature of price competition that places affected pharmaceutical companies in a relatively passive position in the market.

1 Introduction

To ease the pressure on the health insurance fund, China conducted state-based banded purchasing for medicines with competitive patterns from late 2018 to early 2019. The national health insurance department of China announce the national demand for drugs under the same generic name, and companies make bids by submitting their prices and quantities of drugs they can provide. The winning bids are based on the total demand quoted by the government and the price offered by the company [1]. Firms that bid low prices are prioritized for procurement opportunities, and the market share is allocated by the government (Table 1). Drugs must be evaluated to ensure that their quality and efficacy meet national requirements before they can be added for subsequent tenders [2]. A group set up by China's national health insurance department develops a list of collectively procured medicines based on the quantity of medicines required by individual hospitals, the basic medicines catalog of the health insurance, and the requirements of consistency evaluation. It also guarantees the prioritized use of the collectively procured medicines. The state specifies the quantity of drugs to be purchased, and enterprises make offers and bargains. The enterprise with the lowest offer wins the bid. The enterprise that wins the bid occupies at least 50% of the procurement share of public medical institutions within the pilot area for the prescribed procurement cycle, and enterprises that have not won the bid can only compete for the remaining market share, which reflects the characteristics of “volume-price linkage and volume-for-price” of volume-based procurement [3].

This is very different from the dominant drug procurement model globally. Mainstream procurement [4-12] is mainly carried out through agreements and negotiations. Multi-dimensional indicators, such as quality, economy, and enterprise capacity, are used to assess the prices of medicines. More reasonable
prices are arrived at through price-quantity and purchasing agreements to ensure that the health insurance fund is sustainable and enterprises are sustained. Compared with other procurement methods, China's tendering of competitive medicines in the form of band volume bidding is more favorable for a complete market mechanism [13]. Its bidding mechanism (the lowest bidder gets the lowest price) can significantly reduce the price of medicines and effectively cut down on the expenditure of the health insurance fund [14].

However, excessive price reductions are a potential drawback of the policy [15-17]. Over-reliance on the market mechanism can lead to excessive competition among enterprises and lower profits in the industry, which is not conducive to the development of the enterprises concerned. Therefore, the policy needs to formulate better pricing rules and develop feasible price reduction and reasonable market share allocation mechanisms [13] to ensure the balance of interests between enterprises and health insurance payers [18]. This equilibrium is mainly reflected in two aspects. First, the initiative of band purchasing places enterprises involved in the national procurement of various drugs in a dilemma. Successful bidding means that the unit price of the drug is reduced, with a corresponding reduction in the income of the enterprise with the same market share. In contrast, failure to carry out the bidding means that the market share is reduced, and other factors, such as the medication policy of the hospital and saving on medical expenditure, may also lead to the reduction of income [19-21]. Therefore, enterprises are forced to choose between market share and price. Second, health insurance payers aim to spend less money to buy more medicines to ensure the accessibility of medicines and satisfy the needs of the population, and they favor lower prices of medicines. Relying excessively on market mechanisms to lower drug prices can result in reduced incentives for companies to produce drugs and a decline in the quality of drugs [22-24]. Although the price reduction of medicines has reduced the financial burden on patients and fulfilled clinical needs, it has also reduced the expenditure of the health insurance fund and addressed the concerns related to the failure of the health insurance fund to meet its budgetary goals in recent years. However, the mismatch between the market demand and the failure to promptly adjust supply may lead to shortages of medicines. In turn, the lack of timely supply of selected medicines on a large scale may lead to medication insecurity (e.g., spoilage and theft), which will have a marked impact on public security [25].

Studying the impact of the banded purchasing model on corporate revenues will not only improve the purchasing model but also improve the market mechanism, which will effectively reduce drug prices and serve as a model for the current purchasing systems. At present, China has carried out centralized purchasing of medicines for the eighth time, and the role of the market mechanism has led to a significant reduction in the prices of medicines, with an average reduction of more than 40% [26]. This has led to higher requirements for the formulation of purchasing rules. Understanding the impact of China's centralized purchasing on the operating revenues of enterprises can facilitate the improvement of the relevant purchasing system to prevent medicine shortages, decline in the vitality of the industry, and other consequences. This will ensure a balance between the interests of the pharmaceutical enterprises, patients, and health insurance fund. Several scholars have suggested that this equilibrium significantly depends on the drug prices [19, 22, 23, 27, 28], which directly affect the business income. If enterprises
engage in procurement and their operating income is significantly high, there is still room for price reductions. On the contrary, if enterprises engage in procurement and their operating income is significantly low, it is necessary to regulate the medicine prices through other means outside the market mechanism. This will help maintain or revitalize the industry and prevent drug shortages.

2 Background

Impact of Chinese national centralized drug procurement on Chinese pharmaceutical companies

Some studies have reported that China’s centralized purchasing model has led to changes in the behavior of stakeholders [29–34]. After decades of changes in China’s drug procurement, the pharmaceutical market has gradually transformed from a supply-side market in the planned economy to a demand-side market where prices are exchanged for quantity. During this period, changes in procurement policies have altered the collusion between medical institutions and pharmaceutical companies. Additionally, the evolving rules of the market under the influence of procurement policies have led to changes in the policy stance of each stakeholder, the use of resources, and vested interests, which have resulted in the following three types of changes.

First, industrial change is guided by supply and demand [29, 34]. China’s pharmaceutical industry was developed late, and generic drugs have become important for domestic pharmaceutical manufacturers. Over the past few decades, the market for generic drugs has gradually expanded. Drugs are no longer as scarce as they were during the planned economy, the bargaining power of the demand side has gradually increased, and the structure of supply and demand has directly affected the formulation of procurement policies. From the original districts, counties, provinces, and municipalities to the current national centralized procurement, the generic drug market has gradually shifted from the local to the national level under the model of generic management. Concurrently, the change in the competitive landscape has forced generic companies to reduce costs and improve competitiveness through generic innovation and supply chain expansion to prevent the business risks brought by the market expansion. From the procurement perspective, market integration makes the generic drug industry gradually develop toward economies of scale and generic innovation.

Second, changes in the market environment are caused by changes in the way enterprises compete [30, 32]. Changes in procurement policies have transformed the market environment from “pharmaceutical collusion” to “doctor-patient collusion,” and generic drug companies have gradually become passive in the market. Product characteristics related to patient interests, such as quality and price, have gradually become the target. The quality of drugs has become the main factor in determining their price, which has led to a decrease in prices for generic drugs. This has shifted the focus of competition in the pharmaceutical industry from lobbying for government subsidies to reducing production costs, improving scale economies, and promoting innovation. At this time, generic enterprises without core competitiveness and high-quality products will face bankruptcy, mergers, and acquisitions, and changes in competition leads to changes in the generic drug industry.
Third, enterprise structure reform is caused by changes in resource utilization capacity and decision-making inertia [30, 31, 33]. In the past, the model of differentiating the drug quality and purchasing according to the price made it easy to reach a consensus on the collusion between medical institutions and generic drug companies. Additionally, the absence of relevant regulations on the quantity of drugs to be used in winning bids accorded medical institutions marked freedom in using drugs, and enterprises needed to spend large sums of money on lobbying and rent-seeking. Resources were biased toward market promotion and rent-seeking staffing rather than product research and development, supply chain reforms, and production investment, which largely wasted social resources and impeded the improvement of social welfare. Under the band purchasing policy, competition among pharmaceutical companies has shifted to production, procurement, and employment. At the same time, the two-invoice system, abolition of drug price markups, and other policies, in conjunction with band purchasing, have changed the distribution model for drugs. This has largely restricted the transfer of benefits during drug distribution. The change in the sales model has resulted in the redundancy of enterprise marketing and sales departments, leading to departmental reorganization and personnel transfer, which pose challenges for the structural reform of generic drug enterprises.

Mechanisms of the impact of Chinese national centralized drug procurement on corporate revenues in China

Several studies have explored the impact of China's banded bidding on pharmaceutical firm revenues in terms of economics and game theory [28, 35]. From the perspective of the theory of economy of scale, China reduces the original costs of publicity, promotion, and distribution of enterprises by giving the winning enterprises enough market share to reduce the cost of selling their medicines to hospitals. The enterprises can obtain profit margins through the improved volumes of medicine sales, which is a win-win situation for the state, enterprises, and patients. To an extent, the revenues of the enterprises are improved [22]. From the game theory perspective, the implicit income of the hospital is reduced after the implementation of centralized band purchasing. There is a lack of initiative to purchase the collected drugs, and the use of collected drugs is intentionally reduced in the report, creating greater opportunity for the purchase of unsuccessful drugs. This results in a reduction of the market share of the winning drugs, which partially reduces the income of the enterprise [19, 20]. The conclusions vary and are based on theoretical analysis, and we have not conducted a corresponding empirical research.

3 Methods

Empirical strategy

We designed a quasi-natural experiment using data from the 39 firms with centralized procurement in December 2018 and March 2019 as the experimental group. At the end of 2018, China launched the national centralized procurement of medicines, and the centralized procurement policy was gradually applied to the entire country. China's national centralized procurement policy is a key initiative to reform the medical and health system. The main purpose of this policy is to reduce the inflation of drug prices,
accelerate the substitution of imported products, and reduce the drug costs. This is ultimately targeted at driving the reforms of medical insurance and operational mechanisms in public hospitals, amplifying the reform effect, and solving the problem of accessibility of the masses to medical care.

We selected the two time points for two reasons. The policy intervention was initiated at the beginning of 2019, as this is the time when the first centralized drug procurement was implemented in China. In addition, enterprise data before and after the policy may more realistically reflect the quasi-natural relationship between the variables. Finally, the two time points correspond to China’s first and second centralized purchasing, which represent two different market patterns. The first procurement had a larger selection of drugs and higher price cuts, which were more in line with the policy expectations.

We analyzed the net revenue to determine the impact of the policy implementation on enterprise revenue. This has been used in most studies [14, 26, 36, 37]; however, most enterprises produce more than one product, and their revenue is not equal to the revenue of individual products. From the perspective of China’s centralized purchasing policy, however, the purchasing volume is large. The winning enterprises end up with a large production scale, and the winning drugs are the main income source for the winning enterprises. Therefore, net revenue is a good indicator of the impact of the policy.

In particular, we applied the difference-in-differences method to analyze this quasi-natural experiment. The regression model can be expressed as:

\[ Y_{it} = \beta_0 + \beta_1 \text{treat}_i \times \text{post}_{it} \times \gamma X_{it} + \alpha_i + \delta_t + \epsilon_{it} \]

Where \( Y_{it} \) represents the net revenue of the pharmaceutical enterprise in year \( t \), which is expressed using the annual revenue of the enterprise. \( \text{treat}_i \) is a dummy variable for the experimental group. \( \text{treat}_i \) has a value of 1 when the enterprise has won the bid during the tender; otherwise, it has a value of 0. \( \text{post}_{it} \) is a dummy variable for the experimental period; when the value is 1, the enterprise \( i \) would have won the bid during the tender; otherwise, it has a value of 0. \( X_{it} \) is the set of control variables, \( \alpha_i \) is the individual fixed effect, \( \delta_t \) is the time-fixed effect, and \( \epsilon_{it} \) is the randomized disturbance term.

\( \text{did} = \text{treat}_i \times \text{post}_{it} \text{DID} \) is the core explanatory variable of the model, with value of 1 indicating that the pharmaceutical firm \( i \) has won the tender in year \( t \). Its coefficient \( \beta_1 \), which is the focus of attention in the study, measures the net effect of China’s centralized purchasing policy on the revenue level of pharmaceutical firms.

In order to control for potential confounding variables, ensure the accuracy and reliability of causal inferences, and thus reduce bias in the estimation of causal effects and improve internal validity, we introduced corresponding control variables. Based on the variables used in previous studies [14, 26, 36, 38–41], we selected several internal and external control variables to control the regression of the model and conducted a rigorous causality analysis in the inclusion of covariates in accordance with the findings of a previous study [43]. Among the internal control variables, operating costs, compensation payable to employees, and the number of employees are mainly used to determine the costs of the enterprise,
particularly the cost of human resources and commercial rent-seeking. These variables were selected because the winning enterprise substantially saves expenses and manpower in the marketing and sales departments compared to the enterprise that has not won the bid. The winning company’s market share is certain, so it does not need to develop marketing strategies and academic promotional activities to increase its sales. Therefore, its marketing and sales departments working on its bidding products are subjected to layoffs and transfers, which partially reduces the company’s operating costs. The reduction in operating costs of the winning enterprise will affect its revenue and, to a certain extent, can improve its income level. Furthermore, it has a strong causal relationship with the dependent variable, which can affect the results of the model regression. The numbers of intangible assets and research and development (R&D) personnel were mainly used to measure the investment of the enterprise in R&D. They were mainly selected because collective purchasing promotes the transformation of enterprises, reduces their sales expenditure, and increases their investment in R&D. The strategic shift of the winning enterprise will enable the original sales costs that are saved to be used for R&D, which will partly weaken the relationship between “whether to win the bid” and “enterprise cost” less obvious. This will affect the net income of the enterprise. In addition, the increase in R&D costs and intangible assets will directly affect the net revenue of the enterprise. Therefore, the numbers of R&D-related intangible assets and R&D personnel have a causal relationship with the net revenue of enterprises. Scholars have already applied these two variables in their studies of centralized band purchasing of medicines in China [39, 40]. The return on assets, equity structure, and location were also used as control variables to reduce the random error. The abovementioned variables are divided into two control groups according to the source of the indicators (Table 2).

<table>
<thead>
<tr>
<th>Number of enterprises winning the bid</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>≥ 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Committed market share (%)</td>
<td>50</td>
<td>60</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>Average share (%)</td>
<td>50</td>
<td>30</td>
<td>23.3</td>
<td>20</td>
</tr>
</tbody>
</table>
Table 2
Variable selection and grouping

<table>
<thead>
<tr>
<th>Variable grouping</th>
<th>Variable group abbreviation</th>
<th>Variable groups contain variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explanatory variable</td>
<td>Net income</td>
<td></td>
</tr>
<tr>
<td>Core explanatory variables</td>
<td>did</td>
<td>$treat_i \times post_{it}DID$</td>
</tr>
<tr>
<td>Internal control variables</td>
<td>Control 1</td>
<td>Operating cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Payroll payable to employees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quantity of intangible assets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of employees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Overhead rate</td>
</tr>
<tr>
<td>External control variable</td>
<td>Control 2</td>
<td>Return on assets(ROA)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$state_{code}$ (Depending on the administrative division of China, a number from 1 to 100)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$own_{code}$ (State: 1, private: 2, foreign: 3, mixed state-private: 4, private-foreign: 5)</td>
</tr>
</tbody>
</table>

Data

The raw data on the indicators of pharmaceutical companies were obtained from the China Stock Market & Accounting Research Database, Chinese Research Data Services Platform, and CECN statistical database library. Based on the timing of policy intervention for the selected samples and the availability and completeness of the sample data, we selected the listed companies in China's pharmaceutical manufacturing industry from 2015 to 2022 as the research sample. After removing missing data, data anomalies, and ST and *ST category companies for the variables, the final raw data covered 265 pharmaceutical companies, of which 39 were in the experimental group and 226 belonged to the control group, accounting for a total of 1,875 observations. Table 3 presents the descriptive analysis for each variable, demonstrating that there are large differences in the revenue and internal control variables of each enterprise.
Table 3
Descriptive statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net revenue (/billion yuan)</td>
<td>4.489</td>
<td>13.263</td>
<td>0.019</td>
<td>201.495</td>
</tr>
<tr>
<td>Operating cost (/billion yuan)</td>
<td>1.84</td>
<td>6.71</td>
<td>0.0001</td>
<td>136.52</td>
</tr>
<tr>
<td>Payroll payable to employees (/billion yuan)</td>
<td>0.08</td>
<td>0.153</td>
<td>0.00001</td>
<td>1.771</td>
</tr>
<tr>
<td>Quantity of intangible assets (/billion yuan)</td>
<td>7.546</td>
<td>12.372</td>
<td>0.268</td>
<td>198.135</td>
</tr>
<tr>
<td>Number of employees (/1000)</td>
<td>4234.19</td>
<td>6022.6</td>
<td>65</td>
<td>48136</td>
</tr>
<tr>
<td>Overhead rate (%)</td>
<td>0.0989</td>
<td>0.067</td>
<td>0.0054</td>
<td>0.9647</td>
</tr>
<tr>
<td>Return on assets (%)</td>
<td>0.0565</td>
<td>0.084</td>
<td>-0.8469</td>
<td>0.5415</td>
</tr>
</tbody>
</table>

Parallel trend test

One of the prerequisites of the double difference method is to satisfy the parallel trend assumption. It was necessary to verify whether there is a significant difference in the collection capacities of the enterprises that were affected and unaffected by the policy. If there was no significant difference in the net operating income before the policy implementation, the parallel trend assumption was satisfied.

In this paper, the time dummy variable $post_{it}$ in the model is replaced with a dummy variable for each year of the 2015–2022 sample, and the regression analysis is conducted with 2019 as the base year. The results are shown in Fig. 1, with the dotted line in each year representing a 99% confidence interval. As shown in Fig. 1, there was no significant difference between the experimental and control groups in the level of income before the implementation of the collection policy. However, the net income of the enterprises affected by the collection policy was significantly reduced and was significantly lower than that of the control group, indicating that the baseline regression in this paper fulfilled the parallel trend assumption. In addition, in terms of the dynamic effect of the collection policy, the collection policy in late 2018 and early 2019 significantly reduced the net operating income of the winning pharmaceutical enterprises, and the policy effect was significantly negative at the 1% level for both cases. Based on these results, the data satisfied the parallel trend test at the 1% level, indicating that the collection policy has a direct impact on the operating income of enterprises.

4 Empirical results

Basic results

Table 4 presents the regression results. Column 1 includes only the internal control variable group “Control 1” as a control variable. The “did” coefficient of is significantly negative at the 1% level, indicating that the centralized purchasing policy had a significant negative inhibitory effect on the revenue level of pharmaceutical companies. Column 2 adds the external control variable group “Control
“1” to the regression, and the “did” coefficient remains significantly negative at the 1% level. The abovementioned results suggest that the pooling policy negatively affected the net income of firms.

### Table 4
Basic analysis

<table>
<thead>
<tr>
<th></th>
<th>Regression 1</th>
<th>Regression 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Net income</strong></td>
<td><strong>Net income</strong></td>
<td></td>
</tr>
<tr>
<td>did</td>
<td>-2.072***</td>
<td>-2.066***</td>
</tr>
<tr>
<td></td>
<td>(-7.33)</td>
<td>(-7.31)</td>
</tr>
<tr>
<td>Control 1</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Control 2</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Constant</td>
<td>0.219</td>
<td>-0.161</td>
</tr>
<tr>
<td></td>
<td>(1.02)</td>
<td>(-0.14)</td>
</tr>
<tr>
<td>N</td>
<td>1875</td>
<td>1875</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.978</td>
<td>0.978</td>
</tr>
</tbody>
</table>

[1] *** **, and * represent statistical significance at the 1, 5, and 10% levels, respectively. [2] Robust standard errors are reported in parentheses.

1. Figure

Robustness

Before data processing, we conducted a parallel trend test on the data (Fig. 1) and found that the explanatory variable “net income” was significantly different before and after the policy implementation. Despite not being significant before policy implementation, it was significant at the 1% level during and after the policy implementation, which indicates the accuracy of the model. During baseline regression analysis, we controlled the control variable groups separately and found no significant differences in the regression results. The results were significant at the 1% level, which proves the robustness of the model. We also conducted a placebo test and a randomization experiment for the analysis.

### 4.1.1 Placebo testing

To reduce errors in the baseline regression analysis due to omitted variables, a placebo test was conducted. The sample was grouped by firms. One year was randomly selected as the policy time for each firm group, and 1,000 simulated regressions were conducted. Figure 2 presents the results of the simulated regressions. The estimated coefficients of the simulated regressions were clustered around 0, and most of the simulated coefficients had p-values > 0.05, indicating that the results were not significant.
at the 5% level. Therefore, the baseline estimates in this paper are not obtained by chance, and the baseline estimates are not affected by other policies or omitted variables.

### 4.1.2 Randomness test

A prerequisite for using the double-difference method is to ensure that the samples in the experimental and control groups are randomly grouped after controlling for the relevant influencing factors. Therefore, the enterprises participating in state procurement are typically large according to economic scale and strength. However, not all the winning enterprises were large. Some of the enterprises were small, as they used a lower price of the winning bid and used to save sales and marketing inputs to obtain a market share. Therefore, the requirements of randomness were met.

### 5 Conclusion

Because one of the prerequisites for using the double-difference method is to ensure that the samples in the experimental and control groups are randomly grouped after controlling for the relevant influencing factors, the enterprises participating in state procurement are generally considered to be large enterprises with good economic scale and strength. However, not all the winning enterprises in the experimental group were large. Some small enterprises won bids by offering lower prices, which they used to save from sales inputs and gain market share. This meets the requirements of randomness, as the sample of enterprises was selected randomly.

Therefore, China’s health insurance policymakers should avoid the overuse of market mechanisms. Sole emphasis on price reductions may discourage drug producers and manufacturers from producing drugs, given that they already have thin profit margins. Additionally, supervisors of the implementation of the policy should monitor for potential problems such as medicine shortages and reductions in medicine quality.

We have also discussed relevant solutions for the aforementioned problems. The main purpose of drug collection is to reduce drug prices and alleviate the financial burden of patients. However, emphasizing low prices and ignoring the original competitive system and laws of the market will only lead to chaos in the drug market, which is not conducive to the policy implementation. Therefore, the government needs to pay attention to the application of the concept of “value” in selecting drug suppliers by combining the selection criteria from the United Kingdom, Germany, and World Health Organization. Therefore, the government should focus on the application of the concept of “value” and consider drug suppliers based on various factors, especially long-term quality assurance and continuous supply capacity. This will prevent drug shortages caused by an increase in patient demand due to the decrease in drug effectiveness. Furthermore, the government should expedite the formulation and introduction of laws and regulations on the collection and procurement process, which can be modeled according to the current Metric Act of the United States and Fair Accountability and Innovative Research Drug Pricing Act to standardize the process of drug collection and procurement. This will allow reasonable pricing for drug
collection and procurement, improve the profit margins of enterprises, and enhance the motivation of enterprises to participate in drug collection and procurement. In addition, lessons can be learnt from the mature supervision and management systems from other parts of the world based on the respective country conditions. This is modeled on the basis of the tripartite independent system of prequalification, procurement, and supervisory personnel to reduce the intervention of the state and the government in the process of drug collection and procurement, provide hospitals with more purchasing autonomy, and facilitate a competitive mechanism in the market. The government, on the other hand, mainly supervises the entire process of collective procurement through the laws and regulations related to collective procurement and requiring suppliers to give an advance notice of possible increased drug demand to allow macro-control of potential drug supply shortages.

Our empirical study provides a basis for reforming China’s pooled purchasing policy and implementing it in countries or regions that aim to reduce drug prices and the expenditure of health insurance funds through market mechanisms. A limitation of our study is that we focused only on China. Different countries may have distinct social practices and cultures that influence decision-making, suggesting that the influencing decision-making factors may vary. However, medicine procurement in all countries should be based on objective conditions. Therefore, our findings are also instructive for countries with different socio-economic backgrounds. In particular, we focused on the impact of the procurement model of the market mechanism on the revenues of the pharmaceutical producers, which is a special commodity, rather than on specific applications. Future research can further investigate the role of centralized procurement models similar to China’s centralized procurement in terms of health insurance funds, industrial agglomeration, patient satisfaction, and clinical use of drugs.

**Abbreviations**

R&D  research and development

ST and *ST  special treatment. If a listed company has abnormal financial conditions that lead to the risk of delisting its stocks, or if investors find it difficult to judge the company's prospects and their investment rights are damaged, the exchange will issue a risk warning to its stocks. According to different situations, risk warnings can be divided into delisting risk warnings (*ST) and other risk warnings (ST).

**Declarations**

1 **Ethics approval and consent to participate**

Not applicable

2 **Consent for publication**
3 Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

4 Competing interests

The authors declare that they have no competing interests.

5 Funding

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6 Authors’ contributions

FY led the entire study. FY designed the study, led the data collection and analysis, and wrote the manuscript. JS, ZS, and RX participated in the data analysis, literature review, and writing the paper. SC participated in the study design, reviewed the manuscript, and provided comments on the first manuscript. JJ and HY contributed to data interpretation and edited the manuscript. All authors contributed to the article and approved the submitted version.

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8 Authors' information (optional)

References


3. Zheng Y, Ding J, Li J. Empirical study on bidding grouping scheme for banded purchasing of high-
(Gpos) in China within the Context of National Centralized Drug Procurement. Drug Discoveries Ther
(2020) 14(3).
9. Robinson JC. Lower Prices and Greater Patient Access — Lessons from Germany's Drug-Purchasing
12. Sorenson C, Kanavos P. Medical Technology Procurement in Europe: A Cross-Country Comparison of
14. Tang M, He J, Chen M, Cong L, Jin C. 4 + 7 City Drug Volume-Based Purchasing and Using Pilot
16. Wang Y. Problems in the bidding and procurement of medicines and suggestions for improvement.
17. Li Z, Chen S, Zhou L, Zhao K. Practical Operational Problems and Optimization Countermeasures of
20. Sun Y, Zhu Z, Yang L. Analysis of factors affecting price reductions in centralized band purchasing of


Figures
Figure 1

Parallel trend test
Figure 2

Placebo testing

**Supplementary Files**

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