THE CAPACITY ALLOCATION MANAGEMENT POLICY FOR PHOSPHORUS FERTILIZER INDUSTRY IN CHINA

YU QINGQING

DOCTOR OF PHILOSOPHY IN ADMINISTRATIVE SCIENCE
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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT
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IN ADMINISTRATIVE SCIENCE
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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์ 3 ประการคือ 1) เพื่อศึกษานโยบายปุ๋ยฟอสฟอรัสในปัจจุบันและวิเคราะห์ผลกระทบต่อการจัดการจัดสรรกำลังการผลิตของอุตสาหกรรมปุ๋ยฟอสฟอรัสในประเทศจีน 2) เพื่อจำลองแบบจำลองนโยบายการจัดสรรกำลังการผลิตที่เหมาะสมสำหรับอุตสาหกรรมปุ๋ยฟอสฟอรัสในประเทศจีน 3) เพื่อเสนอรูปแบบนโยบายการจัดการการจัดสรรกำลังการผลิตที่เหมาะสมสำหรับอุตสาหกรรมปุ๋ยฟอสฟอรัสในประเทศจีน

งานวิจัยนี้ใช้นโยบายอุตสาหกรรมปุ๋ยฟอสฟอรัสของจีนเป็นวัตถุประสงค์การวิจัย ใช้ทฤษฎีเครื่องมือนโยบายในการคัดแยกและสรุปอุตสาหกรรมปุ๋ยฟอสฟอรัสของจีน ใช้ทฤษฎีวัฏจักรนโยบายเพื่อศึกษาวัฏจักรนโยบายอุตสาหกรรม ใช้วิธีสัมภาษณ์วิเคราะห์เชิงคุณภาพเพื่อศึกษาหลักนโยบายอุตสาหกรรมที่ส่งผลกระทบต่อผู้ประกอบการปุ๋ยฟอสฟอรัสในช่วงไม่กี่ปีที่ผ่านมา จากนั้นจึงใช้แบบจำลองดุลยภาพทั่วไปที่คำนวณได้ (CGE) เพื่อดำเนินการจำลองนโยบายตามผลการวิจัยข้างต้น สุดท้ายนี้ ข้อเสนอแนะสำหรับการปรับนโยบายอุตสาหกรรมปุ๋ยฟอสฟอรัสของจีนให้เหมาะสมต่อไปนั้น ได้รับการต่อยอดขึ้นจากผลการจำลองนโยบายผลการวิจัยพบว่า

1) นโยบายอุตสาหกรรมปุ๋ยฟอสเฟตหลักแปดประการในประเทศจีน นโยบายอุตสาหกรรมปุ๋ยฟอสฟอรัสในจีนมีช่วงเวลาสามช่วงประวัติศาสตร์: “ช่วงสนับสนุน ช่วงเวลาวางแผนการจัดการ และช่วงปรับตัว” ปัจจุบัน อุตสาหกรรมปุ๋ยฟอสฟอรัสอยู่ในขั้นตอนที่สามของการปรับตัวตามประวัติศาสตร์ 2) ปัจจัยที่มีอิทธิพลต่อการเลือกนโยบายอุตสาหกรรมปุ๋ยฟอสฟอรัสของจีนได้รับการวิเคราะห์อย่างเป็นระบบ จากผลการสัมภาษณ์ นโยบายที่มีผลกระทบอย่างมีนัยสำคัญต่ออุตสาหกรรมปุ๋ยฟอสเฟตในช่วง 10 ปีที่ผ่านมา ได้แก่ นโยบายการส่งออก นโยบายภาษีมูลค่าเพิ่มและนโยบายภาษีทรัพยากรหินฟอสเฟต งานวิจัยนี้วิเคราะห์ปัจจัยที่ส่งผลต่อการออกแบบนโยบายอุตสาหกรรมอย่างเป็นระบบ 3) แบบจำลอง CGE แบบคงที่ของอุตสาหกรรมปุ๋ยฟอสฟอรัสของจีน

ได้รับการออกแบบมาสำหรับการจำลองและประเมินนโยบาย จากข้อมูลแห่งชาติของจีนในปี 2560 เมทริกซ์การบัญชีสังคมมหภาคทางสังคม (SAM) ของจีนปี 2560 แบบละเอียดนั้นสำหรับโมเดล CGE ถูกสร้างขึ้นผ่านการแยกและการรวมที่สมเหตุสมผล จากนั้นจึงกำหนดภาษีมูลค่าเพิ่มในการขายและนโยบายการส่งออกในการค้าระหว่างประเทศเป็นสถานการณ์นโยบาย และ 4) จากการวิเคราะห์ผลลัพธ์ที่น่าตกใจเชิงนโยบาย (Policy shocking results) ของแบบจำลอง CGE การศึกษาพบว่าการเพิ่มภาษีมูลค่าเพิ่มในช่วงการขายผลิตภัณฑ์ปุ๋ยฟอสเฟตและการเพิ่มข้อจำกัดทางการค้าในการส่งออกเพื่อลดการส่งออกปุ๋ยฟอสเฟตจะลดการผลิตปุ๋ยฟอสเฟต นโยบายเหล่านี้มีผลกระทบคล้ายกันกับอุตสาหกรรมปุ๋ยฟอสฟอรัสของจีน แต่มีผลกระทบต่างกันต่อตัวชี้วัดเศรษฐกิจมหภาคและภาคอุตสาหกรรมขนาดเล็กอื่น ๆ พวกมันมีผลกระทบทางลบบางอย่างที่คล้ายกันต่อ GDP และอาจทำให้รายได้ของผู้อยู่อาศัยลดลงเล็กน้อยเช่นกัน นโยบายพ่วงเหล่านี้มีผลกระทบที่แตกต่างกันในภาคอุตสาหกรรมขนาดเล็ก ภาคการเกษตรได้รับผลกระทบมากที่สุด ราคาและผลผลิตภาคเกษตรได้รับผลกระทบ ดังนั้น การสร้างแบบจำลอง CGE สำหรับอุตสาหกรรมปุ๋ยฟอสฟอรัสจึงเป็นเครื่องมือวิเคราะห์นโยบายที่มีประโยชน์ ซึ่งสามารถจำลองการเปลี่ยนแปลงนโยบายล่วงหน้า และคาดการณ์ผลกระทบของการดำเนินนโยบายต่อภาคเศรษฐกิจมหภาคและภาคอุตสาหกรรมขนาดเล็ก ปุ๋ยฟอสเฟต แบบจำลองดุลยภาพทั่วไป อาหารปลอดภัย ผลผลิตล้นตลาด

คำสำคัญ : นโยบายปุ๋ยฟอสฟอรัส, ผลผลิตล้นตลาด, การจำลองนโยบาย, แบบจำลองดุลยภาพทั่วไป (CGE)

Title	THE CAPACITY ALLOCATION MANAGEMENT POLICY FOR PHOSPHORUS FERTILIZER INDUSTRY IN CHINA
Author	Mrs. Yu Qingqing
Degree	Doctor of Philosophy in Administrative Science
Advisory Committee Chairperson	Associate Professor Dr. Chalermchai Panyadee

ABSTRACT

This research had 3 objectives: 1) to study the current phosphorus fertilizer policies and analyze the impact on the capacity allocation management of phosphorus fertilizer industry in China. 2) to simulate the appropriate capacity allocation policy model for phosphorus fertilizer industry in China. 3) to propose the appropriate capacity allocation management policy model for phosphorus fertilizer industry in China.

This research took China's phosphorus fertilizer industry as the research object. The policy tool theory was used to sort of and conclude the phosphorus fertilizer industry in China. The policy cycle theory was used to investigate the industrial policy cycle. The qualitative analytical interview method was used to explore industrial principles and policies having an effect on phosphorus fertilizer entrepreneurs in the previous years later on, the computable general equilibrium model (CGE) was used to conduct policy, simulation based on the aforementioned. Suggestions for further optimizing China's phosphorus fertilizer industry policy was put forward based on results of the policy simulation.

The main research results and innovations of this research were as follows: 1) There were eight main phosphate fertilizer industry policies in China phosphorus fertilizer industry policy in China had experienced three historical periods: "supporting period, planning management period and adjustment period". At present, the phosphorus fertilizer industry is in the third stage of historical adjustment. 2) The influencing factors of China's phosphorus fertilizer industry policy selection were systematically analyzed. Based on result of the interview, the policies that had a significant impact on the phosphate fertilizer industry in the past ten years mainly included export policy, value-added tax policy and phosphate rock resource tax policy. This research systematically analyzed the factors affecting the design of industrial policies. 3) The static CGE model of China's phosphorus fertilizer industry was designed for policy simulation and evaluation. Based on the China national input-output table in 2017, the 2017 China's social macro-social accounting matrix (SAM) and detailed 21-department SAM table for the CGE model was formed through reasonable splitting and merging. Then the value-added tax in sales and the export policy in international trade were set as the policy scenarios. and 4) Based on an analysis of policy shocking results of the CGE model, it was has found that increasing value-added tax during the sales phase of phosphate fertilizer products and further increasing export trade restrictions to reduce phosphate fertilizer exports would both reduce phosphate fertilizer production. These two policies have similar impacts on China's phosphorus fertilizer industry, but have different impacts on the macroeconomic indicators and other micro industry sectors. They have the similar certain negative impact on GDP, and can cause a slight decrease in the income of residents too. These two policies had different impacts on the micro industry sectors. The agricultural sector had been most significantly impacted. The price and the production of the agricultural sector negatively affected. Therefore, constructing a CGE model for phosphorus fertilizer industry was a useful policy analysis tool that could simulate policy changes in advance and predicted the impact of policy implementation on macroeconomic and micro industrial sectors.

Keywords : phosphorus fertilizer policy, overcapacity, policy simulation, computable general equilibrium model (CGE)

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Yu Qingqing

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INTRODUCTION

Background of the research

The Chinese government has embarked on a supply-side structural reform science 2015.This reform focus on capacity removal, inventory removal, deleveraging, cost reduction and short-term board replenishment. As far as capacity removal is concerned, designing capacity allocation policy becomes a more and more important and critical task for the Chinese government.

Phosphorus rock, the raw material of fertilizer production, is a limited amount of non-renewable resources. The sustained and healthy development of phosphorus fertilizer industry is related to national food security, agricultural security, environmental security and economic security. China has implemented a socialist market economy system with Chinese characteristics since 1978. The macro-control policy is very important to ensure the healthy and stable development of the national economy. Demand for the removal of excess capacity of industries has become one of the key task of the government's supply-side structural reform since 2015. Overcapacity of phosphorus fertilizer has become an extremely important and serious issue facing Chinese economy. The government urgently needs to formulate a scientific and rational policy for capacity allocation of phosphorus fertilizer industry.

Significance of the Problem

In China, fertilizer production belongs to C category manufacturing industry according to the latest "industry classification of national economy (GB/T 4754-2011)". phosphorus fertilizer industry belongs to Category 2622: " phosphorus fertilizer manufacturing, refers to the production of chemical fertilizers containing phosphorus, a nutrient element of crops, by chemical or physical methods, using phosphorus ores as the main raw material". Phosphate rock as an important un-renewable resources is an important chemical mineral raw material to produce phosphorus fertilizer. Phosphorus resources are irreplaceable and non- renewable, and the global over-consumption of resources has caused international institutions and scholars to worry about the long-term security of resources (Wellmer and Scholz, 2015). Technological advances, advances in public health, and advances in food production have severely disrupted the global phosphorus cycle (Ashley et al., 2011). The sharp fluctuations in phosphate prices in 2008 indicate that the economic characteristics of phosphate rock can significantly affect the price of fertilizers, which in turn affects food prices and ultimately threaten food production safety (Mew, 2016; Nathaneil P. Springer, 2017)

The constraints of phosphate rock resources can be significantly transmitted to the phosphorus fertilizer industry, ultimately threatening the security of food production (Nathaneil P. Springer, 2017). China's phosphorus fertilizer production capacity is remarkably excessive. In 2015, the phosphorus fertilizer production capacity is 23.5 million tons (P2O5), self-sufficiency rate is 143%, the profit margin of the main business of the industry is only 2.16% (Zhang Tao and Xu Qian, 2016), and the phosphorus resource is wasted seriously in China. Wu et al. (2016) estimated the phosphorus loss in Anhui Province in 2011 is about 398 kt, which is significantly higher than the amount of chemical fertilizer used in the same year.(329 kt). Therefore, the capacity management of phosphorus fertilizer industry is urgent and necessary.

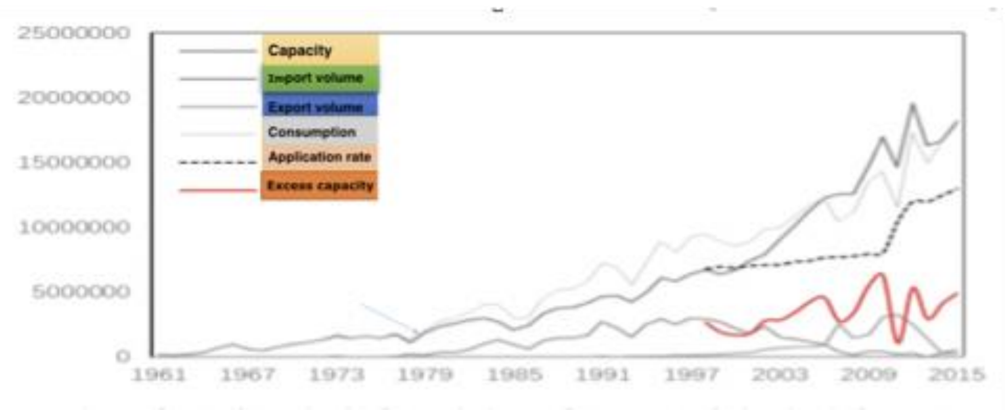

Figure 1 China's phosphorus fertilizer production and consumption, import and export volume, application rate and excess from 1961-2015 (unit: kt)

Data resource: Phosphate and Compound Fertilizer Industry Association

According to the 2017 China Phosphate and Compound Fertilizer Industry Data released by China Phosphate and Compound Fertilizer Industry Association, the total outcome of phosphorus fertilizer produced by 2726 enterprises in 2017 was 16.407 million tons (P_2O_5), down 1.3% year-on-year. Among them, the high-concentration phosphorus fertilizer outcome was 15.354 million tons (equivalent to P_2O_5), down 0.6% year-on- year; the low-concentration phosphorus fertilizer was 1.053 million tons (folded P_2O_5), down 10.7% year-on-year. In 2017, the main income of the phosphate compound fertilizer industry was 479.27 billion yuan, up 5.7% year-on-year; the profit was 18.04 billion yuan, up 33.3% year-on-year; the profit margin of the main business was 3.8%, up 0.2 percentage points year-on-year; among them, the profit rate of the phosphorus fertilizer industry It was 2.1%, up 1.5 percentage points year-on-year.

It is generally believed that the capacity utilization rate of phosphorus fertilizer is less than 79%, which means that there is excess capacity. It can be seen that the production capacity of China's phosphorus fertilizer industry has been in surplus in recent years. (Fig.2) At present, the overcapacity of basic fertilizers in the phosphate and compound fertilizer industry and the shortage of high-end fertilizers exist simultaneously, and supply-side structural reforms still need to be accelerated. De-capacity, restructuring, and improving core competitiveness remain the main tasks.

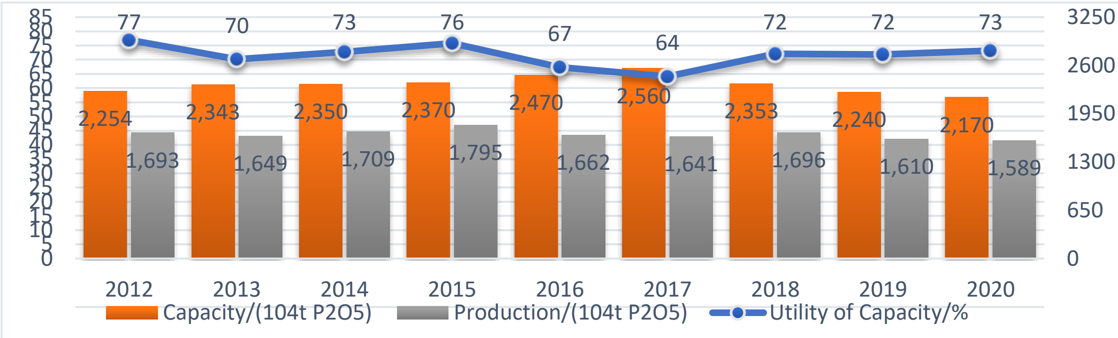

Figure 2 Phosphorus Fertilizer Capacity, Production and Utility rate in 2012-2020 (unit: ten thousand ton)

Data source: Phosphate and Compound Fertilizer Industry Association

With the orderly exit of excess capacity, the operating rate of the industry will gradually increase; from the demand side, the structural contradictions of demand will remain prominent, and the weak market of some fertilizer markets will continue. The international market demand and capacity cooperation will become an important channel for defusing domestic production capacity. Therefore, the capacity management of phosphorus fertilizer industry is urgent and necessary. These indicators may affect the capacity of phosphorus fertilizer industry mostly. (Fig.3)

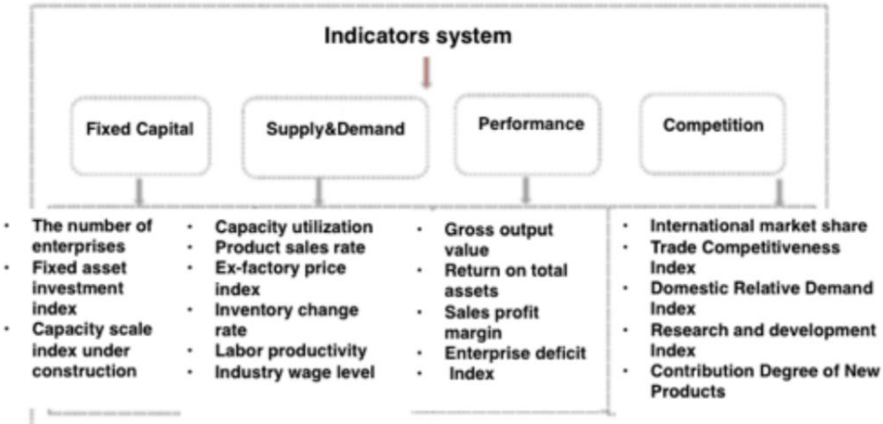

Figure 3 Indicators system for phosphorus fertilizer capacity

Since 1950, the Chinese government has issued and implemented multiple policies for the phosphate fertilizer industry. These industrial policies have profoundly affected the development of Chinese phosphorus fertilizer industry in terms of phosphate raw materials, freight, prices, environmental protection costs, demand, application volume and foreign trade. With the development and changes of the phosphorus fertilizer industry, the Chinese government continuously modifies, improves, and enriches these phosphorus fertilizer industry policies. Phosphorus fertilizer industry in China has experienced a development from nothing, from small to large, from single nutrient, low concentration to high concentration, compounding and multi-variety. China has gone through a process of role in the world fertilizer market, from imported phosphorus fertilizer products to imported phosphorus fertilizer technology, finally to export phosphorus fertilizer country (Gao Yuan, 2011). During the process from the rising to be the world's largest phosphorus fertilizer producer, phosphorus fertilizer industry policy has always played a crucial role.

At present, facing the contradiction of overcapacity in the phosphorus fertilizer industry, how to evaluate the existing phosphorus fertilizer industry policy and optimize the design of phosphorus fertilizer capacity allocation is the primary goal of China's phosphorus fertilizer industry policy.

This research try to build the capacity allocation management policy of phosphorus fertilizer industry based on CGE model. Capacity allocation refers to the situation in which established resources are used for production and final consumption (Gao Hongye, 2000), with more emphasis on the flow of related industries from inefficient to efficient industries, the promotion of total factor productivity, and the integration and unification of market mechanism and government policies (Zhao Tianyu, 2015). The market nature of phosphorus fertilizer industry is an imperfect market. The objective existence of excess production capacity in the inter-industry transmission chain transmission and amplification step by step, and then induce related industries gradually appear unbalanced capacity allocation (Zhao Tianyu, 2015).

The capacity allocation management policy for phosphorus fertilizer industry is a multi-objective decision-making problem. It is shown that in a complex production and decision environment, the relevant data are uncertain and fuzzy. For the feasible region formed by constraints, it is necessary to select the most satisfactory decision-making scheme according to the requirements of multiple objectives. It is an iterative and repeated decision-making process (Alikhani, R. and A. Azar, 2015).

The existing researches on the overcapacity treatment of phosphorus fertilizer in China are mostly aimed at optimizing the industrial structure of the phosphorus fertilizer industry and developing the international market (Zhong Benhe et al., 2014). In the absence of decision-making, the industrial chain transmission mechanism between phosphate rock and phosphorus fertilizer is emphasized. Emphasis on the impact of resource constraints, international demand, policy, investment and capacity allocation, does not pay attention to the uncertainty and ambiguity of relevant data, and the iteration and repetition of multi-objective decision-making.

The research is based on seven criteria (objectives) to rationally plan the capacity allocation of resources, seven objectives of interactive and sustainable three components (Figure 6).

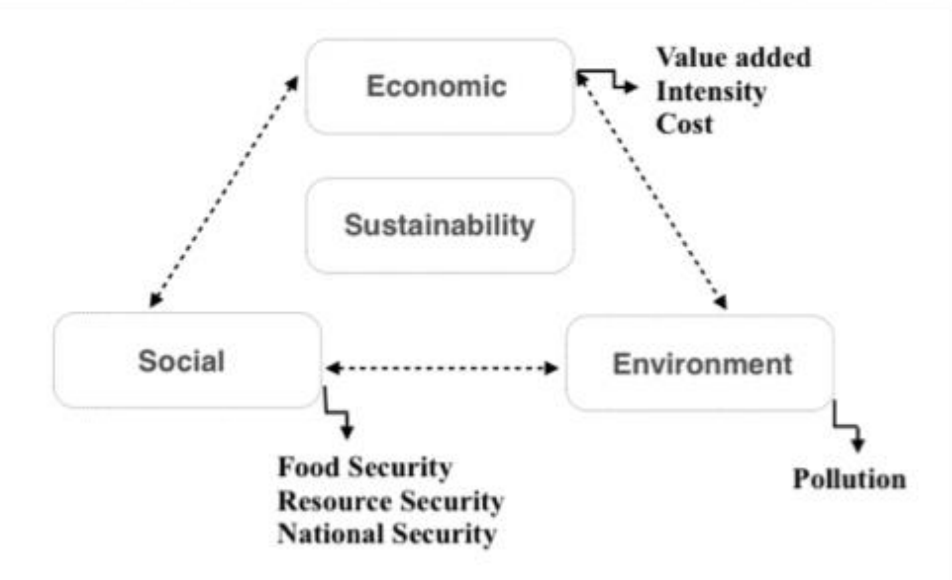

Figure 4 Objectives to rationally plan the capacity allocation of resources

The research tries to build a policy system of capacity allocation optimization management based on strategic resource protection. Policies include three dimensions of time, management and space; four policy orientations: regional differentiation, combination of internal and external parts, improving the operational efficiency of transmission mechanism, monitoring and early warning system; four models: regional differentiation regulation, optimization of management policy tools combination, enhancement of management policy transmission mechanism, management monitoring and early warning system. (Figure 7)

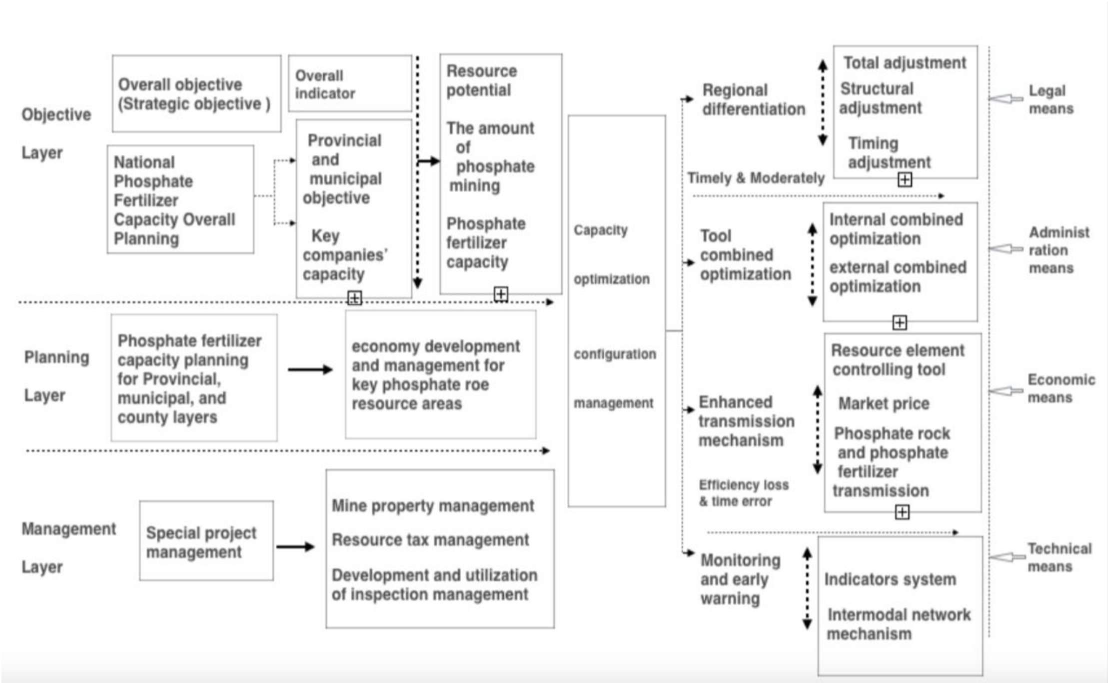

Figure 5 A policy system of capacity allocation optimization management based on strategic resource protection

Research Question

Generally this research wants to find out the suitable capacity allocation management policy for the phosphorus fertilizer industry in China.

Specifically, this research attempts to answer the following questions:

1. What policies can make impact on the capacity allocation management of phosphorus fertilizer industry in China?
2. How to simulate the appropriate capacity allocation policy model for phosphorus fertilizer industry in China?
3. How to propose the appropriate capacity allocation management policy model for phosphorus fertilizer industry in China?

Objectives of the Study

1. To research the current phosphorus fertilizer policies and analyze the impact on the capacity allocation management of phosphorus fertilizer industry in China.
2. To simulate the appropriate capacity allocation policy model for phosphorus fertilizer industry in China.
3. To propose the appropriate capacity allocation management policy model for phosphorus fertilizer industry in China.

Scope and Limitation of the Study

This study tries to research the capacity allocation management policy for Chinese phosphorus fertilizer industry. Therefore the study arear is the national phosphorus fertilizer industry in China.

The research content of this study is China's phosphorus fertilizer industry policies and the construction of appropriate industrial policy models. Therefore, this study investigates the main phosphorus fertilizer industry policies in China from 1950 to 2022, attempting to organize and analyze China's phosphorus fertilizer industry policies. And the research focuses on the capacity reduction policy of China's supply side reform since 2015, using interview methods to try to find the current policies that will have a significant impact on phosphorus fertilizer production capacity. Finally, this study try to construct a CGE model for China's phosphorus fertilizer industry policy. Based on the latest released 2017 China input-outcome table as the model database, construct China's macro SAM table and micro sub sector SAM table, and design simulation scenarios for policy simulation. The policy simulation results are calculated through GAMS software, and the policy impact and impact of changing the phosphorus fertilizer industrial policy on China's macroeconomic and microeconomics industrial sectors are analyzed. Thus, through the policy simulation results of empirical models, suggestions for the government to further optimize the policy of the phosphorus fertilizer industry are proposed for policy tool selection.

The limitation of the study is as following. Firstly, the interview method used in this study included seven out of the eight surveyed companies located in Yunnan Province because of the impact of the Corona Virus Disease 2019(COVID-19). From January 20, 2020 to January 7, 2023, the Chinese government included COVID-19 as a Class B infectious disease under the Law of the People's Republic of China on the Prevention and Control of Infectious Diseases, and take measures to prevent and control Class A infectious diseases. As a result, the interview method designed in this study was unable to conduct face-to-face interviews with large phosphate fertilizer enterprises in various provinces and cities in China. Although Yunnan Province is the second largest province in China in terms of phosphorus fertilizer production, it accounted for 25.5% of the country's total production in 2020. As one of the interviewees, Yuntianhua Group is the largest company in China in terms of phosphorus fertilizer production. The interviewees have obvious representativeness, but they may cannot fully reflect the opinions of phosphorus fertilizer enterprises in other provinces.

Secondly, this study aims to construct a database for the CGE industrial policy model, with the SAM table data sourced from secondary data publicly available by the Chinese government. Due to the technical and difficult nature of data collection, the Chinese government only publishes Input-outcome tables once every five years. Therefore, all economic data related to China used in this research are from 2017. It may differ from the current economic situation. At last, it may affect the generalization of the research result.

Expected Results of the Study

This research is expected to build a policy system of capacity allocation management for phosphorus fertilizer industry will eventually

1. To Influence the approach of government to formulating industrial policies, applying policy simulation models.
2. To give some feasibility suggestion that can really alleviating the problem of overcapacity of the PT.

3. To promote the healthy and sustainable development of phosphorus fertilizer industry in China.

Operational Definition of Terms

In order to facilitate a more clear understanding of the concepts in this research, the following terms are defined either operationally or from their lexical definitions.

1. Macro-economic control

Macro-economic control is the government's overall management of the national economy, which is the crucial economic function of a national government. The government uses economic policies, economic regulations, information guidance, planning guidance and necessary administrative interventions to play a regulatory role in the effective operation of the market economy. The government make the adjustment and control of the social economy, in order to promote market development and regulate market operations.

The process of macroeconomic regulation and control is a series of laws and regulations of the state based on the market economy. The objectives of Macro-economic control are to achieve macroeconomic balance and continuous, stable, coordinated growth economic, by regulating and controlling the total amount of money and expenditure, the total amount of fiscal revenue and expenditure, the total amount of foreign exchange receipts and payments, and the supply and demand of major materials. At the same time, the government apply adjustment means and mechanism to achieve optimal allocation of resources, provide a benign macro environment for microeconomic operation, and enable the market economy to operate normally and balanced develop harmoniously

2. Public policy

According to the role of the makers, the policy has broad and narrow meanings. The policy in the narrow sense is formulated by the government authority or the legislative body to regulate the norms of behavioral goals, codes of conduct, and behaviors within a specific period of time. Compared with the policy in the narrow sense, the role of the policy maker in the broad sense is more diversified, government agencies, legislation Institutions, companies, and non-profit organizations may all become the subject of a policy.

Public policy is to ensure public interest, achieve public goals, respond to public problems, and have regulations that are effective by government. Agencies or agencies commissioned by the government for a certain period of time. Because public policy involves a wide range of interests, its formulation must have a social role division commensurate with it. Affected by various factors, the expected goals of public policy may not be achieved without bias.

Economic policy is an important kind of public policy that often. Industrial policy belongs to public economic policy.

3. Industrial Policy

An industrial policy of a country is its official strategic effort to encourage the development and growth of all or part of the economy, often focused on all or part of the manufacturing sector. The government takes measures "aimed at improving the competitiveness and capabilities of domestic firms and promoting structural transformation." Industrial policies are interventionist measures typical of mixed economy countries.

4. Phosphorus fertilizer industry

phosphorus fertilizer industry refers to the production of chemical fertilizers containing phosphorus of crop nutrients by chemical or physical methods using phosphorus ore as the main raw material. According to the "National Economic Industry Classification and Code" formulated by the National Bureau of Statistics, China has classified phosphorus fertilizer into chemical raw materials and chemical products manufacturing (National Bureau Code 26), and its statistical grade 4 code is 2622.

5. Policy cycle

Policy cycle divides the policy process into a series of stages, from a notional starting point at which policymakers begin to think about a policy problem to a notional end point at which a policy has been implemented and policymakers think about how successful it has been before deciding what to do next. It consists of six main phases, namely, agenda setting, policy formulation, Legitimation, implementation, evaluation, and Policy maintenance, succession or termination.

6. Policy instruments

Policy instruments are the means to achieve policy objectives, and policy tools have a direct impact on policy implementation and determine the achievement of policy objectives. Therefore, the choice of policy tools is important for policy implementation.

Policy instruments are often known as governing tools as well, particularly when they are applied with all conditions associated to them. The implementation of governing tools is usually made to achieve policy targets of resource management but adjusted to social, political, economic, and administrative concerns. Thereby, concerns of sustainability largely depend not only on what instruments are selected but also on how they have been applied. Assessment of policy instrument thereby can be an important component of policy sustainability.

7. Policy simulation

Simulation is the imitation or simulation of real things. The simulation achieves a relatively accurate understanding of the basic behaviors and operational laws of the real world with a small investment, so as to avoid losses caused by misunderstanding and subjective assumptions in the real world.

Policy simulation is a mathematical simulation of policy issues, mathematical calculations, and computer-based policy virtual experiments. Policy simulation is an emerging discipline in the information age, and it is the development of policy science in analytical technology. Faced with various social and economic problems, through the simulation calculation of economic policies, analyzing its impact on many aspects of society and assessing the effects of policies, it can improve the scientific nature of policy formulation.

8. Capacity allocation management

Capacity allocation management, that is, the policy of overcapacity, and the policy of de-capacity. It refers to the unfavorable situation in which some industries in China, especially the manufacturing industry with a serious overcapacity and low capacity utilization rate, and various measures have been taken to resolve the excess capacity of the industry.

Overcapacity has long been a problem difficult to solve in China. As the major strategic decisions currently in China, the importance and urgency of overcapacity cutting has been highly recognized by the whole society, but how to cut overcapacity orderly and smoothly. Much headway has been made in China's supply- side structural reform, especially overcapacity reduction, since 2016, which is highly commendable. Against the macroeconomic backdrop of favorable external demand, China may hopefully make more progress in the reform. Reduction of excessive production capacity is a top priority of the supply- side structural reform and achievement in cutting overcapacity can also be reflected in the improved operation of zombie enterprises, falling leverage levels, declining NPL ratios and increased soundness of the financial system.

9. Policy model

As a theoretical tool of policy analysis, public policy analysis model is a conceptual model that can provide decision makers with a set of assumptions, definitions, descriptions, explanations and countermeasures. These models are being adopted in order to provide the policy for different aspects to simplify and clarify our thinking about politics and public policy, identify important aspects of policy problems, and suggest explanations for public policy and predict its consequences.

10. Capacity

Capacity means the maximum outcome that can be achieved by existing input factors under a certain technical level. Based on the weak substitution relationship between the variable elements of production and the fixed factors, capacity outcome refers to the maximum outcome that can be achieved by using these fixed factors under normal input (there is no extension of working hours of machinery and equipment).

Production capacity refers to the total number of products that can be produced by the company in the planned period of construction, under the established organizational and technical conditions, or the amount of raw materials that can be processed.

11. Overcapacity

Overcapacity at the macro level is limited by the total social demand and cannot be fully utilized due to the inability to reach normal outcome levels. Overcapacity at the micro level and industry level refers to the state in which the actual outcome is lower than the capacity outcome reaches a certain level.

Generally under the established organizational and technical conditions, the surplus of products and the amount of raw materials that can be processed that exceed the market standards are called overcapacity.

12. Capacity utilization

Capacity utilization is the ratio of total industrial outcome to production equipment, and how much actual production capacity is in operation. Capacity utilization is an important indicator for manufacturing companies. It is directly related to the production cost of enterprises. In 2018, China's industrial capacity utilization rate was 76%.

Formula for capacity utilization: capacity utilization = actual capacity / design capacity * 100%.

Kirkley, Paul, Squires (2002) pointed out that capacity utilization is the ratio of the most actual outcome to capacity outcome that can be observed. If capacity utilization is less than 1, there is overcapacity.

The capacity utilization rate is too low, which causes the idleness of personnel and production equipment and waste of costs. In addition, the capacity utilization rate can also assess the demand level of capacity expansion. If the capacity utilization rate is too high, it may indicate the necessity of capacity expansion.

13. phosphorus fertilizer production

phosphorus fertilizer production refers to the actual outcome of all varieties of phosphorus fertilizer production. There are two weights for the statistics of phosphorus fertilizer production. Some statistical agencies calculate the phosphorus fertilizer data by physical quantity. But Some statistical agencies calculate the phosphorus fertilizer data by the conversion of phosphorus fertilizer, which means that the nutrient of each phosphorus fertilizer is calculated by adding the mass percentage of P_2O_5 (phosphorus pentoxide).

14. Application of phosphorus fertilizer

Application of fertilizer refers to the amount of chemical fertilizer actually used for agricultural production during the year, including nitrogen fertilizer, phosphorus fertilizer, potassium fertilizer and compound fertilizer. The amount of chemical fertilizer applied is calculated by the amount of scalar. The scalar amount refers to the amount of nitrogen, phosphorus and potassium fertilizers converted according to nitrogen, phosphorus pentoxide and potassium oxide containing 100%.

Application of phosphorus fertilizer reflects the final consumption of phosphorus fertilizer products in the agricultural sector. It is an important indicator to measure the actual consumption of phosphorus fertilizer in a country.

The amount of phosphorus fertilizer applied per unit of cultivated land (kg/ha) is used as an important indicator to assess the application t of phosphorus fertilizer in the agricultural sector.

15. Electricity preferential policy

Electricity preferential policy means phosphorus fertilizer enterprises can enjoy preferential electricity prices during the process to produce phosphorus fertilizer. Preferential electricity prices are applied to the electricity used for fertilizer production. The Chinese government has always given small fertilizer manufacturers a preferential policy for preferential electricity prices since 1963. This policy can decrease the cost of phosphorus fertilizer.

16. Gas preferential policy

Natural gas price for fertilizer enterprises was strictly regulated by Chinese government before 2005. The lower gas prices brought direct low-cost dividends to fertilizer companies. This policy can decrease the cost of phosphorus fertilizer.

17. Coal preferential policy

Coal preferential policy refers to the policy of limiting the price l of coal for phosphorus fertilizer enterprises that use coal as raw material. Although coal price is one of the earliest market-oriented raw materials for fertilizer production, the Chinese government has adopted a series of measures to ensure full supply and preferential price of coal and its transportation to guarantee phosphorus fertilizer production and stabilize phosphorus fertilizer price. This policy can decrease the cost of phosphorus fertilizer.

18. Railway transport preferential policy

phosphorus fertilizer enterprises have always enjoyed preferential railway transport fee policies for many years. This policy will reduce the cost of freight for phosphorus fertilizer companies when transporting phosphorus fertilizer products.

19. Fertilizer storage in off-season policy

Fertilizer storage in off-season policy refers to reserving a certain amount of fertilizer tin the off-season of chemical fertilizer application (usually in winter) by Chinese government procurement. This policy has gradually evolved from a disaster relief reserve into an off-season commercial reserve. China has implemented a fertilizer reserve policy officially and has continued to this day since 1998.This policy has promoted the sales of phosphorus fertilizer enterprises to a certain extent.

20. Limited price policy

The price policy is a general term for a series of guidelines and measures adopted by the state to achieve certain macroeconomic goals and prices.

In order to support the development of agriculture and ensure that farmers can afford fertilizer, China had imposed strict price limit management on chemical fertilizers for a long time. The price of phosphorus fertilizer products was directly priced by the government for decades. In 1998, the ex-factory price of fertilizers was changed from government pricing to government-guided prices. However, in 2004, the National Development and Reform Commission issued the most stringent price limit policy, and resumed the implementation of government-guided prices for some fertilizers again.

The purpose of this policy is to ensure the low price of phosphorus fertilizer products. This will directly affect the phosphorus fertilizer industry.

21. VAT preferential policy

VAT is a turnover tax levied on the basis of the value-added amount generated by the goods in the process of circulation. It is imposed on the value-added amount realized by units and individuals that sell goods or provide processing, repair and repair services, and imported goods. Value-added tax has become one of the most important taxes in China. The value-added tax accounted for more than 60% of China's total tax revenue and is the largest tax. The value-added tax is levied by the State Administration of Taxation. 50% of the tax revenue is the central fiscal revenue, and 50% is the local income. The value-added tax on the import link is levied by the customs, and the tax revenue is all the central fiscal revenue.

The level of value-added tax has a direct impact on the sales price of phosphorus fertilizer products and the profits of enterprises. This will affect the production and capacity changes of the phosphorus fertilizer industry.

22. Directly subsidize to farmers policies

This policy may reduce the burden on farmers to purchase fertilizer and increase farmers' income. Chinese government had successively established three subsidies since 2004. The subsidy funds come from the central financial agriculture special transfer payment funds. The three subsidies include subsidies for improved crop varieties, comprehensive subsidies for agricultural materials, and direct subsidies for growing grain.

The "three subsidies" for agriculture refer to 1. the subsidies for improved varieties; 2. the direct subsidies for grain production; and the comprehensive subsidies for agricultural materials.

Fine seed subsidies refer to Chinese farmers who give some subsidies to farmers in China by selecting some good quality crops. The state subsidies to farmers are to enable farmers to more actively and spontaneously choose better and better crop seeds to improve the quality of crops, thus making China's agricultural industry more developed,

Direct subsidies for grain production refer to subsidies for farmers who grow grain. As long as they are farmers who grow grain, the state will give certain subsidies. The purpose is to increase the enthusiasm of farmers for planting land, so that farmers can live better.

Comprehensive subsidies for agricultural materials refer to subsidies given by the state and the government to farmers when purchasing some agricultural auxiliary assets such as fertilizers and seeds. With such subsidies, they can promote the enthusiasm of farmers and ensure the quality of crops. And even to ensure the safety of China's agricultural products and various things. These "three subsidies" for agriculture was combined into agricultural support protection subsidies in 2016.

23. Import tariffs policy

Tariff is the tax collected by the customs set up by the government when the import and export commodities pass through the customs of a country.

The import duty is the normal tariff imposed on the importer of the country when the customs of the importing country enters the foreign commodity. In order to reduce the burden of farmers, China has always given considerable preferential treatment to the import tariffs on phosphorus fertilizer.

The import quota system refers to a regulation that restricts the importation of foreign goods. A country's import quantity or amount of a certain commodity for a certain period of time is limited in advance, and the excess is not allowed to be imported. China has always implemented an import quota system for the fertilizer industry.

Import tariff policies will affect the amount of product supplied by the phosphorus fertilizer industry.

24. Export tariff policy

An export tax is a tariff imposed on goods exported from the country when it is shipped out of the country. Imposing export tariffs will increase the cost of exporting goods, which is not conducive to the competition of domestic goods in the international market.

Based on the continuous increase in the production of phosphorus fertilizer in China, the Chinese government has implemented a higher export tax rate for phosphorus fertilizer to implement a zero export tariff policy for phosphorus fertilizer. It is obvious that preferential export tariffs are conducive to China's phosphorus fertilizer industry to expand exports and resolve domestic excess capacity.

25. Phosphate resource tax policy

The resource tax is a tax that is levied on various taxable natural resources, in order to regulate the income difference of resources and to reflect the paid use of state-owned resources. Resource tax, as a means of universal regulation, its main role is to regulate the differential income of resources, promote the rational development of resources, curb the indiscriminate exploitation of resources, and make the cost and price of resource products reflect its scarcity. At the same time, through taxation, it also raises the necessary funds for the government to control the environment and maintains intergenerational equity.

The level of phosphorus rock resource tax may directly affect the production cost of phosphorus fertilizer enterprises.

26. Phosphate export policy

China has implemented export quotas and export licensing systems for phosphorus rock export policies.

Export Quotas are systems in which a government imposes a maximum amount on the quantity or amount of exports of certain exports during a certain period of time. Goods within the limit can be exported, and additional goods are not allowed to be exported or penalized. In 2018, the total export quota for phosphorus rock is 800,000 tons.

The export licensing system is a measure for the control of a country's exports. In general, some countries implement export licensing systems for raw materials, semi-finished products, and some tight-selling materials and commodities that are in short supply in the country. Protect the national economy by issuing licenses to control exports or export restrictions to meet the needs of the domestic market and consumers.

27. Environmental Tax

Environmental Taxation is an economic means of internalizing environmental costs of environmental pollution and ecological destruction into production costs and market prices, and then distributing environmental resources through market mechanisms. From January 1, 2018, the "Environmental Protection Tax Law of the People's Republic of China" was implemented and the environmental tax was officially levied. The implementation of this policy will increase the cost of phosphorus fertilizer companies.

28. The Social Accounting Matrix

In order to achieve the computability of the general equilibrium model, firstly it is necessary to assign values to the exogenous variables and parameters in the model. This is also a prerequisite for simulation implementation. The Social Accounting Matrix (SAM) can meet the requirements of the CGE model data set. Therefore, the preparation of the SAM table needs to be based on the basic assumptions of the CGE model. Firstly, the supply and demand of commodities are equal. Secondly, all industries have zero profits; thirdly, they meet the requirements of budgetary constraints; Finally, international needs remain balanced. In fact ,the SAM has become the most common form of standard data organization for the CGE model. Activity Account The active account mainly accounts for the total input and total outcome of the enterprises' production activities. The line of active accounts reflects the total outcome of domestic firms, where the total outcome is derived from the total domestic outcome of the commodity account. The column of the activity account reflects the total investment of domestic enterprises, including factor inputs, intermediate inputs and net production taxes.

28. 1 National Input and out table

The input-outcome table can comprehensively and systematically reflect the input-outcome relationship between various departments of the national economy, revealing the economic and technological connections that rely on and constrain each other in the production process. On the one hand, it can tell people the outcome situation of various sectors of the national economy, as well as how the outcome of these sectors is allocated to other sectors for production or to residents and society for final consumption or export to foreign countries; On the other hand, it can also tell people how each department obtains intermediate input products from other departments and the initial input status for their own production. The function of input-outcome accounting is not only to reflect the direct and obvious economic and technological connections between various departments in the production process, but more importantly, it reveals the indirect, relatively hidden, and even overlooked economic and technological connections between various departments. The input-outcome table provides a basis for studying the industrial structure, especially for formulating and inspecting the national economic planning, studying price decisions, and conducting various quantitative analyses. The Chinese government publishes the national input-outcome table every five years. This article uses the latest 2017 China National input-outcome Table as the data source.

28.2 The China Statistical Yearbook

The China Statistical Yearbook is an informative annual publication that comprehensively reflects the economic and social development situation of the People's Republic of China. It systematically collects statistical data on various aspects of the economy and society of the country and provinces, autonomous regions, and municipalities directly under the central government from the previous year. A statistical yearbook of a certain year contains a large amount of economic and social data from various provinces, autonomous regions, and municipalities directly under the central government in the previous year, as well as major statistical data from important historical years and the past two decades. It is published and distributed annually by the National Bureau of Statistics and is the most comprehensive and authoritative comprehensive statistical yearbook in China.

29. The General Mathematical Modeling System

The General Mathematical Modeling System (GAMS) is a software system that can make it possible to build large-scale or ultra-large-scale CGE models. As a general-purpose modeling system, GAMS is especially suitable for solving large-scale and complex mathematical models that can be established through many steps of adjustment or processing. It can describe the various characteristics of the model object in a concise and accurate manner. The auto-generation feature allows the modeler to easily debug and debug based on the errors and types indicated by the GAMS system. There are four main algorithms for solving general equilibrium models: Johansen-Euler algorithm, Newton algorithm, fixed point algorithm and planning algorithm.

CHAPTER 2
REVIEW OF LITERATURE AND RELATED STUDIES

This chapter discusses the current status and characteristics of phosphorus fertilizer industry in China, the problem of overcapacity in phosphorus fertilizer industry, the main phosphorus fertilizer industrial policies in China and the ways to analyze and formulate the overcapacity allocation management policy. The computation of various literatures and citations will provide an in-depth, concrete, relevant, and sufficient foundation from what policy model is suitable to the overcapacity allocation management policy for phosphorus fertilizer industry in China.

A review of related literature and description of relevant concepts from the major part of the chapter. The concepts of the related theories will be explained. This research will adapt Computable general equilibrium theory as a suitable theory to formulate the overcapacity allocation management policy for phosphorus fertilizer industry in China. Ultimately, the literature, theories and concepts will be helpful to research the phosphorus fertilizer industry in China in shaping the scope, focus and conclusion.

The Related Theories

This section discusses in brief the various theoretical underpinnings and conceptual frameworks belonging or simply related to communication for development as applicable to this research. Industrial policy introduce the related theories to , and explain why these theories are suitable to research the capacity allocation management policy for phosphorus fertilizer industry by literature review. The capacity allocation management policy is an important part of phosphorus fertilizer industrial policy which belongs to Chinese public economic policy. Therefore this research will follow some public policy theories to analyze and formulate phosphorus fertilizer industrial policy. The related theories of this research need to apply include Police science theory, Policy cycle, Policy instruments, Policy simulation theory and Computable general equilibrium theory.

1. Policy science theory

Policy science is also called policy analysis. The method of researching the whole process of policy research, formulation, analysis, screening, implementation and evaluation is called policy science. The core issue of policy analysis is the analysis of the effects, nature, and causes of alternative policies. It was developed on the basis of operations research and system analysis. Operations research and systems analysis focus on quantitative analysis of systems, while policy analysis focuses on the analysis of the nature of problems to discover new policy options and solutions.

Professor H.A. Simon, a Nobel laureate in economics, has pioneered the research direction of policy science and laid a solid research paradigm for the quantitative research of public policy since the 1950s.

Policy science originated in the United States. In 1951, Leswell collaborated with Lenner to publish the book "Policy Science" in the United States, which laid the foundation for policy science. It was not until the late 1960s that policy analysis began to receive attention because of the constant emergence of various complex social problems and the limitations of systematic analysis methods.

Policy analysis is gradually developed by operations research and system analysis. In the early 1940s, operations research played a very good role in solving tactical problems such as optimal radar configuration, and gradually expanded from the military field to social issues such as economy, energy, transportation, and security. However, relying solely on the optimization techniques in operations research to solve social problems is not ideal because it only considers the optimization of the system and does not fully consider the impact on larger systems. In the mid-1950s, the missile crisis accelerated the development of systems analysis and systems engineering involving systems-related and non-quantitative issues. Systematic analysis methods such as cost-benefit analysis combine optimization techniques in operations research with economic analysis and logical reasoning. In the 1950s and 1960s, there was a wave of systematic analysis. System analysis requires prediction of alternative results, requiring clear and quantitative representation of system variables and system models. Local decisions are consistent with overall decision objectives, technical and economic analysis standards are consistent, and logical reasoning processes are consistent. However, it is actually difficult to meet the above requirements in the policy making process. Because policy making is the process of mutual communication and coordination between various interested organizations, groups, individuals, and the authors themselves, rather than the result of rigorous reasoning. Systematic analysis takes the optimal choice as the end of the analysis process, and policy analysis also considers the relationship between policy formulation and policy implementation, screening, evaluation, etc., involving some aspects of anthropology and behavioral science (such as organization, culture, personal values, social psychology). Etc.) and issues like ideology. The selection criteria for systematic analysis of alternatives are efficiency or performance indicators, while the evaluation criteria for policy options are much more complicated. Policy analysis applies some methods of system analysis, but policy analysis considers the scope of the problem to be much broader, and qualitative analysis involves much more. Policy analysis is more comprehensive and easy to meet the actual situation of the society.

Policy science theory is increasingly concerned with public policy processes, instruments selection, simulation, experimentation, and predictive research. Based on cross-disciplinary integration, focusing on the frontiers of international public policy theory and methods, using behavioral research, experimental research, predictive research, simulation, data mining and other methods and techniques to explore public policy systems and their operational mechanisms and methods, and test policy options Evaluate the effectiveness of policy implementation and improve the level of policy analysis.

According to the policy science theory, industrial policy is an important part of public policy, which can be analyzed by policy cycle theory, policy instrument theory and policy simulation theory in policy science theory.

2. Policy cycle theory

The process of public policy has a cyclical nature and can generally be divided into a policy life cycle and a policy change cycle. The life cycle of a policy is a complete process from the birth to the end of the policy, and the period of change of the policy is that the policy is regularly and repeatedly cycled over a period of time. Mey and Verdaviski divided the policy process into six phases: problem definition, program design, program evaluation, program selection, policy implementation, and policy evaluation. The definition of policy issues is a dynamic process of history. The key to defining policy issues is to select appropriate identification methods to analyze the objective social reality. The design and evaluation of policy options should clarify the nature, scope, and related interests of public issues, and prioritize according to the strengths, weaknesses, and importance of different policies. The process of policy implementation is divided into three stages: preparation, implementation, and summarization. The policy implementation body corrects the current policy based on changes in the policy environment, deepening of people's understanding, generation of policy deviations, and generation of policy side effects. The evaluation of the policy determines whether the policy achieves the expected goal within the time of the reservation, and determines whether it is a dynamic process that is long or short, and the standard changes with time and changes in the external environment. In essence, the policy evaluation and the implementation summary of the previous stage are all preparing for the policy to enter the recirculation stage. The essence of the policy cycle process is that policy issues need to be resolved through repeated cycles and cumulative improvements based on changes in the policy environment. Public policy must be based on the economic foundation. The formulation of public policy should be based on the total social and economic structure and economic structure within a certain period of time. Policy cycle divides the policy process into a series of stages, from a notional starting point at which policymakers begin to think about a policy problem to a notional end point at which a policy has been implemented and policymakers think about how successful it has been before deciding what to do next. (Fig.8). The image is of a continuous process rather than a single event. The evaluation stage of policy 1 represents the first stage of policy 2, as lessons learned in the past set the agenda for choices to be made in the future:

- Agenda setting. Identifying problems that require government attention, deciding which issues deserve the most attention and defining the nature of the problem.

- Policy formulation. Setting objectives, identifying the cost and estimating the effect of solutions, choosing from a list of solutions and selecting policy instruments.

- Legitimation. Ensuring that the chosen policy instruments have support. It can involve one or a combination of: legislative approval, executive approval, seeking consent through consultation with interest groups, and referenda.

- Implementation. Establishing or employing an organization to take responsibility for implementation, ensuring that the organization has the resources (such as staffing, money and legal authority) to do so, and making sure that policy decisions are carried out as planned.

- Evaluation. Assessing the extent to which the policy was successful or the policy decision was the correct one; if it was implemented correctly and, if so, had the desired effect.

- Policy maintenance, succession or termination. Considering if the policy should be continued, modified or discontinued.

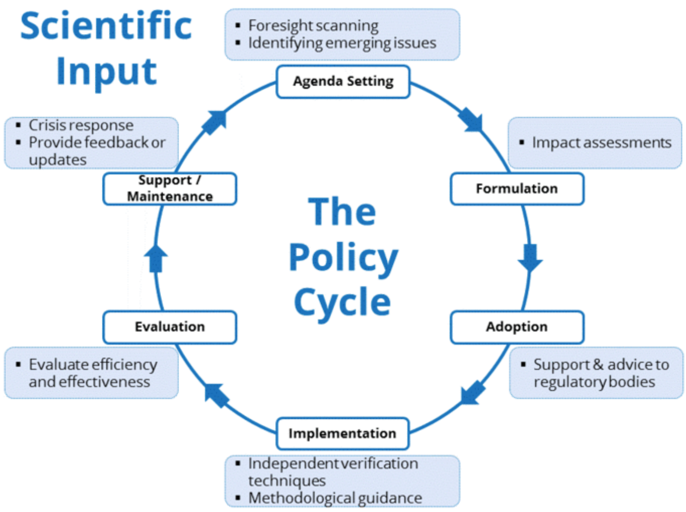

Figure 6 The policy cycle

Data resource: Sarah Connors (2016)

Industrial policy is an important part of public policy, so it is possible to use the dynamic cycle model of policy science to understand the phosphorus fertilizer industrial policy. According to the policy cycle theory, after the policy environment changes, the feasibility of the current implementation of the phosphorus fertilizer industrial policy should be discussed again. Based on the changes in the policy environment, the policy should be advanced to a new round of the cycle, and the policy cycle should be rationally adjusted. This research tries to analyze the reasons for the incompatibility between the existing phosphorus fertilizer industrial policy and the policy environment, through the policy cycle theory. This research also tries to analyze how to properly adjust the six stages of the policy cycle., especially he setting of policy content, the choice of implementation methods and the evaluation process.

3. Policy instruments theory

Policy instrument is a linkage between policy formulation and policy implementation. The intention in policy formulation is reflected in policy implementation through instrument. Policy instruments are often known as governing tools as well, particularly when they are applied with all conditions associated to them. The implementation of governing tools is usually made to achieve policy targets of resource management but adjusted to social, political, economic, and administrative concerns. Thereby, concerns of sustainability largely depend not only on what instruments are selected but also on how they have been applied. Assessment of policy instrument thereby can be an important component of policy sustainability.

Policy instruments are the means to achieve policy objectives. A reasonable selection policy plays an important role in the realization of policy objectives. Due to the means of policy instruments, it plays an irreplaceable role in the policy implementation stage.

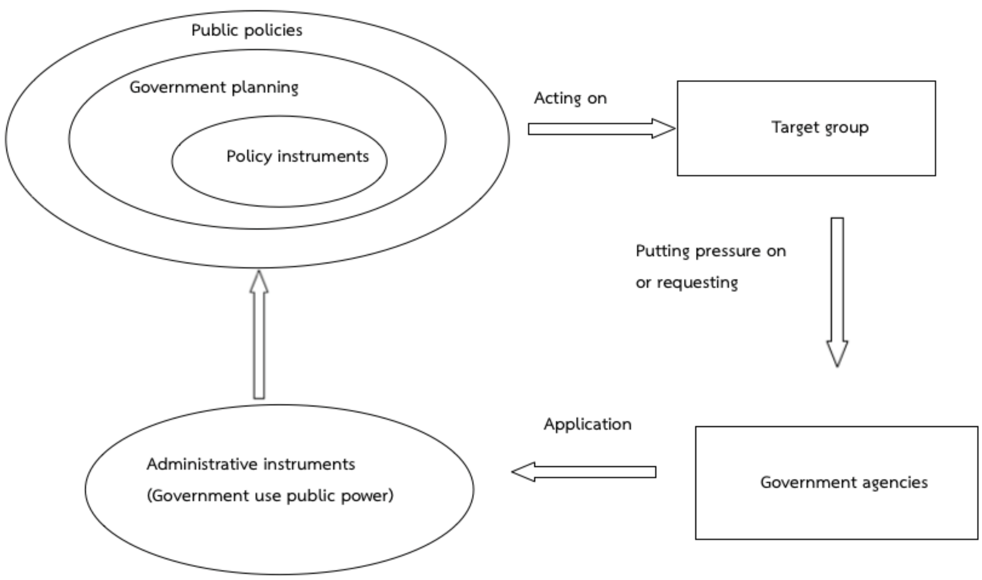

Figure 7 Theoretical connotation of policy instruments

Data resource: Chen Hengjun, Huang Wanling (2004))

3.1 Implications of policy instruments

The research of policy tools originated in the 1980s and developed rapidly in the 1990s and early 2000s. For policy tools, there is currently no uniform definition in the academic world. But policy tools, administrative tools, government programs, and public policies need to be differentiated before defining the concept of policy instruments. Public policy has the widest scope, followed by government programs, followed by policy tools, and finally administrative tools. The concepts related to policy tools can be represented in Figure 9.

In terms of the definition of policy instruments, some scholars believe that policy tools are an authoritative means for the realization of goals, and they are indispensable (Elmore and Rechard F., 1987). Some scholars believe that policy tools refer to the various treatment methods used by government agencies to achieve policy objectives. They are the methods and means of actual use. The government needs to choose appropriate means in the implementation process (Howlett et al., 2003), while Owen E. (2004) Define policy instruments as ways in which governments behave and through some means to regulate government behavior. Salamon (2002) considers it to be a tool for public action, to achieve public questioning the solution of the problem. Zhang Chengfu, Dang Xiuyun (2001) believes that policy tools can also be used as governance tools. It means that the government translates its substantive goals into action paths or mechanisms. Without policy tools, there will be no policy objectives. This research agrees with this view: “Decision makers can use policy tools to achieve their goals”.

3.2 Classification and selection of policy instruments

The research of policy tools began in the 1980s and was further developed in the 1990s. There are several representative views on the research of policy instruments. Hood (1986) proposed the NATO model, which includes advice, investigation, law, registration, grants, registration, grants and loans, consulting, service delivery, and statistical policy tools. M. Mcdonell & F. Elmore divides policy instruments into four categories: imperative tools, incentive tools, capacity building tools, and system change tools. S.Linder and B.Peters believe that policy tools should include commands, controls, financial aid, authority, advice, and contracts. B. Doern and R. Phidd argue that policy tools are divided into private behaviors, persuasion, expenditure, regulation, and public ownership according to the degree of coercion, and that various tools can be substituted for each other (Zhu Chunkui, 2011). Schneider et al. (1993) combine predecessors' perspectives to classify policy instruments into authoritative tools, incentive tools, competency tools, symbolic and persuasive tools, and learning tools. Chinese scholars divide policy tools into: direct tools, indirect tools, basic tools, and guided tools. Howlett and Ramesh classify policy instruments into voluntary tools, hybrid tools, and mandatory tools based on the extent to which government involvement in public goods and services. Mandatory instruments, also known as guiding tools or regulatory tools, are characterized by the influence of regulation and direct action on market organizations and individuals to achieve desired policy objectives. Voluntary tools refer to the government's less involvement in the tasks that are expected to be achieved, and are operated by private forces or markets. A hybrid tool is the part of the government tool that is mandatory between the forcing tool and the volunteer tool.

Scholars have proposed different theoretical models for policy tool selection scholars. It can be summarized in three aspects: (1) Policy objectives. The policy objectives set the criteria for judging from the direction, and the policy objectives must be clearly defined in the choice of policies. The problems that the policy needs to solve are often more complicated, even conflicting, and often the organic combination of multiple objectives. After the implementation of the policy for a period of time, it is necessary to consider whether the target is changed or not, and whether it is necessary to choose a new policy tool; The environment in which policy tools are selected. This refers to the ecological environment or context in which policy instruments are selected, including those of the executing organization, the target group, other tools and policy areas; and (3) policy stakeholders. The choice of policy tools is limited by previous choices. Constructivism believes that the choice of tools is not only related to the effectiveness of the tools, but also the "legitimate process" of establishing policy instruments.

This research will use the policy instruments of Howlett and Ramesh to research the choice of phosphorus fertilizer industrial policy instruments, mainly based on two reasons. First, the classification of Howlett and Ramesh's policy tools is based on the government's involvement in the provision of public goods and services, which is consistent with the role of the government in the phosphorus industry incentives as the primary industry. In addition, Howlett and Ramesh have a more systematic classification of policy tools, which is conducive to the selection and analysis of the phosphorus fertilizer industrial policy with complex content and diversity goals.

4. Policy simulation theory

Policy science theories are increasingly concerned with behavioral, simulation, experimental, and predictive research in public policy. Based on cross-disciplinary integration, focusing on the frontiers of international public policy theory and methods, using behavioral research, experimental research, predictive research, simulation, data mining and other methods and techniques to explore public policy systems and their operational mechanisms and methods, and test policy options Evaluate the effectiveness of policy implementation and improve the level of policy analysis.

With the development of the economy, various natural resources and social materials are increasingly scarce. Formulating efficient and reasonable policies, ensuring the rational and efficient use of various resources, and accelerating social and economic development have become important management tasks in various countries. Research on policies has become a hot topic in today's social economy, especially regarding oil and gas, some unrefreshed resource, regional development, financial markets, agriculture and forestry economy.

The scientificization of public policy formulation methods and processes can greatly reduce the rate of decision-making failures and improve the implementation of public policies. Through the simulation modeling technology, the pre-implementation simulation of the formulation and implementation of public policies is an important method to judge the correctness of public policy formulation and enhance its scientific nature. If we can ensure the correctness and credibility of the whole process of public policy simulation, it is undoubtedly possible to maximize the public policy simulation to meet actual needs and further improve the scientific and rationality of public policy formulation.

The implementation of any policy is just one-off, with great risks and long time periods. With the development of computer technology, the simulation research of policies is gradually emerging and developing. Policy simulation can conduct more accurate predictions and analysis, and perform repeated experiments in a virtual environment to help decision makers formulate correct policies and policies to minimize the risk and cost of policy implementation. Finally it can achieve lower cost and implementation effect.

Policy simulation, as an emerging discipline in the information age, is a modeling, computational simulation, and computer-based policy virtual experiment for policy issues. It is widely used in national development policies, local social and economic policies, and corporate development policy development. The pre-implementation simulation of the formulation and implementation of public policy is an important method to judge the correctness of public policy formulation and enhance its scientific nature, through the simulation modeling technology. If we can ensure the correctness and credibility of the whole process of public policy simulation, it is undoubtedly possible to maximize the public policy simulation to meet actual needs. Therefore, the verification and confirmation of public policy simulation work has important theoretical significance and practical value for the public policy field.

Policy simulation is the development of policy science in analytical technology. In the face of various social and economic problems, analyzing its impact on many aspects of society and assessing the effects of policies through the simulation calculation of economic policies, the scientific nature of policy formulation can be improved. The development of policy simulations helps countries formulate economic and trade policies, energy and environmental policies, and determine the state of the country's economy. In particular, China has joined the WTO, and it is of practical significance to improve the government's decision-making level in the face of market competition in developed countries that formulate policies through simulation.

Through the review of relevant literature, it is found that various fields have research on policy simulation, such as energy policy, agriculture and forestry policy, population policy, financial policy, science and technology innovation policy and so on. In the field of policy simulation research, scholars have used computer technology to develop a variety of policy simulation systems. The US economic model ASPEN is a new economic simulation experimental platform. Its prototype is mainly used for the analysis of economic cycle fluctuations, and then extended to analyze the policy effects of monetary policy. Takashi Iba designed a Boxed Economy Foundation Model, providing an open model development environment; Zhang Shiwei and others developed the macroeconomic model platform ASMEC-I for the simulation of financial and monetary policy effects. Huang Ji and others established the Chinese agricultural policy analysis and prediction model CAPSiM for analysis of various policies and the impact of external impact on the production, consumption, price, market and trade of various agricultural products in China.

Computable general equilibrium (CGE) models are a class of economic policy simulation models that use actual economic data to estimate how an economy might react to changes in policy, technology or other external factors.

5. General equilibrium theory

5.1 Characteristics

General equilibrium theory was initiated by Walras at the end of the 19th century. This theory focuses on the economic theory and analysis method determined by the price and supply and demand of commodities and production factors of the whole economy. It holds that various economic phenomena can be expressed in quantitative relationship. There is a very close relationship between these quantities. In the two major markets of the entire economic system (commodity market and production factor market), the prices of all commodities and production factors are interrelated, mutually influential and mutually restrictive. The change in the price of a commodity or factor of production is not only affected by its own supply and demand, but also by the supply and demand of other commodities and factors of production and the price in the competitive market. Once the production function and consumer demand function are given, the price and supply and demand of all production factors and products can be adjusted to a specific stable state and compatible with each other. A set of established basic determinants can only match a defined set of price and supply balances, and any change in these factors will affect and change the equilibrium of the entire economy.

The general equilibrium theory seeks to explain supply, demand, and price behavior within the framework of multiple interactive markets for the overall economy. It tries to prove that there is such a price system in the economy that can make:

a) Each consumer can provide their own production factors at a given price and purchase products under their own budget constraints to maximize their consumption.

b) Each firm will determine its production and demand for factors of production at a given price to maximize its profits.

c) Each market (product market and factor market) will achieve equal (equilibrium) total supply and aggregate demand under this price system.

When the economy has such conditions, it is to achieve a general equilibrium, and the price at this time is the general equilibrium price. The general equilibrium attempt starts from a single market and the main body, and understands the entire economy from the bottom to up.

5.2 Walras' general equilibrium theory

Walras is one of the founders of the Marginal Utility School. His price theory is based on the marginal utility value theory. He believes that the process of achieving a balanced price or value is consistent, so price decisions and value decisions are one thing. He uses "sparseness" to explain the ultimate cause of price decisions. He believes that the quantity and price of supply and demand for various commodities and services are interrelated. The change in the price and quantity of a commodity can cause changes in the quantity and price of other commodities. Therefore, it is not possible to research only one commodity, one supply and demand change in the market, and must simultaneously research the changes in supply and demand of all commodities and all markets. Only when all markets are in equilibrium can individual markets be in equilibrium.

Walras' general equilibrium price decision is explained by mathematical formulas. He assumes that there are n kinds of resources in the society to produce kinds of goods. Everyone in the society holds a certain amount of resources or factors of production. That is, his analysis is based on the established method of income distribution. In such an economic society, consumers seek to maximize their effectiveness, entrepreneurs seek to maximize profits, and resource owners seek to get the most compensation.

By solving the equation, Walras proved that there are a series of market prices and the number of transactions in the market (these prices and quantities are the equilibrium price and quantity), which enables each consumer, entrepreneur and resource owner to reach Their respective purposes, so that society can exist in harmony and stability.

Continental European economists made important advances in the 1930s. Walras' proofs of the existence of general equilibrium often were based on the counting of equations and variables. Such arguments are inadequate for non-linear systems of equations and do not imply that equilibrium prices and quantities cannot be negative, a meaningless solution for his models. The replacement of certain equations by inequalities and the use of more rigorous mathematics improved general equilibrium modeling.

The input-outcome method was founded by the American economist Wasily Leontief, who earned the Nobel Prize in Economics for his development of this model in 1973. According to Leontief, the theoretical basis of the "input and outcome analysis" and the mathematical methods used are mainly derived from Walras's general equilibrium theory. Therefore, Leontief's self-proclaimed input-outcome model is "a simplified solution to the classical general equilibrium theory". In economics, an input–outcome model is a quantitative economic model that represents the interdependencies between different branches of a national economy or different regional economies. The model depicts inter-industry relationships within an economy, showing how outcome from one industrial sector may become an input to another industrial sector. In the inter-industry matrix, column entries typically represent inputs to an industrial sector, while row entries represent outcomes from a given sector. This format therefore shows how dependent each sector is on every other sector, both as a customer of outcomes from other sectors and as a supplier of inputs. Each column of the input–outcome matrix shows the monetary value of inputs to each sector and each row represents the value of each sector's outcomes.

Francois Quesnay had developed a cruder version of this technique called Tableau économique, and Léon Walras's work Elements of Pure Economics on general equilibrium theory also was a forerunner and made a generalization of Leontief's seminal concept.

Alexander Bogdanov has been credited with originating the concept in a report delivered to the All Russia Conference on the Scientific Organisation of Labour and Production Processes, in January 1921. This approach was also developed by L. N. Kritsman and T. F. Remington, who has argued that their work provided a link between Quesnay's tableau economic and the subsequent contributions by Vladimir Groman and Vladimir Bazarov to Gosplan's method of material balance planning.

Wassily Leontief's work in the input-outcome model was influenced by the works of the classical economists Karl Marx and Jean Charles Léonard de Sismondi. Karl Marx's economics provided an early outline involving a set of tables where the economy consisted of two interlinked departments.

5.3 Applied general equilibrium (AGE) models

Until the 1970s general equilibrium analysis remained theoretical. With advances in computing power and the development of input–outcome tables, it became possible to model national economies, or even the world economy, and attempts were made to solve for general equilibrium prices and quantities empirically.

Applied general equilibrium (AGE) models were pioneered by Herbert Scarf in 1967, and offered a method for solving the Arrow–Debreu General Equilibrium system in a numerical fashion. This was first implemented by John Shoven and John

Whalley (students of Scarf at Yale) in 1972 and 1973, and were a popular method up through the 1970s.

In the 1980s however, AGE models faded from popularity due to their inability to provide a precise solution and its high cost of computation.

Computable general equilibrium (CGE) models surpassed and replaced AGE models in the mid-1980s, as the CGE model was able to provide relatively quick and large computable models for a whole economy, and was the preferred method of governments and the World Bank.

6. The Computable General Equilibrium (CGE) models

6.1 Basic principle of CGE Models

The Computable General Equilibrium (CGE) models describes the interaction and influence between the macroeconomics and individual independent decision-making economies, based on the general equilibrium theory. The basic principle is to use a set of equations to describe the supply, demand and market relations, and solve the set of equations under a series of constraints, and get in each market. Both reach the quantity and price of a set of commodities and elements at equilibrium.

The CGE model characterizes the supply and demand decisions of various economies, and thus determines the prices of commodities and factors.

Equilibrium: For each commodity and element, the market is required to be cleared, and the total supply is equal to the total demand, so it is called "equilibrium".

General: The CGE model incorporates the optimal behavior of a range of economies, such as households and businesses. These optimization behaviors affect the decisions of firms, households, and governments through the prices of commodities and factors, hence the so-called "general."

Computable: The CGE model refers to the coefficients and parameters of the estimated benchmark database equations, and by calculating the effects of policy changes and exogenous shocks on the economic and predicted macro variables, the results can be calculated by the results are calculated by computer, and thus become "computable".

CGE models always contain more variables than equations—so some variables must be set outside the model. These variables are termed exogenous; the remainder, determined by the model, are called endogenous. The choice of which variables are to be exogenous is called the model closure, and may give rise to controversy. For example, some modelers hold employment and the trade balance fixed; others allow these to vary. Variables defining technology, consumer tastes, and government instruments (such as tax rates) are usually exogenous.

6.2 Characteristics of CGE models

Based on Walras's general equilibrium theory, the CGE model describes the supply, demand, and market price relationships in the economic system, and the overall economic system is the object of analysis.

The most important success of the CGE model is that it establishes a quantitative link between the various components of the economy, allowing us to examine the impact of disturbances from one part of the economy on another part of the economy. For the input-outcome model, it emphasizes the input-outcome linkage or correlation effect of the industry. The CGE model links the various economic sectors and industries within the entire economic constraints, thus surpassing the input-outcome model. These constraints include constraints on the size of the government's budget deficit, constraints on trade deficits, constraints on labor, capital, and land, and constraints on environmental considerations such as air and water quality.

Compared with the popular econometric model, the CGE model has the advantage of being able to build an overall macroeconomics based on microeconomic entities, and there is a clear relationship between micro and macro. The CGE model can describe the economic behavior of multiple market participants with a set of equations that can simulate the microscopic and macroscopic effects of a policy measure. the CGE model is widely used in environmental policies, wage adjustments, consumption changes, tax changes, and scientific and technological improvements to influence the industrial structure, resident welfare, government revenue, import and export, etc. of a country or region (Liu Yu et al., 2015).

The advantage of the CGE model is that there is a quantitative connection between the various components of the economy, allowing us to examine the impact of disturbances from one part of the economy on another part of the economy. The CGE model has been widely used in various policy analyses, not only for research. It provides an economic system-level policy assessment tool and provides a framework for policy makers to understand the operational mechanisms of the policy. Compared with the input-outcome linkage or correlation effect of the industry emphasized by the input-outcome model, the CGE model pays more attention to linking economic sectors and industries within the entire economic constraints; compared with the econometric model, the CGE model commodity market and The price of the factor market is endogenous, emphasizing the importance of relative price changes. In recent years, the CGE model has gradually become a standard model that is effectively applied to the analysis of various issues, including analysis of the impact of taxation, public policy, international trade, environmental policy, technological change, etc. on the economic system.

Compared with the statistical or econometric model obtained by data fitting, the CGE model is based on solid economic theory. Its most powerful feature is the behavior of various economic entities based on the hypothesis of microeconomics. The inclusion of the description into the two system frameworks makes it easier for model builders to judge the rationality of the model results based on the corresponding theory. Under the general equilibrium analysis framework, the CGE model fully utilizes the transaction information between the department and the economic entity to capture the transmission and feedback mechanisms of the complex connections and interactions of various departments and economic entities in the economic system. Therefore, the significance of applying the CGE model to research economic management policies is that it can more closely describe the interrelationships and dependencies between various economic entities in the complex economic system, so that the calculation results can better explain the causes of the phenomena. Once the CGE model is established, it provides a convenient simulation tool for various policy analysis.

Essentially, the CGE model is a multi-sector application model that sets no excess or excess supply of goods and factors in all competitive markets. This description has three points that reflect the main characteristics of the CGE model.

First, the CGE model clearly defines the behavior of all economic entities in accordance with the usual neoclassical microeconomic theory. It is therefore a model of general and non-local economic subject behavior.

The typical CGE model sets all subjects to be price acceptors. The producers pursue cost minimization and obtain zero net profit under technical constraints, and consumers pursue utility maximization under budget constraints. The needs and supply of all subjects come from solutions to these optimization problems. By using such an optimization behavior hypothesis, the CGE model emphasizes the role of the price of commodities and factors in influencing the needs and supply decisions of the entity. In addition to producers and residents, the model can further include entities such as government, trade unions, capital creators, importers and exporters.

Second, it uses the assumption of market equilibrium rather than market imbalance, and all markets are settled at the same time.

In other words, the CGE model characterizes the mechanism of supply and demand decisions of different economic entities on the prices of some commodities and factors. Under normal equilibrium conditions, the quantity and price of all commodities and factors are simultaneously determined endogenously. Therefore, the CGE model considers the interaction of the entire economy in a consistent manner.

Third, it is computable rather than purely theoretical and produces concrete numerical results.

The CGE model uses data to describe the economy of a base year, impacting the economy by changing a component and changing the value of all data items in the model. The core data of the CGE model is the input-outcome account, and the benchmark for the CGE model is actually a copy of the economic data solution for an observation year. The CGE model can be impacted by policy changes; by solving the CGE model, a new general equilibrium state after the impact can be obtained.

The variables in CGE models are divided into exogenous and endogenous variables. Exogenous variables are generally variables used to simulate policy shocks. Endogenous variables are those that can be automatically changed and equalized after changes in exogenous variables through the intrinsic relationship of the equations. The model makes the economic system reach a new equilibrium state from the original equilibrium state through the impact of exogenous variables.

6.3 The history of CGE models

The history of the Computable General Equilibrium models can be calculated retrospectively. It is based on the general equilibrium theory of Walras in modern microeconomics. After more than 40 years of development, it gradually matured and became a fairly standardized model.

The first CGE model in the word was a multi-sectoral growth model proposed by Norwegian economist Johensan in 1960, in the article "A Multisectoral Study of Economic Growth" (Johansen, 1960). In this research, the author establishes a Norwegian 22-sector economic model. Obvious difference from other models is that the model considers the maximization of household utility, the budget constraint of household consumption expenditure, the minimum cost of the manufacturer, and the largest profit. The company will determine the amount of investment based on the level of outcome And profit, thus causing changes in the capital stock., the model comprehensively considers the economic behavior of the economic participants. Since the CGE model has been available for more than 50 years, many related research results have appeared (Zhang Xiaotong, 2015; Zhang Xiaotong and Liu Xueyue, 2015; Ha and Kompas, 2016; Liu et al., 2016; Vrontisi et al., 2016; Xu et al., 2015).

CGE models are descended from the input-outcome models pioneered by Wassily Leontief, but assign a more important role to prices. Thus, where Leontief assumed that, say, a fixed amount of labor was required to produce a ton of iron, a CGE model would normally allow wage levels to (negatively) affect labor demands.

The model depicts inter-industry relationships within an economy, showing how outcome from one industrial sector may become an input to another industrial sector. In the inter-industry matrix, column entries typically represent inputs to an industrial sector, while row entries represent outcomes from a given sector. This format therefore shows how dependent each sector is on every other sector, both as a customer of outcomes from other sectors and as a supplier of inputs. Each column of the input–outcome matrix shows the monetary value of inputs to each sector and each row represents the value of each sector's outcomes.

CGE models derive too from the models for planning the economies of poorer countries constructed (usually by a foreign expert) from 1960 onwards. Compared to the Leontief model, development planning models focused more on constraints or shortages—of skilled labor, capital, or foreign exchange.

CGE models of richer economies descends from Leif Johansen's 1960 MSG model of Norway, and the static model developed by the Cambridge Growth Project in the UK. Both models were pragmatic in flavor, and traced variables through time. The Australian MONASH model is a modern representative of this class. Perhaps the first CGE model similar to those of today was that of Taylor and Black (1974).

Today there are many CGE models of different countries. One of the most well-known CGE models is global: the GTAP model of world trade. The developing economies are often analyzed using CGE models, such as those based on the IFPRI template model.

6.4 Application of CGE models

CGE models are useful whenever we wish to estimate the effect of changes in one part of the economy upon the rest too. They can be used to analyze the whole of the economic system. Through the simulation of the economic system as a whole, it analyzes the changes of specific economic strategies, and examines various commodities and production in an economic system from a comprehensive perspective. The relationship between supply and demand between elements. The CGE model divides the macroeconomic system into a large number of computable parts, and studies the impact of price changes on the economic system under the general equilibrium framework through computational simulation rather than analytical analysis. Based on CGE technology, developed countries have established many macroeconomic simulation systems, such as the US Fair-model system, Australia's Murphy Model system, the US, Japan, Germany, Australia and other SG2 multinational models, and so on. More recently, CGE has been a popular way to estimate the economic effects of measures to reduce greenhouse gas emissions in China.

The widely use of the CGE model to assess the impact of industrial policies in public policy has attracted widespread interest among scholars. The application of the CGE model to quantitatively assess the impact of industrial policy is mainly due to several important features of it:

a) The CGE model provides a unified framework with a rational microeconomic foundation that can portray the direct and indirect effects of policy changes on the economy;

b) The CGE model considers the conditions for market clearing and economic; constraints when analyzing the interaction between various economies, which is more in line with the reality;

c) Another advantage of CGE is the ability to analyze the linkages between different economies and industries, so it can better reflect the interaction of economic questions, which is not available in the cost-benefit analysis under the framework of partial equilibrium analysis. (Conrad and Schroder, 1993);

d) The dynamic CGE model can analyze changes based on dynamic baseline policy shocks and compare the pros and cons of different policy measures, which can reflect the real economy more.

This research will try to use some suitable CGE model to estimate the impact or influence of concerned phosphorus fertilizer industry policies to phosphorus fertilizer industry. Then it will very helpful find the focusing policies that can react to capacity management for phosphorus fertilizer industry in China.

6.5 Types of CGE models

According to the region of the CGE model, it can be divided into a national model, a multi-region model, and a global multinational model. In terms of the national model, Norway and Australia are typical representatives. This is closely related to the long-term CGE model research projects in both countries. The CGE model research and development plan of both countries has continued to this day. The Norwegian Ministry of Statistics established the Multi-Sectoral Growth (MSG) program in the 1960s, which laid a solid foundation for the development of the CGE model. Since then, several national models have been published (Bergman, 1985). Bergman, 1988; Bhattacharyya, 1996). Australia established the IMPACT project in 1975 and later transformed it into the Monash project, which laid a good foundation for the later development of the Monash model. Later generations used the model to conduct various studies (Hassed et al., 2008; Hein, 2002; Shea et al., 2016; Wagg and Chapman, 1995).

The national model treats the entire country as an economy, distinguishing only sectors rather than geographic locations. For example, all coal sectors in China are analyzed as a whole, without distinguishing Hainan, Heilongjiang and other provinces. Corresponding to this is the national multi-regional model, which is subdivided by geographic location based on the national model. The multi-region model can be further divided into a top-down model and a bottom-up (Bottom-Up) model. The former is based on the calculation of the national model, and determines the variables of each region according to a certain proportional relationship. The typical representative is the ORANIG model (Horridge, 2003). This model has obtained many scholars' advantages because of its simple calculation and less data. Widely used (Simola, 2015; Zhan et al., 2015). The bottom-up multi-region model requires more detailed raw data and its more complex models than the former. Assuming that a country is divided into N regions, it is not only the data of the N-fold national model, but also the data of commodities and factor flows among the N regions. The typical representative is MMRF (Monash Multi-Regional). Forecasting) model (Adams et al., 2003; Dwyer et al., 2004; Santos et al., 2013; Verikios and Zhang, 2015; Ye, 2008).

The global multinational model is similar to the multi-region model, but slightly simpler than the multi-region model. Inter-regional trade in a multi-regional model is equivalent to international trade in a multinational model, but multi-regional models include inter-regional trade, including international import and export trade. In addition, some multi-regional models divide the government into local governments and central government, and are therefore more complex than multinational models. Typical representatives of the multinational model are the GTAP (Global Trade Analysis Project) model developed by Purdue University (Adams, 2005), the GTAP-E (Global Trade Analysis Project Energy) model (McDougall and Golub, 2007), and the LINKAGE model developed by the World Bank. (van der Mensbrugghe, 2011), PEP-W-1 (Lemelin et al., 2011) and PEP-WT model developed by the Partnership for Economic Policy (PEP) (Robichaud et al., 2013).

According to the time dimension, the CGE model can be divided into static model and dynamic model. The static model only simulates the base period data (Mochizuki et al., 2015; Wang et al., 2015). For example, when using China's 2012 input-outcome table as the static model analysis for the base period data, it is necessary to assume that China's economic structure has not undergone essential changes since 2012. Under the premise of this hypothesis, analyze the strength of a policy tool and its direction. Dynamic models have significant advantages over static models. The dynamic model generally extends the research period to the next few years or decades, and sets the baseline scenario for the dynamic CGE model based on the predictions made by scholars on future economic and social development. Then, a policy simulation based on the baseline scenario can take into account structural changes in the economy and society (Materazzi et al., 2016; Walker et al., 2015; Wang et al., 2015).

Any CGE models are comparative-static: they model the reactions of the economy at only one point in time. For policy analysis, results from such a model are often interpreted as showing the reaction of the economy in some future period to one or a few external shocks or policy changes. That is, the results show the difference (usually reported in percent change form) between two alternative future states (with and without the policy shock). The process of adjustment to the new equilibrium is not explicitly represented in such a model, although details of the closure (for example, whether capital stocks are allowed to adjust) lead modellers to distinguish between short-run and long-run equilibria.

CGE-LHR Model. This model is centered on the LHR model (the standard CGE model developed by the International Food Policy Institute, Lofgren, Hariss and Robinson 2002) and consists of four components: the production market, the commodity market, the economic entity, and the macro equilibrium. The main features of the CGE-LHR model are: allowing flexible division of departments, elements, etc., which can be applied to different levels of research in rural areas, towns, and countries; models, data separation, and different base period data can be easily applied in models; The SAM table distinguishes activities and commodities, allows one production activity to produce multiple commodities; allows domestic and foreign trade and generates transaction costs; the model considers the self-sufficient economy of some commodities in developing country residents; and can flexibly choose the model's macro The closing rule and the way the element market is closed.

By contrast, dynamic CGE models explicitly trace each variable through time—often at annual intervals. These models are more realistic, but more challenging to construct and solve—they require for instance that future changes are predicted for all exogenous variables, not just those affected by a possible policy change. The dynamic elements may arise from partial adjustment processes or from stock/flow accumulation relations: between capital stocks and investment, and between foreign debt and trade deficits. However there is a potential consistency problem because the variables that change from one equilibrium solution to the next are not necessarily consistent with each other during the period of change.

Based on the characteristics of developing countries in China, this research try to construct a CGE model for China's phosphorus fertilizer industry policy analysis based on the standard CGE-LHR (Lofgren, Hariss and Robinson) model. The CGE-LHR model belongs to the neoclassical traditional model. It is a static CGE model in a single country. The producers and consumers pursue the maximization of production profit and the maximization of consumption utility, while promoting the balance of supply and demand of the entire economic system. The consumption equation is derived from nonlinear first-order optimization conditions.

Conclusions

Policy science is the method of researching the whole process of policy research, formulation, analysis, screening, implementation and evaluation. Industrial policies have a huge impact on the industry, the macro economy and even other industrial sectors. Therefor this research try to research phosphorus fertilizer Industrial policies based on policy science theory including policy cycle theory, policy instruments theory and policy simulation theory.

Policy simulation theory is the development of policy science theory in the information age, which is widely used in social and economic policies, Due to the unrepeatable nature of the real economic system, it is difficult or impossible for policy makers to experiment in the real economic environment. The various elements that influence the operation of the modern economy are interconnected and interact in increasingly complex forms, and policy makers need certain simulation tools to test the effectiveness of the policy.

For industrial policies, policy simulation can conduct more accurate predictions and analysis, and perform repeated experiments in a virtual environment to help decision makers formulate correct policies and policies to minimize the risk and cost of policy implementation. Finally it can achieve lower cost and implementation effect.

The Computable General Equilibrium (CGE) model is a policy simulation model currently applied in the macroeconomic field. General equilibrium theory holds that various economic phenomena can be expressed in quantitative relationship. This theory seeks to explain supply, demand, and price behavior within the framework of multiple interactive markets for the overall economy. It tries to prove that there is such a price system in the economy that can make the economy to achieve a general equilibrium. Under the general equilibrium analysis framework, the CGE model fully utilizes the transaction information between the department and the economic entity to capture the transmission and feedback mechanisms of the complex connections and interactions of various departments and economic entities in the economic system.

The CGE model has the advantage of being able to build an overall macroeconomics based on microeconomic entities, and there is a clear relationship between micro and macro. The CGE model can describe the economic behavior of multiple market participants with a set of equations that can simulate the microscopic and macroscopic effects of a policy measure. Therefore the significance of applying the CGE model to research economic management policies is that it can more closely describe the interrelationships and dependencies between various economic entities in the complex economic system, so that the calculation results can better explain the causes of the phenomena. Once the CGE model is established, it provides a convenient simulation tool for various policy analysis.

In conclusion, the CGE model provides a rational analytical framework for comprehensive industrial policy evaluation, by the literature review of theories. The construction of the CGE model of the phosphorus fertilizer industry can more comprehensively analyze the impact of the main phosphorus fertilizer industrial policies. After completing a comprehensive analysis of phosphorus fertilizer industrial policies in China, the main industrial policies will be introduced into the CGE model. The specific method is based on the different modules that make different policies, and the corresponding variables are added to the model.

The Related Research Issue Progress

This section discuss three main content focusing on the research on capacity allocation management policy for phosphorus fertilizer industry policy in China. The first one is the phosphorus fertilizer industry in China to analyze the characteristics of phosphorus fertilizer industry in China. The conclusion of this part is that overcapacity has become the most serious problem for phosphorus fertilizer industry in China by plentiful literature and latest data. The second one is analyzing main phosphorus fertilizer industrial policies in China by historical documents and literature. The conclusion is that there are eight main types of phosphorus fertilizer industry policies in China. These policies always can affect phosphorus fertilizer industry by various way from producing to foreign trading. The third one is the existing studies to the phosphorus fertilizer industrial policy.

1. The phosphorus fertilizer industry in China

1.1 Definition and targets of phosphorus fertilizer industry

phosphorus fertilizer production refers to the production of chemical fertilizers containing phosphorus of crop nutrients by chemical or physical methods using phosphorus ore as the main raw material. Phosphorus is an essential nutrient for all living things. It is an indispensable component of nucleoprotein phospholipids and phytochemicals.

It is involved in the synthesis and metabolism of sugars and starches in plants. The application of phosphorus fertilizer can promote the more efficient absorption of nutrients and water from the soil by crops, improve the growth and development of crops, mature early, increase the grain of the ears, and the seeds are full, greatly increasing the yield of grain and root crops. At the same time, it can also enhance the drought and cold tolerance of crops and increase the content of sugar and starch in root crops.

At present, the phosphorus fertilizer produced in China can be divided into two categories: high-concentration phosphorus fertilizer and low-concentration phosphorus fertilizer. High-concentration phosphorus fertilizer include DAP, MAP, NPK compound fertilizer (P-NPK), heavy calcium (TPP), and nitro phosphorus (NP); low-concentration phosphorus include super phosphorus (SSP) and calcium magnesium phosphorus (FMP).

In general, the position of phosphorus fertilizer industry in China is an industry that provides phosphorus-based phosphorus products and related engineering services to domestic and foreign markets. The targets of phosphorus fertilizer industry in China are: guarantee Chinese food security, maintenance of domestic phosphorus fertilizer supply, optimization of fertilizer products, expansion of phosphorus chemical products, and keeping international leader position in technology and environmental protection.

1.2 Upstream and downstream supply chain of phosphorus fertilizer industry

The of the phosphorus fertilizer industry is mainly sulfur, sulfuric acid and phosphorus ore. The upstream industry's

impact on the phosphorus fertilizer industry is mainly in terms of cost. For example, the increase in phosphorus ore price will directly lead to an increase in the cost of the phosphorus fertilizer industry. (Figure 10). The increase in cost may compress the phosphorus fertilizer industry. The profit margin of Chinese enterprises forces some enterprises to withdraw from the phosphorus fertilizer industry; it may also lead to an increase in the price of phosphorus fertilizer. If the prices of other fertilizer products remain unchanged, phosphorus fertilizer are at a disadvantage in competition with other fertilizer products.

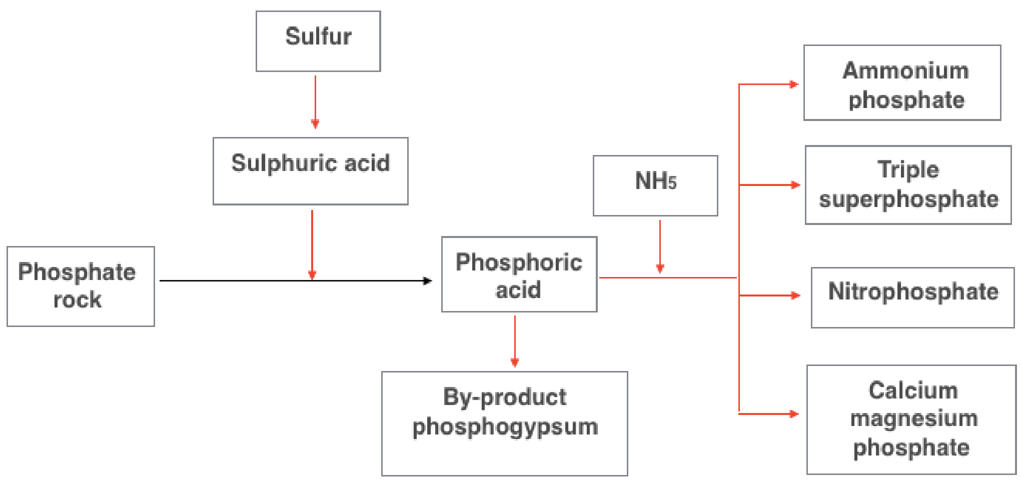

Figure 8 The upstream supply chain for phosphorus fertilizer industry

Data resource: China Phosphorus and Compound Fertilizer Industry Association

Phosphate rock as an important un renewable resources is an important chemical mineral raw material to produce phosphorus fertilizer. Phosphorus resources are irreplaceable and non-renewable, and the global over-consumption of resources has caused international institutions and scholars to worry about the long-term security of resources (Wellmer and Scholz, 2015). Technological advances, advances in public health, and advances in food production have severely disrupted the global phosphorus cycle (Ashley et al., 2011). The sharp fluctuations in phosphorus prices in 2008 indicate that the economic characteristics of phosphorus rock can significantly affect the price of fertilizers, which in turn affects food prices and ultimately threaten food production safety (Mew, 2016; Nathaneil P. Springer, 2017).

The constraints of phosphorus rock resources can be significantly transmitted to the phosphorus fertilizer industry, ultimately threatening the safety of food production (Nathaneil P. Springer, 2017). China's phosphorus fertilizer production capacity is remarkably excessive. In 2015, the phosphorus fertilizer production capacity is 23.5 million tons (P2O5), self-sufficiency rate is 143%, the profit margin of the main business of the industry is only 2.16% (Zhang Tao and Xu Qian, 2016), and the phosphorus resource is wasted seriously in China. Wu et al. (2014) estimated the phosphorus loss in Anhui Province in 2011 is about 398 kt, which is significantly higher than the amount of chemical fertilizer used in the same year. (329 kt).

The downstream of the phosphorus fertilizer industry is mainly agricultural production. Rational application of phosphorus fertilizer can increase crop yield, improve crop quality, accelerate tillering of cereal crops and promote fullness of grain; promote flowering results of cotton, melons, solanaceous vegetables and fruit trees, increase the rate of results; increase beet, sugar cane, watermelon, etc. Sugar; oil content of rapeseed. Therefore, phosphorus fertilizer is one of the main fertilizers for crops, and it is closely related to the development of agriculture and the living standards of farmers.

1.3 Characteristics of phosphorus fertilizer industry in China

1.3.1 Increasing phosphorus fertilizer production

The world's phosphorus producers mainly include China, the United States, Morocco, Russia, and India. The annual production of world phosphorus fertilizer (P2O5) reached 69.1 million tons in 2017(The statistics of China Phosphate and Compound Fertilizer Industry Association, 2018). Chinese phosphorus fertilizer production in 2017 was 16.64 million tons, accounting for 23.7% of the total production of world phosphorus fertilizer. (Jing Shaohui, 2019)

After China was founded in 1949, China began to work on the research, development and industrial installation of phosphorus fertilizer technology. Four super phosphorus plants were built in 1952-1957, which unveiled the development of China's phosphorus fertilizer industry. After decades years of phased expansion and upgrading, China's phosphorus fertilizer industry has realized the transformation from a large phosphorus importing country to a large phosphorus manufacturing country. China's phosphorus fertilizer industry has developed rapidly. phosphorus fertilizer production has increased from 120,000 tons of P2O5 in 1961 to 7.29 million tons of P2O5 in 2000, with an average annual increase of 180,000 tons. After 2000, the increase was even more pronounced, accounting for 76.2% of the increase in world phosphorus fertilizer production (International Fertilizer Industry Association,2012). In 2005, China surpassed the United States to become the largest producer of phosphorus fertilizer, with a production of 11.25 million tons of phosphorus fertilizer, accounting for 30.8% of world production.

1.3.2 Increasing capacity and overcapacity

The world's phosphorus fertilizer capacity growth has been limited this year, all from Morocco, China and Vietnam. OCP (Morocco), the world's largest phosphorus fertilizer producer, has a capacity of 1.35 million tons per year in 2015-2016; Vinachem in Vietnam has a capacity of 150,000 tons per year in 2016; China will have a new capacity of 900,000 tons per year. Phosphorus-increasing fertilizer capacity is in 2015-2016, and there is basically no new capacity in other regions. Saudi Arabia's second phase 1.2 million tons / year capacity of DAP project is expected to be put into production by 2017; several planned phosphorus fertilizer projects in Brazil are expected to be put into production at least until 2018. Considering the decline in the capacity of phosphorus fertilizer in the United States and the operating rate of the plant, the actual amount of global phosphorus fertilizer in 2015-2016 is about 1.5 million tons. (International Fertilizer Industry Association, 2017)

Table 1 World DAP & MAP capacity by region in 2013—2020

(unit: thousand ton/ P_2O_5)

Region	World DAPMAP Capacity							
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
West Europe	213	213	213	0	0	0	0	0
Central Europe	382	327	327	327	327	327	147	147
East Europe & Central Asia	3538	3278	3198	3352	3473	3723	3730	3700
North America	7451	7293	6955	6619	6829	6829	7039	6694
Latin America	1379	1379	1379	1386	1386	1386	1546	1546
Africa	2516	2982	3882	46350	4900	5730	6180	6180
West Asia	2532	2590	2590	2590	3090	4090	4290	4290
South Asia	4347	4347	4347	4440	4440	4440	4670	4670
East Asia	16898	17000	17302	17460	17736	17736	17736	17736
Oceania	540	540	540	540	540	540	540	540
Total World	**39886**	**39948**	**40732**	**41063**	**42720**	**44800**	**45877**	**45502**

Data source: International Fertilizer Industry Association (2019)

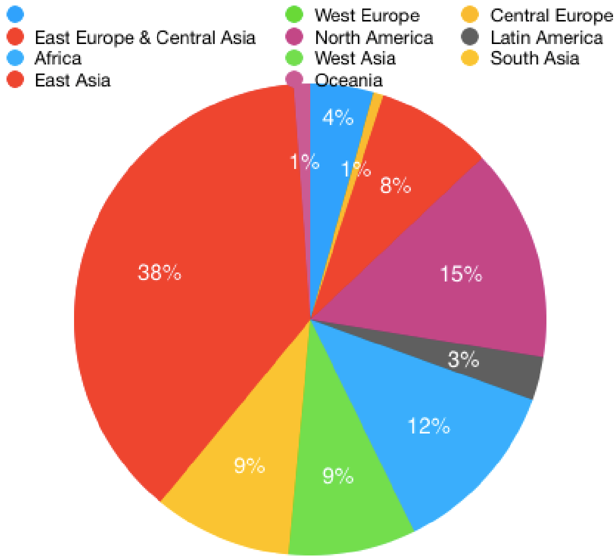

Figure 9 World DAP & MAP capacity by region in 2018

(unit: thousand ton/ P_2O_5)

Data source: International Fertilizer Industry Association (2019)

Due to the continuous enhancement of new technologies and equipment, the phosphorus fertilizer industry and fertilizer technology have developed rapidly. Since 2008, China's phosphorus fertilizer capacity has turned from self-sufficiency to surplus. As of the end of 2016, China's total phosphorus fertilizer production capacity was P_2O_5 24.7 million tons, and the capacity utilization rate was 67.3%(Table), down 8.44% year-on-year. In recent years, China's phosphorus fertilizer capacity utilization rate fluctuated, showing a trend of lowering, rising, and lowering. In 2012, the capacity utilization rate was the highest, reaching 76.17%; in 2016, the lowest was only 67.30%. It is generally believed that the capacity utilization rate of phosphorus fertilizer is less than 79%, which means that there is excess capacity. It can be seen that the production capacity of China's phosphorus fertilizer industry has been in surplus in recent years. According to statistics, the demand for phosphorus fertilizer in China has been stable at 11 million to 12 million t/a per year, while the production capacity of phosphorus fertilizer has been on the rise. This oversupply industry production and consumption situation is the main cause of overcapacity in China's phosphorus fertilizer industry.

Table 2 phosphorus fertilizer Capacity, Production and Utility rate in 2012-2018

Year	2012	2013	2014	2015	2016	2017	2018
Capacity/(10^4t P_2O_5)	2254	2342	2350	2370	2470	2560	2353
Production/(10^4t P_2O_5)	1693	1649.0	1708.8	1795.1	1662.3	1640.7	1696.3
Utility of Capacity/%	76.97	70.17	72.71	75.74	67.30	64.1	72.1

Data source: Phosphate and Compound Fertilizer Industry Association

1.3.3 Increasing industrial concentration

According to the National Bureau of Statistics, in 2017, there were 206 phosphorus fertilizer enterprises in China. The distribution of the phosphorus fertilizer industry depends on the distribution of phosphorus resources. China's phosphorus resources are mainly distributed in the central and southwestern provinces, resulting in the concentration of China's phosphorus industry in Hubei, Yunnan, Guizhou, Sichuan and Anhui provinces. In recent years, the total outcome of phosphorus fertilizer in the five provinces accounted for more than 80% of domestic phosphorus fertilizer production. Especially in 2017, the proportion of phosphorus fertilizer production in the five provinces reached 80.88%, and the concentration of phosphorus fertilizer industry in China is still increasing in 2018. (Table 3)

In 2015, the top 10 enterprises' production capacity accounted for 70% of the total capacity, and the number of enterprises decreased to less than 100. It is estimated that the top 10 production capacity in 2020 will account for 85% of the total capacity and the number of enterprises will be reduced to less than 50.

Table 3 China's major phosphorus fertilizer enterprises' capacity in 2018

(unit: Physical quantity/10^4 ton)

Company name	Capacity of MAP	Capacity of DAP	Location	Resource
Yuntianhua	120	520	Yunnan Shuifu	Phosphate rock
Guizhou Kailing	80	370	Guizhou Kaiyang	Phosphate rock
Guizhou Mengfu	80	260	Guizhou Meng'an	Phosphate rock
Hubei Yihua	50	210	Hubei Yichang	Phosphate rock
Yunnan Xiangfeng	0	120	Yunnan Baoshan	Phosphate rock
Yunnan Sanhuan	0	180	Yunnan Kunming	Phosphate rock
Xinyangfeng	200	0	Hubei Jingmen	Phosphate rock
Sichuan Longmang	100	0	Sichuan Deyang	Phosphate rock, Sulfur-containing gas field
Liuguo Chemical	0	120	Anhui, Hubei, Jiangxi	Phosphate rock, Sulfur-bearing copper ore
Hubei Daxiagu	96	0	Hubei Zhongxiang	Phosphate rock
Xingfa Group	25	48	Hubei Yichang	Phosphate rock

Data source: China Phosphate and Compound Fertilizer Industry Association)

Table 4 phosphorus fertilizer production by provinces in 2017

(unit: Physical quantity/10^4 ton)

Ranking	Provinces	Production	Proportion %
	Total	**1640.7**	**100.0**
1	Hubei	582.6	35.5
2	Yunnan	388.9	23.7
3	Guizhou	251.5	15.3
4	Anhui	99.4	6.1
5	Sichuan	89.9	5.5
6	Shandong	55.1	3.4
7	Chongqing	33.6	2.0
8	Gansu	23.2	1.4
9	Guangdong	18.5	1.1
10	Henan	16.3	1.0

Data source: Phosphate and Compound Fertilizer Industry Association

1.3.4 Decreasing consumption and application

Most of China's phosphorus fertilizer is used in agriculture, and more than 90% of it is used in planting. Corn, vegetables, wheat and rice are the main crops for the application of phosphorus fertilizer in China. From the perspective of development trends, the proportion of phosphorus fertilizer consumption in food crops is declining, and the consumption of cash crops including fruits and vegetables is rising significantly.

Although phosphorus fertilizer use has increased in China between 2010 and 2016, crop yield per hectare actually decreased by 0.99% (Table 5). After years of growth, the consumption of phosphorus fertilizer in China has leveled off in recent years. Consumption per capita averaged 10.64 kg from 2010 to 2015, and between 2015 and 2016, total phosphorus fertilizer use actually decreased by 1.57%.

Table 5 Historical crop yield and phosphorus fertilizer use in China (1997–2016).

	Grop yield per ha (ton/ha)	**Growth (%)**	**phosphorus fertilizer use (Mt)**	**Growth (%)**
1997	4.48		6.89	
2000	4.26	-2.71%	6.90	0.2%
2005	4.64	8.20%	7.44	7.17%
2008	4.95	6.24%	7.8	4.65%
2010	5.51	10.08%	8.06	3.17%
2014	5.35	8.06%	8.45	7.72%
2015	5.48	1.78%	8.43	0.27%
2016	5.45	-0.56%	8.30	1.57%

Data resource: Chinese National Bureau of Statistics

Maintaining phosphorus in the soil at levels adequate for plant growth requires assessing the long-term phosphorus balance. Historically, common phosphorus fertilizer application methods have resulted in excessive applications, and long-term excessive phosphorus fertilizer use led to positive phosphorus budgets in most of China (Li et al., 2016; March et al., 2016).

In 2017, the apparent consumption of phosphorus fertilizer in China was P2O5 1.714 million tons, down 3.3% year-on-year, accounting for 26% of the world's total consumption. According to China Agricultural Development Research Report, since 2009, China's phosphorus fertilizer consumption has been stable at P2O5 11 million to 12 million tons. In 2017, the pilot area of arable land rotation for fallow has been expanded to 800,000 hm2, and the corn planting area will continue to decrease (by 2020, the corn planting area will be reduced by 3.333 million hm2). The Ministry of Agriculture proposes an organic fertilizer replacement fertilizer operation plan and zero fertilizer growth. Policies will all curb fertilizer demand. In addition, due to the low food prices and the policy of market pricing and price separation, the enthusiasm of farmers for planting is significantly reduced, and the enthusiasm for fertilizer purchase is affected.

1.3.5 From phosphorus fertilizer importing country to an exporting country

In the early stage of the development of China's phosphorus fertilizer industry, the outcome of phosphorus fertilizer was insufficient, and it was necessary to rely on imports to meet domestic demand. In 1980, the import volume was 60,000 tons of P_2O_5, and there was no export. In 1998, the import volume increased to 29.46 million P_2O_5, reaching the highest peak in history. In the same year, it exported 149,000 tons of P_2O_5.

Since then, with the increase of China's phosphorus fertilizer production, the import volume has decreased year by year, and the export volume has increased year by year. In 2007, it imported 463,000 t P_2O_5 and exported 2.209 million tons P_2O_5. It achieved net export for the first time and net export of 1.746 million tons P_2O_5. In 2010, the export of phosphorus fertilizer was 246,900 tons of P_2O_5, accounting for 18.1% of the world's total exports. In 2011, the export volume of phosphorus fertilizer reached a record high, with an outcome of 32.75 million P_2O_5 and an import of 21.7 million tons.

The main imported product of China's phosphorus fertilizer is compound fertilizer, and the main export product is DAP. In 2012, compound fertilizer accounted for 67.8% of total imports, and DAP exports accounted for 63.3% of total exports, accounting for 25% of the world's total exports of DAP. China's phosphorus fertilizer is mainly exported to India. In 2012, the export of Indian phosphorus fertilizer accounted for 46.1% of the export of phosphorus fertilizer.

Table 6 Phosphorus fertilizer production, imports, exports, net exports in China 2007-2016

(unit: 10^4 ton)

Year	Production	Imports	Exports	Net exports
2007	1372.0	40.4	251.7	
2008	1289.1	14.3	155.0	
2009	143.4	54.10	175.7	
2010	1599.8	27.8	298.2	
2012	1638.7	31.6	350.5	
2013	1654.5	35.6	269.0	
2014	1657.6	33.5	399.2	
2015	1722.4	26.4	570.5	
2016	1729.6	19.9	471.4	

Data source: International Fertilizer Industry Association

China, the United States, and Morocco are the world's three major exporters of phosphorus fertilizers, accounting for about 73% of the world's total phosphorus fertilizer exports. Since 2007, China has realized a transition from a phosphorus fertilizer importing country to a major phosphorus fertilizer exporting country. In

2012, China's phosphorus fertilizer export volume was 25.17 million tons, making it the second largest phosphorus fertilizer exporter.

In conclusion, At present, the overcapacity of basic fertilizers in the phosphorus fertilizer industry and the shortage of high-end fertilizers exist simultaneously, and supply-side structural reforms still need to be accelerated. De-capacity, restructuring, and improving core competitiveness remain the main tasks.

With the orderly exit of excess capacity, the operating rate of the industry will gradually increase; from the demand side, the structural contradictions of demand will remain prominent, and the weak market of some fertilizer markets will continue. The international market demand and capacity cooperation will become an important channel for defusing domestic production capacity. Therefore, the capacity management of phosphorus fertilizer industry is urgent and necessary.

2. Research to evaluate the existing phosphorus fertilizer industrial policy

Zhang Weifeng (2005) applied a comparative analysis of the advantages and development strategies of phosphorus resources in Central Europe, the United States and Morocco, concluded that China should change its trade strategy, make full use of the international market, control the export of phosphorus rock, and encourage high-value products to export to Asia's huge market. It provides a broad space for the development of China's phosphorus compound fertilizer. Therefore, enterprises with export capabilities are encouraged to enhance the international export capacity of ammonium phosphorus and high-concentration compound fertilizers, so that phosphorus resources can be utilized more effectively and the best benefits can be obtained. At the same time, the direct export of phosphorus rock should be stopped, and the development of China's phosphorus fertilizer industry should be protected while protecting China's resources.

Zhang Weifeng (2007) analyzed the impact of the “three-step” reform plan for China's fertilizer industry, namely, canceling natural gas concessions first, then canceling power and transportation concessions, and eliminating the VAT concessions in the third step, accounting for the impact of industrial policies. The results show that China's fertilizer industry is greatly affected by the policy. The policy support of the whole industry has reached 40.31 billion yuan, and the degree of influence is VAT, electricity, transportation and natural gas. By analyzing the problems that may be caused by various policy reforms, although the impact of policy reforms on the fertilizer industry can be adjusted through industrial restructuring, the impact of rising fertilizer prices on farmers can only be borne by farmers, and only more than 400 industrial incentives are transferred. The billion farmers are unable to guard against the impact of market volatility, and must combine a number of measures to regulate the market and ensure supply.

In 2014, the phosphorus fertilizer consumption market continued to expand. The proportion of phosphorus fertilizer in the world increased from 78.00% to 80.47%. The global phosphorus chemical industry increased by 10.76 million tons, 90% of which was phosphorus fertilizer growth and industrial phosphorus growth was only 10%. %. In the global phosphorus fertilizer industry expansion, after deducting the growth of China's phosphorus fertilizer, the global average annual growth of phosphorus fertilizer is only 1%. China has become the absolute main force of global phosphorus fertilizer growth, and it is followed by a serious overcapacity. BoYin (2016) puts forward the development proposal of China's phosphorus fertilizer industry based on the current situation of overcapacity of phosphorus fertilizer in China: Stabilizing exports, accelerating overseas expansion, adhering to technological innovation, optimizing product structure, promoting mergers and acquisitions, transformation and upgrading, and taking green sustainable development.

Cui Zhouquan (2016) analyzed the occurrence and distribution characteristics of phosphorus rock resources in China, and pointed out that it is difficult to carry out extensive industrialization development and utilization of low-grade phosphorus mines under the current technical and economic conditions, strengthen the research and development of mining technology and establish adaptation to phosphorus in China. The taxation system of scientific and rational development and utilization of mineral resources is particularly important. By comparing and analyzing the advantages and disadvantages of various types of resource tax collection methods, a set of phosphorus and mineral resources tax and fee collection schemes related to reserves consumption and mining parameters were initially established. The collection scheme introduced mining parameters, which can adjust the phosphorus mining enterprises. Mining behavior, from the institutional level to promote the development and comprehensive utilization of low-grade phosphorus resources, accelerate the adjustment of industrial structure, promote the sustainable and healthy development of the phosphorus mining industry, and promote the enthusiasm of mining enterprises to build green mines.

2.1 Research to design the capacity allocation policy model for phosphorus fertilizer industry

Large-scale excess capacity is a waste of valuable resources, while bringing in a large number of ineffective outcomes, and environmental pollution is also more serious. More importantly, overcapacity has been an important obstacle to the upgrading of China's industrial structure and the improvement of the quality of economic growth.

At present, there is less literature on the research and construction of China's phosphorus fertilizer capacity allocation policy model. However, many scholars have conducted modeling studies on overcapacity in other industries. The Chinese government usually applies overcapacity governance and remediation measures mainly include setting the industry entry threshold, strict project approval, and cleaning up excess capacity.

There are many documents in China that pay attention to the problem of de-capacity. The analysis of international experience shows that the United States, Germany, Japan, South Korea, etc. all have a system of effective and effective policy measures for clearing excess capacity, that is, through institutional guarantees and institutional innovations, on the supply side, by promoting innovation to foster industrial competitiveness, on the demand side. Take a variety of ways to expand domestic demand, while giving full play to the advantages of the country to promote the global transfer of industry. The biggest commonality of these countries is that the market's spontaneous regulation mechanism plays the most important role in resolving excess capacity (Sheng Chaoxun, 2013; Shi Wei, 2014; Liu Jianjiang et al., 2015).

Domestically, relevant research suggests that China's overcapacity barriers are too low compared to developed countries due to lack of social security such as employment and lagging capital and factor market reforms, coupled with strong incentives for local government intervention to exit. And the exit barrier is too high. The current policy of resolving excess capacity has many contradictions with the market. It has obvious short-term, contingency and decentralization characteristics, weakening the effect of the policy and causing the overcapacity of the overcapacity. In particular, the market exit barrier is the overcapacity of the overcapacity. Important reasons for difficulty in resolving (Sheng Chaoxun, 2013; Wang Liguo, Gao Yueqing, 2014; Lin Ke, Lu Zhen, 2017). Regarding the impact of de-capacity, relevant research believes that the reduction of excess capacity will have a negative impact on economic growth, employment, enterprises, taxation and social stability. The process of de-capacity needs to prevent unemployment, financial and other risks (Chen Wenling, 2014; Zhang Chunyu, Tang Jun, 2015).

The main points of view on how to design de-capacity policy measures include: drawing on the experience of developed countries, promoting political and economic system reform, improving market systems, and adopting various means and measures to resolve excess capacity from the supply side and the demand side (Sheng Chaoxun, 2013; Shi Wei, 2014); "De-capacity" must be based on the establishment of an effective government and state-owned economy. The industrial policy should give way to competition policy and strive to eliminate barriers to exit from existing markets. The key is It is necessary to establish a long-term mechanism to curb excess capacity (Wang Liguo, Gao Yueqing, 2014; Liu Jianjiang et al., 2015; Yu Li, Zhang Jie, 2014; Huang Qunhui, 2016; Bai Letang, 2016). There are advantages and disadvantages in the administrative methods and market methods for de-capacity. It is necessary to actively seek to resolve the "stable way" and effective mode of overcapacity, and accelerate the systematic support measures including support, hedging and security. Progression (Zhang Junxuan, Zhao Changwen, 2014; Liu Bing, 2016; Pan Wenxuan, 2016); and so on.

Gao Yueqing (2015) believes that overcapacity is actually one of the concrete manifestations of structural imbalances in the supply end of the national economy. Using the fixed effect model of panel data, the data of 28 industries in China's industrial manufacturing industry were tested in 2000-2013. The test results show that accelerating technological innovation has a significant positive effect on the resolution of overcapacity. At the same time, accelerating the reform of the factor market and changing the current situation of the market are important to resolve the overcapacity of our country.

Wang Haibin (2018) analyzed the experience of the United States and Japan in using industrial policies to resolve overcapacity in steel, and proposed that a comprehensive and differentiated policy system must be established to resolve overcapacity. For example, in the process of dissolving overcapacity in the steel industry, the United States and Japan have flexibly applied fiscal, taxation, currency, trade, social security, education, environmental protection and other policy systems to reduce income tax rates, provide loans, accelerate depreciation, subsidize research and development, and formulate plans. Support re-employment training, increase tariffs, implement quotas, and raise environmental standards to support the revitalization of the steel industry. The difference means that the resource allocation basis of industrial policy is not the same in different regions, different stages and different industries. For example, the industrial policy in the process of resolving overcapacity in the United States pays more attention to the market-oriented allocation of resources. In the early days of Japan, more emphasis was placed on the allocation of resources in the form of administration. In recent years, resources have been gradually allocated to the market.

Guo Changlin (2016) introduced the Dynamic Stochastic General Equilibrium (DSGE) model, which analyzes the impact of fiscal policy expansion on capacity utilization of upstream and downstream sectors and its mechanism of action based on the perspective of vertical industrial structure. Theoretical analysis shows that the expansion of government investment expenditure has a significant difference in the capacity utilization rate of different sectors. It has caused the price of upstream enterprises to rise, which has led to the expansion of capacity of the sector, while suppressing the level of capacity utilization of downstream industries. Along with the gradual fading out of fiscal policy, the lack of demand in the downstream industry eventually led to overcapacity in the upstream sector and the price of its products continued to fall. The vertical industrial structure plays a very significant role in this process. Based on the macro quarterly data of China's 1998Q1~2014Q4, this research uses the structural method to estimate the utilization rate of upstream and downstream departments during the sample period, and verifies the significance of vertical industry correlation from the empirical level. Counterfactual analysis shows that fiscal policy and credit factors are important reasons for the current overcapacity in China. The phasing out of the excess capacity of the upstream sector and the efforts to activate the economic vitality of the downstream sector are both under the control of both the symptoms and the root causes of overcapacity in China.

In summary, on the issue of overcapacity, there are still obvious deficiencies in the existing research: almost all the literature analyzes the problem of de-capacity from qualitative and theoretical perspectives, and puts forward suggestions on whether the de-capacity will bring economic and social development. There are key issues such as the impact of the impact and the impact of different industries on the production capacity. The literature does not give a clear answer. It is precisely because of this that the recommendations in the literature have been clearly lacking in pertinence and operability, and there has not been a decommissioning path arrangement for different industry characteristics and a systematic response plan to deal with shocks and risks. In view of this, this research will systematically and quantitatively research the impact and impact of de-capacity to better serve the government departments to make capacity decisions. In addition, this research has a very important reference value for the construction of a long-term mechanism to suppress overcapacity.

2.2 Research on capacity allocation management for phosphorus fertilizer industry in China

At present, there are few related literatures on the construction of the optimal allocation policy system for phosphorus fertilizer capacity based on the protection of strategic phosphorus resources. However, the literature based on the CGE model used in this research can be used to construct a multi-objective policy system in other fields.

Bruvoll, Glomsrod & Vennemo (1999) established a Norwegian dynamic general equilibrium model to research the retardation of environmental quality degradation on economic development. The model establishes a feedback relationship between economic and environmental systems. Economic growth affects environmental quality, while environmental quality declines affects economic systems by affecting the productivity of capital goods and labor and the welfare of consumers. Studies have shown that environmental degradation has a moderate impact on production, but considering the material consumption of residents and the replacement of leisure time, the impact of leisure environmental quality and environmental services on consumers' welfare is more significant. In the 21st century, the speed of capital technology advancement is very important to eliminate the retardation of environmental degradation.

Dellink et al. (2004), Dellink (2005), and Dellink & Van Ierland (2006) used a dynamic general equilibrium model to analyze the economic impact of environmental policies on the reduction of major pollutants in the Netherlands. The model is characterized by the inclusion of major pollutants to reduce cost information, that is, the cost curve of each major pollutant reduction is introduced as input information of the dynamic CGE model, so that most CGE models are top-down (Top) The Down method is combined with a bottom-up (Bottom Up) method based on detailed pollution control information. This article not only considers the direct reduction of pollution caused by environmental pollution discharge, but also calculates the cost change of pollution control to the whole society.

Jin Yanming, Lei Ming and Huang Tao (2007) constructed a regional resource-economy-environment CGE model based on the three regional green social accounting matrix (GSAM) in 2002, Guangdong and Guizhou, and examined the effect of environmental taxation from the perspective of regional differences. As a result, it was found that Guizhou Province is rich in energy and the coal mining industry and the power industry are the pillar industries. The collection of environmental taxes has increased the production cost of the industry, resulting in a shrinking economic scale. The lack of resources in Guangdong Province mainly relies on external transfer and environmental taxation. Its impact is limited. Therefore, the economic structure, factor endowment and competitive strength of each region restrict the implementation effect of environmental taxation.

Cong xiaolan (2014) developed a global multi-regional CGE policy simulator for geopolitical economic analysis using a mixed programming approach and simulated the impact of the US and EU on carbon tariffs imposed on other economies around the world. The simulation results show that the carbon tariffs have a large negative impact on the economies of developing countries, resulting in a decline in their total outcome and terms of trade. Among them, the Chinese economy has suffered the most negative impacts, its mineral processing and metallurgy, plastics. Outcomes in the rubber chemical and mining and mining sectors have fallen sharply, with low levels of developing countries suffering the least negative impact. At the same time, it also found that the EU has benefited more from the carbon tariff than the United States, which has become an important driving force for its implementation of carbon tariffs.

Zhang Shihui et al. (2017) used a dynamic CGE model with energy and carbon emission modules to evaluate the impacts under different scenarios. The results implied that large scale of shale gas development will stimulate economy, when the supply of shale gas increases by 500% from 2010 to 2030, the GDP in 2030 will be 2.59% higher than BAU scenario; technology change that reduces the costs of shale gas utilization will not further stimulate economic growth on the basis of large scale exploitation, but will improve the diffusion of gas and make the energy structure cleaner therefore contribute the carbon mitigation. Hence, it is important for policy makers to take into account the varied effects of different shale gas promotion approaches.

Drawing on the CGE model literature research on resource tax. In terms of sulfur tax, Xu and Masui (2009) compiled a social accounting matrix based on the 1997 China Input-Outcome Table, and studied four scenarios for controlling sulfur dioxide emissions by sulfur tax based on the CGE model. The top-level production structure of the article is set to the Leontief function, so SO2 emissions are reduced and the macro economy is positively improved in the context of improved energy efficiency. In the Cap scenario, where the annual SO2 emissions are reduced by 1.5%, the sulfur tax to be collected will increase year by year. In 2020, it will be about 16,000 yuan per ton of sulfur dioxide. The negative impact on the economy is also very large. The GDP growth rate in 2020 is relative to The baseline scenario has dropped by about 2%. The optimal scenario simulated by the article is to control the SO2 displacement while accelerating the efficiency of energy utilization. Under this scenario, the Sulphur tax to be levied in 2020 is about 10,500 yuan / ton of sulfur dioxide; while the GDP growth rate has declined in the short term, and has benefited from this for a long time. It is predicted that the GDP growth rate in 2020 will increase by about 0.15% compared with the baseline scenario. He (2005) used the 1997 China Input Generation Table to establish a social accounting matrix and used the CGE model to analyze the economic impact of industrial sulfur dioxide emissions reduction. The article considers the baseline scenario, the desulfurization scenario, and the trade open scenario. In the trade open scenario, the research denied the hypothesis of "pollution paradise" and argued that trade openness does not necessarily bring more SO2 emissions to China. The research found that the economic growth rate will decline under the desulfurization policy. The author summarizes the key factors of SO2 emission reduction as the substitution between energy sources, that is, low-pollution and non-polluting energy instead of polluting energy. Ma Shiguo and Shi Lei (2014) used the CGE model to analyze the impact of the sulfur tax on China's economy and industrial structure based on China's 2007 input-outcome table. The analysis shows that the imposition of a sulfur tax will increase government revenue and government savings. However, other variables are mostly lower than the baseline scenario in the sulfur tax scenario. The outcome of coal, oil and other industries dropped sharply, and the prices of the power and natural gas industries increased significantly. Wei Yuxian et al. (2016) set a tax rate of RMB 2,000/ton and RMB 5,000/ton when simulating the economic impact of the sulfur tax. The imposition of a Sulphur tax will not only improve the air pollution problem, but also bring synergies in carbon reduction. Of course, the imposition of a sulfur tax also has certain side effects, such as a decline in the welfare level of the residents and a decline in the total economic outcome of the country.

Conceptual Framework

The conceptual framework of this research was based on the literature review and related studies previously mentioned, which were used in this regard to fit to the environment of the research.

According to the literature review of development and history of phosphorus fertilizer industry and phosphorus fertilizer industrial policies, it can be concluded that phosphorus fertilizer industrial policies has always been the important Macro-control tool for Chinese government. phosphorus fertilizer industry is facing a serious overcapacity problem. This research intends to formulate capacity optimization allocation policies to alleviate this problem.

The policy cycle theory and policy instruments theory in policy science theory are important theoretical basis and theoretical support for analyzing the phosphorus fertilizer industrial policy. In order to research the status quo of the phosphorus fertilizer industrial policy, this research will analyze the characteristics of the six stages of the phosphorus fertilizer industrial policy cycle, the main influencing factors in each stage and existing problems in current phosphorus fertilizer industrial policies through the policy cycle theory. phosphorus fertilizer industrial policy in China has experienced three historical periods: "supporting period, planning management period and adjustment period. In order to research the content and framework of phosphorus fertilizer industrial policy in China, this research will adopt the policy instruments theory combined the three development stages to classify and analyze the industrial policies promulgated by the Chinese government from the start of the phosphorus fertilizer industry in China to the present.

The CGE model provides a rational analytical framework for comprehensive industrial policy evaluation, by the literature review of theories. The construction of the CGE model of the phosphorus fertilizer industry can more comprehensively analyze the impact of the main phosphorus fertilizer industrial policies. After completing a comprehensive analysis of phosphorus fertilizer industrial policies in China, the main industrial policies will be introduced into the CGE model. The specific method is based on the different modules that make different policies, and the corresponding variables are added to the model.

This research will try to use some suitable CGE model to estimate the impact or influence of concerned phosphorus fertilizer industrial policies to phosphorus fertilizer industry. Then it will very hel phosphorus fertilizerul to find the focusing policies that can react to capacity management.

The purpose of the CGE model in this research was to conduct a policy simulation of the phosphorus fertilizer industrial policy. phosphorus fertilizer industrial policy concluded by literature review can be used to carry out policy simulation, and then evaluate and analyze the results of policy shocks. After completing a comprehensive analysis of phosphorus fertilizer industry policy in China, this research will introduce key industrial policies into the CGE model. Based on the core model of CGE, the environmental tax mechanism is introduced, embedding phosphorus resource tax, import and export tax, VAT tax, fertilizer winter storage module, and tax module. The specific method is based on the different modules that make different policies, and the corresponding variables are added to the model.

This research will conduct policy simulations in three phases and several scenarios.

Scenario design:

Stage 1: Policy simulation of phosphorus mining and production of phosphorus fertilizer production raw materials. Mainly to control the production of phosphorus rock resources and the production of phosphorus rock products. Scenario simulation of the phosphorus rock resource tax and the import and export quota of phosphorus rock, and the import and export tax of phosphorus rock.

Stage 2: Simulation of the financial subsidy policy for the phosphorus fertilizer production process. Mainly to reduce or cancel existing subsidies or preferential policies. Including coal discounts, natural gas discounts, electricity tariffs, and transportation price concessions

Stage 3: Conduct a policy simulation of the phosphorus fertilizer circulation. It mainly includes price limit policy, phosphorus fertilizer application policy, import and export tax policy, and import and export quota policy simulation.

Through the use of GAMS software, the results of the policy simulation shock are obtained. Focus on the impact of industrial policies on the outcome of the phosphorus fertilizer industry, the impact on the macro economy and the impact on the income of residents. That is to say comparing the changing data of variables in macro- SAM with the base data to analyze the policy impacts on the macro-economy. Then comparing the changing data of variables in concerned economic department in micro- SAM with the base data, to analyze the policy impacts on the micro-economy. That means the influence of the policies on phosphorus fertilizer industry and other concerned or important industry.

Among them, macro-effect analysis selects total absorption, household consumption, government consumption, total investment, export value, import value, nominal GDP and real GDP as macroeconomic indicators. The analysis of industrial effects mainly analyzes the impact of relevant policies on various industries mainly through the price, outcome volume, factor price and factor input of the production sector and the commodity sector.

Through the analysis of the results of the policy scenario simulation, it is concluded which industrial policies will have an important impact on phosphorus fertilizer production. Through the combined simulation of policy scenarios at different stages, the macro-effects and industrial effects of industrial policies are comprehensively evaluated. Finally, the industrial policy combination proposal for constructing rationally optimized phosphorus fertilizer production capacity control is obtained.

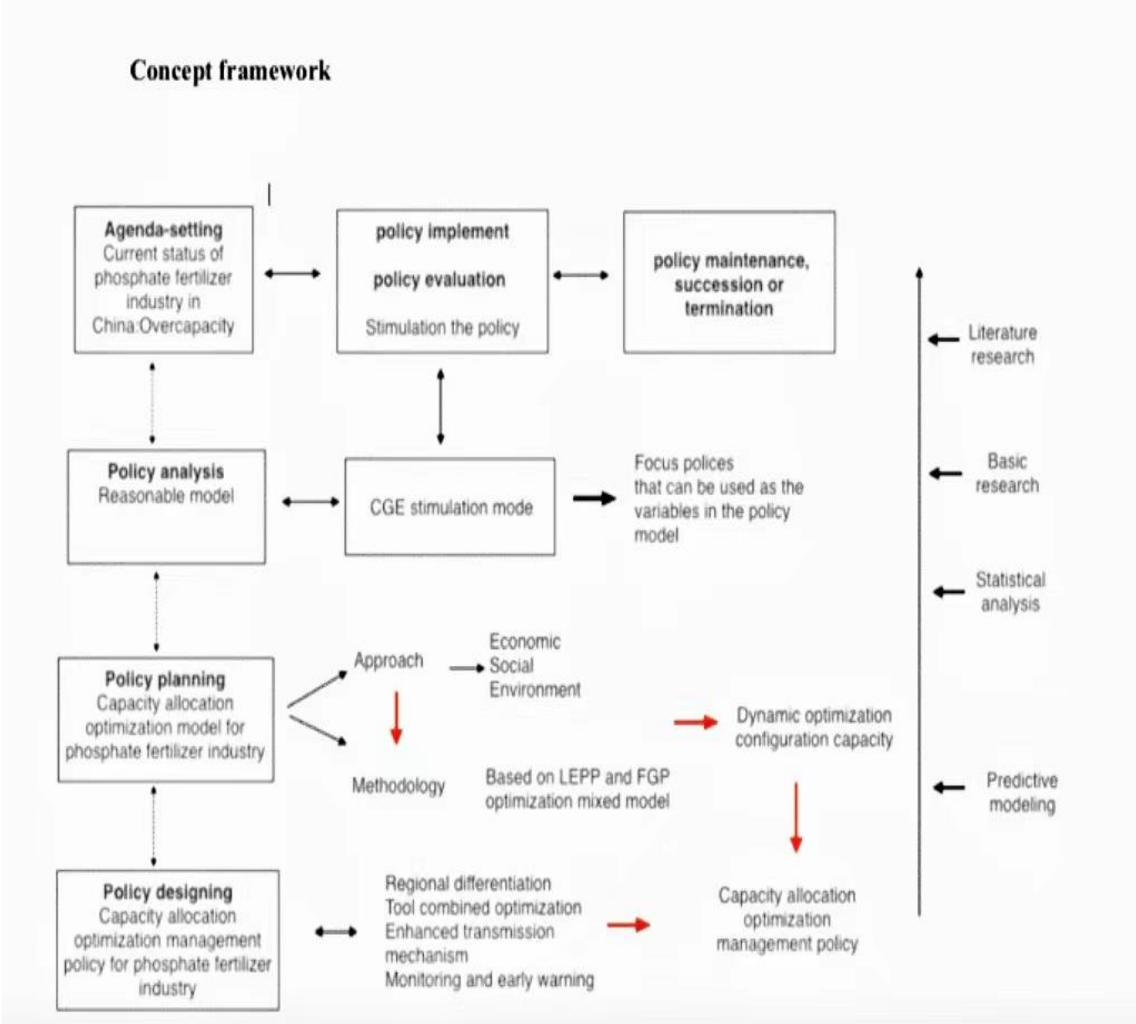

Figure 10 Conceptual framework

CHAPTER 3

RESEARCH METHODOLOGY

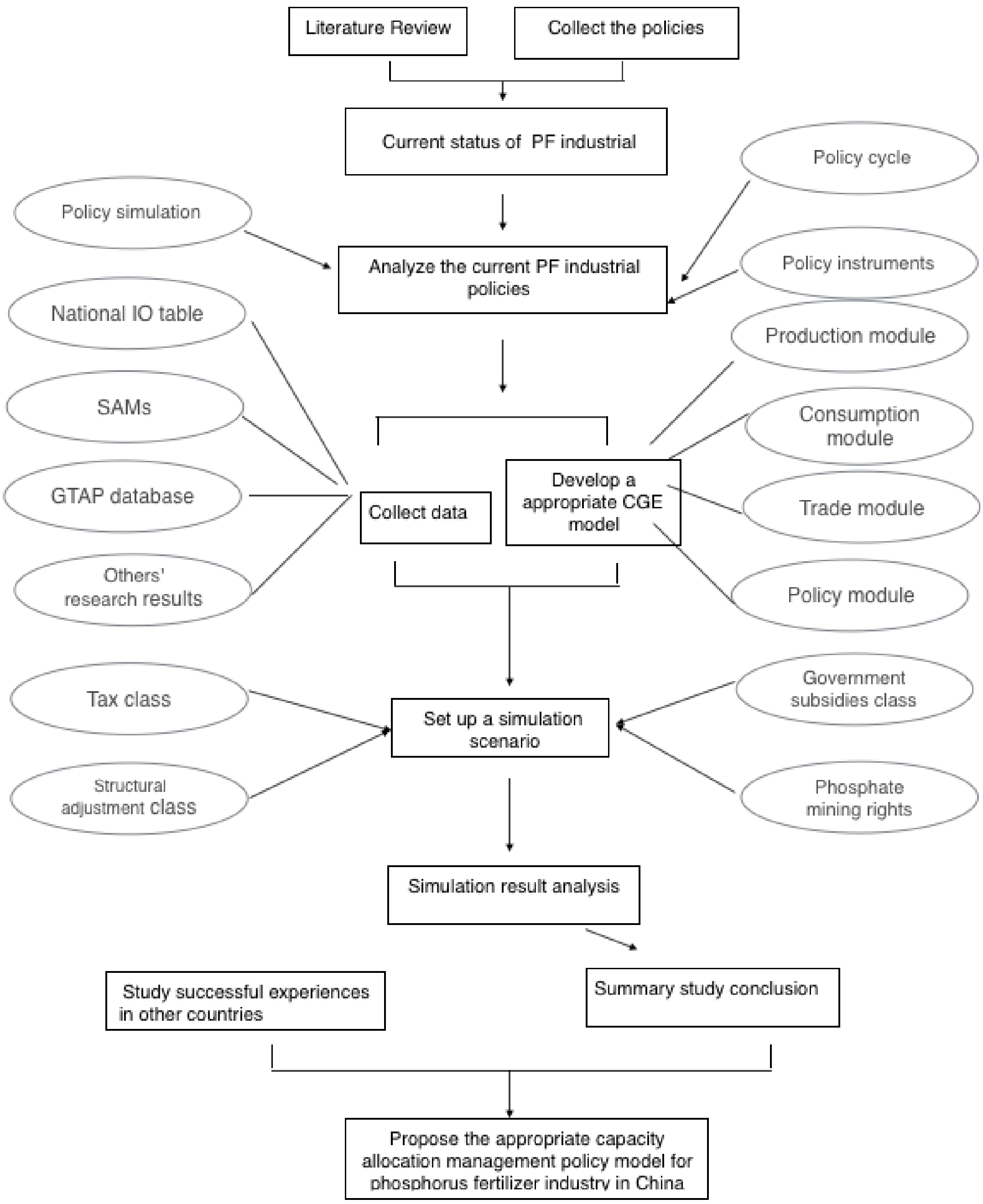

Figure 11 Methodology

Location of the Study

The location of this research is the phosphorus fertilizer industry policy in China. The research regions is the nationwide of Chinese phosphorus fertilizer industry and the national policies from Chinese government.

China, officially the People's Republic of China (PRC), is a country in East Asia and the world's most populous country, with a population of around 1.404 billion. Covering approximately 9,600,000 square kilometers (3,700,000 sq mi), it is the third- or fourth-largest country by total area. Governed by the Communist Party of China, the state exercises jurisdiction over 22 provinces, five autonomous regions, four direct-controlled municipalities (Beijing, Tianjin, Shanghai, and Chongqing), and the special administrative regions of Hong Kong and Macau.

China emerged as one of the world's earliest civilizations, in the fertile basin of the Yellow River in the North China Plain. For millennia, China's political system was based on hereditary monarchies, or dynasties, beginning with the semi-legendary Xia dynastyin 21st century BCE. Since then, China has expanded, fractured, and re-unified numerous times. In the 3rd century BCE, the Qin reunited core China and established the first Chinese empire. The succeeding Han dynasty, which ruled from 206 BC until 220 AD, saw some of the most advanced technology at that time, including researchmaking and the compass, along with agricultural and medical improvements. The invention of gunpowder and movable type in the Tang dynasty (618–907) and Northern Song (960–1127) completed the Four Great Inventions. Tang culture spread widely in Asia, as the new Silk Route brought traders to as far as Mesopotamia and the Horn of Africa. Dynastic rule ended in 1912 with the Xinhai Revolution, when the republic replaced the Qing dynasty. China as a whole was ravaged by Japan during World War II, and the subsequent Chinese Civil War resulted in a division of territory in 1949, when the Communist Party of China established the People's Republic of China, a unitary one-party sovereign state on the majority of China, while the Kuomintang-led nationalist government retreated to the island of Taiwan. The political status of Taiwan remains disputed.

Since the introduction of economic reforms in 1978, China's economy has been one of the world's fastest-growing with annual growth rates consistently above 6 percent. According to the World Bank, China's GDP grew from $150 billion in 1978 to $12.24 trillion by 2017.According to official data, China's GDP in 2018 was 90 trillion Yuan ($13.28 trillion).Since 2010, China has been the world's second-largest economy by nominal GDP and since 2014, the largest economy in the world by purchasing power parity (PPP). China is also the world's largest exporter and second-largest importer of goods. China is a recognized nuclear weapons state and has the world's largest standing army and second-largest defense budget. The PRC is a permanent member of the United Nations Security Council as it replaced the ROC in 1971, as well as an active global partner of ASEAN Plus mechanism. China is also a leading member of numerous formal and informal multilateral organizations, including the Shanghai Cooperation Organization (SCO), WTO, APEC, BRICS, the BCIM, and the G20. China has been characterized as a potential superpower, holding the capacity to rival the United State.

Research Methods

The basic tasks of public policy research design include two aspects: First, selecting and determining the methods and methods of collecting and analyzing research data, ensuring that the methods and methods adopted by the research institute are reasonable, reliable and economical. Second, conceiving and formulating the implementation research. The purpose of the operational procedures and control programs to ensure that the research is effective, objective and clear. The core of the research design is to ensure that the questions answered and the purpose of the research are met.

Considering that the research mainly focusing on the capacity management policy of phosphorus fertilizer industry in China, which belongs to public economic policy, this research design to be applied by quantitative research methods and deductive methods, followed positivism research paradigm.

1. Positivism research paradigm

This research mainly uses the empirical research paradigm, and the phosphorus fertilizer industry policy belongs to the national macroeconomic policy. The research of industrial policy applies to the positivism research paradigm more scientific and objective.

Positivism is a philosophical theory stating that certain ("positive") knowledge is based on natural phenomena and their properties and relations. Thus, information derived from sensory experience, interpreted through reason and logic, forms the exclusive source of all certain knowledge. Positivism holds that valid knowledge (certitude or truth) is found only in this a posteriori knowledge.

Verified data (positive facts) received from the senses are known as empirical evidence; thus positivism is based on empiricism.

Positivism also holds that society, like the physical world, operates according to general laws. Introspective and intuitive knowledge is rejected, as are metaphysics and theology because metaphysical and theological claims cannot be verified by sense experience. Although the positivist approach has been a recurrent theme in the history of western thought, the modern approach was formulated by the philosopher Auguste Comte in the early 19th century.

In philosophy, empiricism is a theory that states that knowledge comes only or primarily from sensory experience.(Curd, Martin ,2010). It is one of several views of epistemology, the research of human knowledge, along with rationalism and skepticism. Empiricism emphasizes the role of empirical evidence in the formation of ideas, rather than innate ideas or traditions. However, empiricists may argue that traditions (or customs) arise due to relations of previous sense experiences.

Empiricism in the philosophy of science emphasizes evidence, especially as discovered in experiments. It is a fundamental part of the scientific method that all hypotheses and theories must be tested against observations of the natural world rather than resting solely on a priori reasoning, intuition, or revelation.

Any sound scientific theory, whether of time or of any other concept, should be based on the most workable philosophy of science: the positivist approach put forward by Karl Popper and others. According to this way of thinking, a scientific theory is a mathematical model that describes and codifies the observations we make. A good theory will describe a large range of phenomena on the basis of a few simple postulates and will make definite predictions that can be tested. ... If one takes the positivist position, as I do, one cannot say what time actually is. All one can do is describe what has been found to be a very good mathematical model for time and say what predictions it makes. (Stephen Hawking,2001)

2. Quantitative research methods

This research mainly uses quantitative research methods to research China's phosphorus fertilizer industry policy. Quantitative research methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data collected through questionnaires, and surveys. Quantitative research is the process of establishing statistical hypotheses, collecting accurate data, and then performing statistical analysis and testing, through statistical investigations or experimental methods. The theoretical cornerstone of quantitative analysis is positivism. From the logical process of research, quantitative analysis is closer to the hypothesis-deductive method research, which not only retains the characteristics of observing experiments and collecting empirical data, but also retains the characteristics of logical thinking deductive reasoning. The application hypothesis makes observation experimental methods and mathematical interpretation forms combined.

In modern management science, mathematical models are widely used, especially in economic forecasting and management. Because they cannot be verified by experiments, mathematical models are usually used to analyze and predict the possible outcomes of economic decision-making.

This research apply mathematical models to simulate the phosphorus fertilizer industrial policy in China, to find out the influence of the industrial policies to the capacity management of phosphorus fertilizer. Through the construction of the CGE model of industrial policy analysis, and based on the input and outcome, the relevant statistical yearbook data to build a macro-SAM, on this basis, according to the needs of the 41 department input-outcome table to split, separate the application of phosphorus fertilizer production 21 The department subdivides the

SAM table. And using the constructed CGE model, the policy simulation is carried out by changing the intensity of each industrial policy in the three stages of phosphorus mining and production, phosphorus fertilizer production and phosphorus fertilizer circulation. These are quantitative research methods.

3. Inductive method

This research will adopt the policy instruments of Howlett and Ramesh to research the choice of phosphorus fertilizer industrial policy instruments. Applying this theory, the phosphorus fertilizer industrial policies of the three stages are analyzed and summarized according to the voluntary policies, mandatory policies and mixed policies classification. Then the current phosphorus fertilizer industrial policy framework can be concluded combined with the comprehensive policy cycle model.

Table 7 Analysis on the Application of phosphorus fertilizer Industrial Policy Instruments in China of each development stage

Tool categories	**Tool name**	**Policy content**		
Related policy name		**(1)**	**(2)**	**(3)**
Voluntary tool				
Mandatory tool	Command line and authoritative tools			
	Supervision			
	Rules			
Hybrid tool	Production subsidy			
	Tax subsidy			
	Information and advice			

4. Deductive approach

A deductive approach is concerned with "developing a hypothesis (or hypotheses) based on existing theory, and then designing a research strategy to test the hypothesis". This research adopts this deductive method. It has been stated that "deductive means reasoning from the particular to the general. If a causal relationship or link seems to be implied by a particular theory or case example, it might be true in many cases. A deductive design might test to see if this relationship or link did obtain on more general circumstances".

Deductive approach can be explained by the means of hypotheses, which can be derived from the propositions of the theory. In other words, deductive approach is concerned with deducting conclusions from premises or propositions.

Deduction begins with an expected pattern "that is tested against observations, whereas induction begins with observations and seeks to find a pattern within them".

Deductive approach offers the following advantages: Possibility to explain causal relationships between concepts and variables; Possibility to measure concepts quantitatively; Possibility to generalize research findings to a certain extent.

This research uses the CGE policy simulation model that has been constructed and assumed to be a good theoretical structure, based on literature review, policy list, real economic data to analyze phosphorus fertilizer industrial policy in China, which is incorporated into the appropriate modules of the model, and the major industrial policies that may have an impact are designed as exogenous variables .Finally this research will design the CGE model for phosphorus fertilizer industry in China, which may affect The development phosphorus fertilizer industry, especially the rational allocation of phosphorus fertilizer capacity in China. Through the policy simulation of the model, the main policy framework for phosphorus fertilizer industrial capacity management policy capacity management in China will be finally obtained. This is a deductive research approach.

5. The Interviewee

The interview research method refers to the qualitative research method of direct communication between the visitor and the interviewee to explore and think about a certain problem. Interview research method refers to a method in which the investigator, based on a predetermined plan, uses certain tools such as interview forms, or auxiliary tools such as tape recorders, networks, emails), to directly ask oral questions to the respondents, record answers on the spot, and thus understand the actual social situation. In order to understand the changes of the phosphorus fertilizer industry policies in the past ten years, a interview should be designed for this research.

Research Tools and Techniques

This research uses the mathematical model method - CGE model as a research tool. Mathematical models are widely used in macroeconomic regulation and control, especially in industrial economic policy economic management. Through mathematical models to scientifically and objectively analyze and predict the possible outcomes of relevant industrial policies.

As an effective positivism analysis tool in the field of economic policy, CGE model is being used more and more widely in the field of public policy analysis. Macroeconomic regulation and control policies interact with each other, so a public economic policy will not only affect the development of the industry, but also the development of other sectors and the entire national economy. The CGE model method can research the interaction between variables in the economic system, reflect the nonlinearity of the role of each phosphorus fertilizer policy, and can research the impact of the phosphorus fertilizer policy on the entire macro-economy and other countries' economic sectors and even the environment, thus enabling Conduct multi-index evaluation on the effect of phosphorus fertilizer industry policy, and even realize the construction of multi-purpose phosphorus fertilizer capacity policy model.

By establishing a CGE model for phosphorus fertilizer industry in China capacity, it is not only possible to find out the policies that have the most significant impact on phosphorus fertilizer capacity through policy simulation, but also to simulate the optimal strength and optimality of relevant policies by simulating these influential policies. The policy mix assesses whether the policy model has the sustainable development of the phosphorus fertilizer industry and whether it will affect the healthy and stable development of the entire national economy or important economic sectors.

CHAPTER 4
RESULTS

This chapter introduces the results of this research, focusing on the analysis of China's phosphorus fertilizer industrial policies, finding out the government industrial policies that will have a significant impact on the allocation of phosphorus fertilizer capacity, and conducting policy simulation through empirical analysis to simulate the impact of policy changes on China's macroeconomic and industrial sectors. This research adopts the research method of combining quantitative analysis and qualitative analysis. First, it uses the literature analysis method, policy theoretical tools, and policy cycle theory to research, classify, and summarize China's phosphorus fertilizer industry, and concludes the main eight categories of China's phosphorus fertilizer industrial policies and three policy cycles of China's phosphorus fertilizer industrial policies. Based on the above research, an interview questionnaire was designed to investigate several major phosphorus fertilizer companies in Yunnan by using the interview method to understand the current situation of the phosphorus fertilizer industry affected by policies in recent years, and the main policies affecting the production plan of phosphorus fertilizer producers and the profit of phosphorus fertilizer companies were obtained. Finally, based on the research on the industrial policies that will have a significant impact on the phosphorus fertilizer industry, the CGE model of China's phosphorus fertilizer industrial policy is constructed, and the empirical analysis is used to research how to optimize the current phosphorus fertilizer industrial policy through policy simulation

Objective 1 What Policies can make impact on the capacity allocation management of phosphorus fertilizer industry in China

1. phosphorus fertilizer industrial policy in China

This research focus on the phosphorus fertilizer industrial policy. So it is necessary to analyze and sort out China's phosphorus fertilizer industry policies from

1950 to the present. By listing a list of policy documents issued by a large number of Chinese governments and analyzing sufficient literature, it is concluded that there are main eight phosphorus fertilizer industry policies in China.

There are eight types of phosphorus fertilizer industry policies in China. (Table 9)

Table 8 Main phosphorus fertilizer industry policies list.

1	Preferential policies in manufacture	Electricity preferential policy Gas preferential policy Coal preferential policy
2	Preferential policies in transport and reserve	Railway transport preferential policy Fertilizer storage in off-season policy
3	Preferential policies in sale	Limited price policy VAT preferential policy
4	Preferential subsidy policy for phosphorus fertilizer application	Optimize subsidies for fertilization structures policy Directly subsidize to farmers policies
5	Tariff policies in foreign trade	Import tariffs policy Export tariff policy
6	Policies in decreasing phosphorus fertilizer demand	Zero fertilizer application growth policy Other suppress fertilizer demand policies
7	Phosphate rock resource policies	Phosphate export license and export quota policy Phosphate resource tax policy
8	Environmental policy	Environmental tax

These eight industrial policies have profoundly affected the development of Chinese phosphorus fertilizer industry in terms of phosphorus raw materials, freight, prices, environmental protection costs, demand, application volume and foreign trade. (Figure 14)

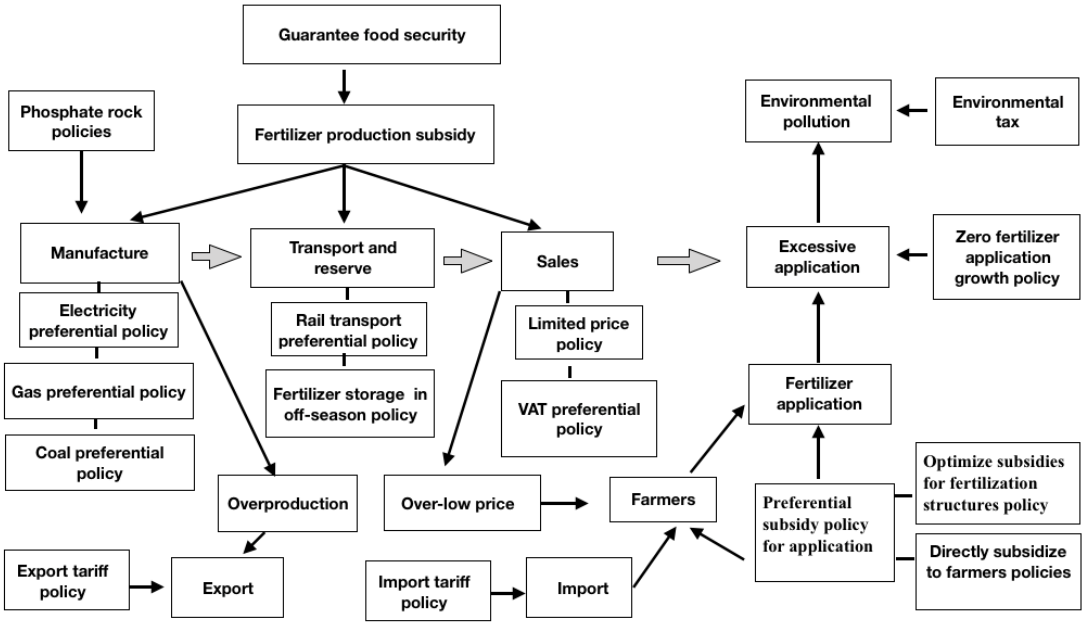

Figure 12 Main phosphorus fertilizer industry policies

1.1 Preferential policies in manufacture

1.1.1 Electricity preferential policy

Electricity preferential policy means phosphorus fertilizer enterprises can enjoy preferential electricity prices during the process to produce phosphorus fertilizer. Preferential electricity prices are applied to the electricity used for fertilizer production. The Chinese government has always given small fertilizer manufacturers a preferential policy for preferential electricity prices since 1963. According to calculations by relevant departments, the preferential policy may reduce the cost of chemical fertilizer production by more than 6 billion CNY per year.

In 2013, the price reform in the power sector gradually began, and the call to abolish the preferential policies for fertilizers and electricity was gradually put on the agenda. In 2015, the National Development and Reform Commission issued the "Notice on Reducing the On-grid Electricity Price of Coal-fired Power Generation and the Price of Industrial and Commercial Electricity" (Development and Reform Price [2015] No. 748), clearly stipulating that the price of chemical fertilizers will be gradually eliminated from April 20, 2015. Since then, the 52-year preferential electricity policy has been completely withdrawn from the historical arena.

1.1.2 Gas preferential policy

Natural gas price for fertilizer enterprises was strictly regulated by Chinese government before 2005. The lower gas prices brought direct low-cost dividends to fertilizer companies. It was estimated that this policy could reduce the production cost of producing urea enterprises from natural gas as raw materials by about 1 billion CNY per year.

However, in order to meet the requirements of the market economy, Chinese government has been continuously reforming natural gas prices since 2005.In 2016, the National Development and Reform Commission issued the "Notice on Promoting the Marketization Reform of Chemical Fertilizer Gas Price", which stipulates that the price of chemical fertilizer gas will be fully opened from November 10, 2016. From then on, preferential gas policy for phosphorus fertilizer industry has officially ended.

1.1.3 Coal preferential policy

Coal preferential policy refers to the policy of limiting the price l of coal for phosphorus fertilizer enterprises that use coal as raw material. Although coal price is one of the earliest market-oriented raw materials for fertilizer production, the Chinese government has adopted a series of measures to ensure full supply and preferential price of coal and its transportation to guarantee phosphorus fertilizer production and stabilize phosphorus fertilizer price.

1.2 Preferential policies in transport and reserve policy

1.2.1 Railway transport preferential policy

phosphorus fertilizer enterprises have always enjoyed preferential railway transport fee policies for many years. Even in 2003, the National Development and Reform Commission and the Ministry of Railways adjusted the price of railway freight, but the railway freight rate for fertilizers still retained the original preferential policies and continued to be exempted from railway construction funds. Fertilizer railway freight rates were only about 30% of the similar chemicals. According to the calculation of the preferential tariff of fertilizer, the transportation cost of fertilizer can be reduced by an average of nearly 80 CNY / ton, and the government subsidized 5 billion CNY per year.

However, with the deepening of China's price reform, the preferential tariff policy for fertilizer railway transportation may also be fully finished. In 2015, the National Development and Reform Commission established a price mechanism for railway freight transportation, which was up and down. The agricultural fertilizer was adjusted to implement the No. 4 freight rate. The railway transportation enterprises can increase the benchmark price of the country by 10% The preferential policy for exempting the railway construction fund has been retained. According to the Notice of the National Development and Reform Commission on Deepening the Market-oriented Reform of Railway Freight Price and Other Issues, from January 1, 2018, the whole railway freight rate of chemical fertilizers and organic fertilizers still implemented the government guidance price, canceling the single After the electrification surcharge is imposed, the upper limit that can be raised is adjusted from the previous 10% to 15%. This also means that the cost of freight for fertilizer companies has risen.

1.2.2 Fertilizer storage in off-season policy

Fertilizer storage in off-season policy refers to reserving a certain amount of fertilizer tin the off-season of chemical fertilizer application (usually in winter) by Chinese government procurement. This policy has gradually evolved from a disaster relief reserve into an off-season commercial reserve. China has implemented a fertilizer reserve policy officially and has continued to this day since 1998. The annual reserve chemical fertilizer volume has increased from 1 million tons to 18 million tons in 2013, and a new 5 million tons of storage was added in 2014. This policy has also evolved from a simple function to respond to emergencies into an important means of regulating the supply of fertilizers and stabilizing the market price of fertilizers.

1.3 Preferential policies in sale

1.3.1 Limited price policy

In order to support the development of agriculture and ensure that farmers can afford fertilizer, China had imposed strict price limit management on chemical fertilizers for a long time. The price of phosphorus fertilizer products was directly priced by the government for decades. In 1998, the ex-factory price of fertilizers was changed from government pricing to government-guided prices. However, in 2004, the National Development and Reform Commission issued the most stringent price limit policy, and resumed the implementation of government-guided prices for some fertilizers again. For the wholesale and retail prices of fertilizers, the management of the rate of invoicing, the batch-to-zero rate or the ceiling price was still implemented. As the prices of major raw materials such as coal, Sulphur and phosphorus rock for chemical fertilizer production had been completely marketized and changed frequently, restricting the price of chemical fertilizers is not conducive to the normal organization of production and management activities. In 2009, the National Development and Reform Commission changed the ex-factory price of domestic fertilizers to the market adjustment price. At this point, the fertilizer price limit policy has completely withdrawn from the historical stage finally.

1.3.2 VAT preferential policy

The value-added tax (VAT) is a tax levied on the value-added amount that the phosphorus fertilizer enterprise imposes on the units and individuals that sell phosphorus fertilizer and imported phosphorus fertilizer, phosphorus fertilizer companies have enjoyed different levels of VAT tax incentives for a long time, In 1994, China implemented the reform of the taxation system. The basic rate of value-added tax was 17%. In order to promote the production of agricultural fertilizers and other agricultural production materials, the cost of applying fertilizers to farmers was reduced, and the tax rate applicable to taxpayers selling or importing fertilizers was set at 13%.The State Council and the Ministry of Finance had repeatedly adjusted the types of VAT fertilizers in the production chain, but they had continued the regulations on tax exemption for wholesale and retail of fertilizers since1996.

The average annual VAT discount reached 30.8 billion CNY from 2011 to 2014, which greatly stimulated the enthusiasm of fertilizer enterprises.

There was a big change in 2015 for VAT policy. The Chinese government re-unified taxpayers' production, sales, wholesale, retail, and imported phosphorus fertilizer at a tax rate of 13%, and resumed the collection of value-added tax on some fertilizer imports DAN VAT preferential policy. Then two years later, China reduced the structure of the VAT rate, and the tax rate for taxpayers selling or importing fertilizers fell to 11%. In March 2018, China imposed a further 10% reduction in the VAT rate applicable to the sale or import of phosphorus fertilizer.

1.4 Preferential subsidy policy for phosphorus fertilizer application

1.4.1 Optimize subsidies for fertilization structures policy

The subsidies for optimizing fertilization structure mainly include subsidies for soil testing formula, subsidies for the promotion and application of organic fertilizers, and subsidies for soil organic matter enhancement. Since 2005, it has mainly provided subsidies and project management fees for soil testing, formula, and fertilizer distribution for agricultural technology extension agencies and enterprises that are subject to formula fertilization. At present, this subsidy has become a major project to improve soil quality and guide farmers in scientific fertilization. In 2006, the Ministry of Finance and the Ministry of Agriculture began to implement the Soil Organic Quality Upgrading Subsidy Project to subsidize straw returning, fertility and green manure cultivation. In 2004, Shanghai took the lead in implementing the subsidy for the promotion and application of organic fertilizer.

1.4.2 Directly subsidize to farmers policies

Directly subsidize to farmers policies are the crucial parts of Chinese agricultural policy. Chinese government had successively established three subsidies since 2004. The subsidy funds come from the central financial agriculture special transfer payment funds. The three subsidies include subsidies for improved crop varieties, comprehensive subsidies for agricultural materials, and direct subsidies for growing grain. The comprehensive subsidies for agricultural materials had been implemented since 2006, mainly to directly subsidize agricultural production materials such as fertilizers, pesticides and diesel oil purchased by farmers.

Since the implementation of the subsidy policy, it had reduced the cost of food production, mobilized the enthusiasm of farmers to grow grain, promoted stable grain production and increased production, and increased farmers' income.

In order to support the protection of cultivated land and the moderate scale of grain management, Chinese government comprehensively promoted the "three subsidies" reform of agriculture in 2016.This new reform consolidated crop subsidies, direct subsidies for grain farmers, and comprehensive subsidies for agricultural materials into just one subsidy called "agricultural support protection subsidies". The standards for the distribution of agricultural support protection subsidies vary from province to province. (In 2019, the subsidy standard for Jiangsu Province was 120 CNY/mu, and the subsidy standard for Anhui Province was 70.6 CNY/mu).

In addition, the agricultural subsidies related to fertilization have been continuously enriched in recent years. In 2017, for example, the subsidies for the protection of cultivated land are increased. , farmland rotation for fallow subsidies, farmland protection and quality improvement actions, livestock and poultry manure resource treatment actions, fruit and vegetable tea organic fertilizer to replace fertilizer operations.

1.5 Tariff policies in foreign trade

phosphorus fertilizer production was insufficient before 2000 in China. The phosphorus fertilizer demand for agriculture was mainly dependent on imports. Therefore, the general direction of phosphorus fertilizer tariff policy in foreign trade had long been to encourage imports and restrict exports.

1.5.1 Import tariffs policy

In order to reduce the burden of farmers, China has always given considerable preferential treatment to the import tariffs on phosphorus fertilizer. China had implemented different tariff rates policy on imported phosphorus fertilizer implemented within and after quotas since 1997, From 1997 to 2002, China imposed quota license restrictions on the import of DAP. China implemented quota management for all fertilizers in 2002. In order to alleviate the contradiction between supply and demand of fertilizers, different fertilizer would have different preferential policies for importing fertilizers in different years. The actual implementation tariff rate was as low as 1%.

China imposed low tariffs on imported phosphorus fertilizer and its raw materials. There were even the direct subsidy policy for the price of imported fertilizer products. In 2004, the Chinese government subsidized 100 CNY per ton of imported DAP, with a total subsidy of 6.7 million CNY/ton and a total subsidy of 670 million CNY. (Fan Zhongming, 2014)

From 2006 to 2018, the total import tariff quota of China's fertilizers was 13.65 million tons, including 3.3 million tons of urea, 6.9 million tons of DAP, and 3.45 million tons of compound fertilizer. Fertilizer import tariff quotas are implemented first-time first. Any enterprise registered in the administrative department for industry and commerce may apply for import tariff quotas for fertilizers within its business scope. The import tariff quota for phosphorus fertilizer is the same as the total amount of DAP 6.9 million tons. Distribution in 2006: DAP 6.9 million t, its trade in China's battalion is 4.49 million tons, and non-state-owned trade is 2.41 million. In 2018, the number of DAP tariff quotas was 3.52 million tons for state-run trade and 3.38 million tons for non-state-run trade quotas.

1.5.2 Export tariff policy

In order to ensure the stable supply of domestic fertilizers, while implementing the price control of fertilizers, the Chinese government has successively introduced macro measures to regulate the export of fertilizers, and adjusted tariffs several times until the export of fertilizers is strictly prohibited. (Han Han, 2009) The fertilizer tariff policy has gone through the process of exporting VAT refunds, canceling export tax rebates, and then increasing export tariffs, and then adding special export tariffs, reflecting the government's restrictions on fertilizer exports and domestic protection. Market supply and firm determination to allow farmers to buy fertilizer.

The export tax rebate policy for DPA has been suspended since 2004.In 2010, the export tariff was imposed on phosphorus fertilizer at a tentative rate of 35%, and a special export tariff of 75% was imposed.

Due to the long-term implementation of strict export tariffs, China's phosphorus fertilizer industry exports were blocked and lacked international market support. The domestic market could not effectively digest corporate production capacity and cause large inventories. If this continues, not only will the phosphorus fertilizer industry be hit hard, but it will also jeopardize agricultural development, increase farmers' income, and ultimately affect national food security.

The Chinese government began reforming the export tariff policy for phosphorus fertilizer in 2014. The export tariffs of DAP and MAP are adjusted to 50 CNY/ton in the off-season (May 16-October 15) and 15%+50 CNY/ton in the peak season.

In the first half of 2014, the export volume of domestic phosphorus fertilizer increased significantly. The cumulative export volume of MAP and DAP increased by 201% and 146% respectively. Internationally, the price of MAP in Brazil has increased by 16.0% since mid-May, and the MAP in different provinces of China has also increased by 3-8%. Brazil is the main exporter of MAP phosphorus in China, and the increase in the price of MAP will be beneficial to the export and price increase of MAP in China. At the same time, Sulphur is one of the main raw materials for phosphorus fertilizer production. Since April, the price of sulphur at home and abroad has increased by about 27%. The increase in the price of this raw material will contribute to the increase in the price of phosphorus fertilizer. In terms of policies, according to the “2014 Tariff Implementation Plan”, the tax rate for urea and phosphorus fertilizer exports has been greatly reduced. The program will be beneficial to the export of fertilizers this year. The division of fertilizer exports will be reduced. The export of fertilizers is expected to increase significantly throughout the year, which is conducive to the elimination of domestic excess fertilizer capacity.

In 2016, China began to implement zero tariffs on phosphorus fertilizer exports.

In the latest tariff adjustment program for 2018, the phosphorus ore export tariff was lowered from 15% to 10%,and phosphorus fertilizer continues to implement zero-tariff exports rate.

1.6 Policies in decreasing phosphorus fertilizer demand

1.6.1 Zero fertilizer application growth policy

Overuse of chemical fertilizer and pesticides has been a concern in China for some years due to the implications for food safety, agricultural sustainability and the health of the ecological environment. In 2015, the Chinese Ministry of Agriculture introduced two important measures that seek to halt the growth in the use of fertilizers and pesticides: the "Action to Achieve Zero Growth of Chemical Fertilizer Use by 2020" and the "Action to Achieve Zero Growth of Pesticide Use by 2020" (MOA, 2015).

1.6.1.1 Back ground of the policy

Agricultural development faces two main constraints: resources and the ecological environment. The Actions to achieve zero growth of chemical fertilizer and pesticide use have the potential to help promote improved methods for and structural adjustments of agriculture, control agricultural non-point source pollution, increase cost efficiency, energy conservation and emission reductions, ensure the safety of the national grain supply, the quality and safety of agricultural products and the safety of the ecological environment, and realize the sustainable development of agriculture. They will therefore bring significant economic, environmental and social benefits.

Fertilizers and pesticides are double-edged swords for agriculture. Their use raises expectations for increased outcome of agricultural products, but it also has unwanted consequences such as non-point source pollution. The large amount of fertilizer and pesticide use, and the high intensity combined with low efficiency and unscientific application methods increase the cost of agricultural production and waste resources, and result in problems like degraded soil fertility, excessive pesticide residues, and agricultural non-point source pollution. The use of these inputs influences the safety of the ecological environment and agricultural production, and the quality and safety of agricultural products, and it threatens human health and sustainable agricultural development (Xing & Zhu, 2000; Lai et al., 2009; Fischer et al., 2010; Xin et al., 2013; Shen & Zhang, 2015).

1.6.1.2 Key tasks of the policy

The key tasks to achieve zero growth of pesticide use are the "one build and three promotes":

1) Build up a pest monitoring and early warning system. Automated, intelligent field monitoring networks will be built based on the principles of advancement and practicability to improve pest monitoring.

2) Promote scientific pesticide use. The focus is the simultaneous enhancement of "pesticides, devices and farmers". First, efficient, low toxicity, low residue pesticides will be promoted. Second, new and efficient crop protection machinery will be promoted. Third, scientific knowledge of pesticides will be popularized.

3) Promote green prevention. Government support will be consolidated and market mechanisms will come fully into play to accelerate the pace of green prevention, including the promotion of integrated technology methods, the construction of green prevention demonstration zones and the training of technical staff.

4) Promote unified control. Professional unified control of pests will be promoted with an emphasis on expanding service scope and improving service quality, including enhancements to devices, technology and service content.

The above shows that the actions to realize zero growth of chemical fertilizer and pesticide use focus on source reduction, end to end monitoring of chemical fertilizer and pesticide use, and end-of-pipe control of the pollution that is generated.

1.6.1.3 Execution effect

In 2016, the total application rate of agricultural fertilizers in the country was 59.841 million tons, a decrease of 385,000 tons from 2015, a decrease of 0.64%. This is the first time in the history of chemical fertilizer application statistics in China that the reduction of chemical fertilizer application has been achieved. (Jin Shuqin, 2018)

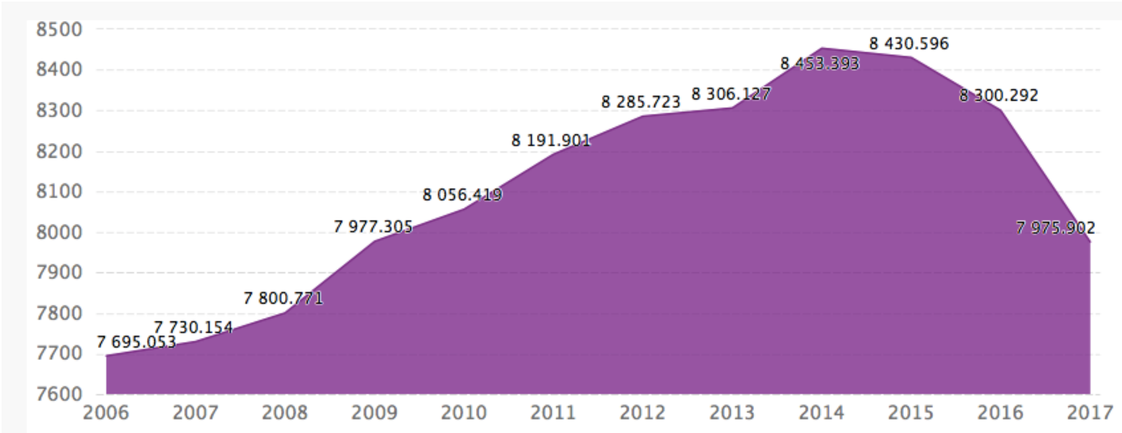

Figure 13 Application of phosphorus fertilizer from 2006-2017 (unit: thousand ton)

Data source: National Bureau of Statistics

At present, the use of pesticides in China has been negative for three consecutive years, and the use of chemical fertilizers has achieved zero growth. The application of phosphorus fertilizer decreased obviously from 8.43 million tons in 2015 to 7.96 million tons in 2017. (Figure 15). The reduction in the use of chemical fertilizers not only strengthens the company's determination to actively eliminate the "zombie production capacity", but also consolidates its advancement in technological advancement, actively develops environmentally-friendly high-energy, high-efficiency new-type fertilizers, and promotes land-based water pollution caused by excessive use of chemical fertilizers. Etc. also played a certain mitigation role.

1.6.2 Other suppress fertilizer demand policies

Affected by the Chinese government's urban expansion, returning farmland to forests and other policies, the area of cultivated land in China has been decreasing since 2013. The reduction in the area of cultivated land means that the overall demand for fertilizer is declining. In 2017, the pilot area for arable land rotation will be expanded to 12 million mu, and the corn planting area will continue to be reduced. By 2020, the corn planting area will be reduced by 50 million mu. The Ministry of Agriculture's policy of replacing organic fertilizers with fertilizers will also curb fertilizer demand.

1.7 Phosphate rock resource policies

Phosphate resource is an important and indispensable strategic resource for the phosphorus fertilizer industry and production of food security in China. Phosphate resource has also been identified as dominant mineral resources. Although Chinese phosphorus reserve ranks the second in the world, it only account for 5.36% of the total world reserves. The distribution of phosphorus reserve in China is uneven, and is short of the high-grade rich ore. In 2015, phosphorus rock reserves were 3.1 billion tons (USGS,2016), and the phosphorus rock production outcome was about 140 million tons. Based on this calculation, the phosphorus rock resource storage ratio is only can be used for 22 years; far lower than the world reserve ratio. The global phosphorus rock are 68 billion tons in 2015, the outcome is 241 million tons. So the world phosphorus rock resource storage ratio is about 282 years. Coupled with the depletion and non-renewable nature of phosphorus rock resources, phosphorus fertilizer industry and agriculture will face a severe crisis in the supply of phosphorus rock raw materials in the future. In order to ensure the long-term sustainable development of Chines phosphorus fertilizer industry, phosphorus rock resources must be rationally mined. That’s why Chinese government has always adopted a sustainable phosphorus rock resource policy.

1.7.1 Phosphate export license and export quota policy

China implemented an export licensing policy for phosphorus rock exports before 2009. The licensing system is a measure for a country to regulate the export of goods. In general, some countries implement export licensing systems for raw materials, semi-finished products, and some tight-selling materials and commodities that are in short supply in the country. Protect the national economy by issuing licenses to control exports or export restrictions to meet the needs of the domestic market and consumers.

The export quota policy refers to a system in which a government imposes a maximum amount on the quantity or amount of exports of certain export commodities within a certain period of time. Goods within the limit can be exported, and additional goods are not allowed to be exported or penalized. Since 2009, the export quota license management system has been adopted for the export of phosphorus rock. A total of 1 million tons. 850,000 tons of old enterprises and 150,000 tons of new enterprises. In 2018, the total export quota for phosphorus rock was reduced to 800,000 tons. The phosphorus rock export policy was adjusted again in 2018. Since January 1, 2019, the management of phosphorus ore quotas has been suspended and adjusted to implement license management. Any foreign trade operator who meets the requirements for exporting phosphorus rock may apply for an export license with a valid export contract for goods, and go through customs formalities for customs clearance with the export license.

1.7.2 Phosphate resource tax policy

Resource tax, as a means of universal regulation, its main role is to regulate the differential income of resources, promote the rational development of resources, curb the indiscriminate exploitation of resources, and make the cost and price of resource products reflect its scarcity. At the same time, through taxation, it also raises the necessary funds for the government to control the environment and maintains intergenerational equity.

Since the establishment of China's resource tax in 1984, it has undergone several adjustments. In 1994, a resource tax was levied on the amount of phosphorus ore. The taxation standard was CNY 3/ton. In 2008, the phosphorus resource tax was raised from CNY 3/ton to CNY 15/ton. Since domestic phosphorus fertilizer enterprises consumed about 50 million tons of phosphorus ore in the same year, the resource tax adjustment has increased the cost to the phosphorus fertilizer industry by more than 6 billion CNY per year. In order to reduce the cost of phosphorus fertilizer enterprises, the phosphorus rock resource tax has been adjusted to CNY 4/ton since 2013.

1.8 Environmental Policy: Environmental Tax Policy

Environmental protection tax was officially levied in China from January 1st, 2018. and 38 years of sewage charges were suspended. The environmental protection tax is paid quarterly. According to estimates, the scale of environmental protection tax collection is 50 billion CNY.

The opening of the environmental protection tax will inevitably increase the operating costs of phosphorus fertilizer enterprises. Increased operating costs mean that companies either increase the price of phosphorus fertilizer, or reduce start-ups, reduce expenditures, and maintain low profitability. In other words, the introduction of environmental protection tax is actually pushing the enterprise, winning the fittest, improving the level of equipment, and realizing the de-capacity of the phosphorus fertilizer industry in disguise.

Three historical development stage

By applying the policy cycle theory and combining the development of China's phosphorus fertilizer industry and the history of the promulgation and change of eight major policies, it is concluded that the history of China's phosphorus fertilizer industry policy can be divided into three historical cycles. of phosphorus fertilizer industry policies in China. phosphorus fertilizer industry in China has experienced a development from nothing, from small to large, from single nutrient, low concentration to high concentration, compounding and multi-variety. China has gone through a process of role in the world phosphorus fertilizer market, from imported phosphorus fertilizer products to imported phosphorus fertilizer technology, finally to export phosphorus fertilizer country (Gao Yuan, 2011). During the process from the rising to be the world's largest phosphorus fertilizer producer , phosphorus fertilizer industry policy has always played a crucial role.

Phosphorus fertilizer industrial policy in China has experienced three historical periods: “supporting period, planning management period and adjustment period” (Zhang Weifeng al et.,2007). This study summarizes the main phosphate fertilizer industry policies implemented in three different historical stages through the policy cycle theory, as shown in Figure 16. At present, China's phosphorus fertilizer industry policy is in the third stage of historical adjustment. Facing the contradiction of overcapacity in the phosphorus fertilizer industry, how to evaluate the existing phosphorus fertilizer industry policy and optimize the design of phosphorus fertilizer capacity allocation is the primary goal of China's phosphorus fertilizer industry policy.

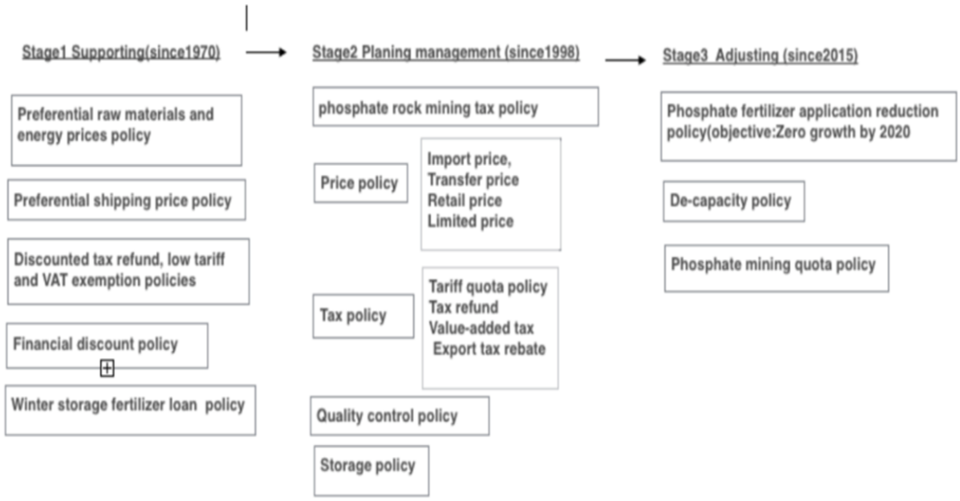

Figure 14 Historical development stage of phosphorus fertilizer industry

Based on the theory of policy tools, this study summarizes and analyzes China's phosphate fertilizer industry policies since 1950, as shown in Table 9. It was found that the policies issued by the Chinese government for the phosphate fertilizer industry have different characteristics in three different historical stages. In the third stage at present, in order to better control the production capacity of the phosphate fertilizer industry and control the export volume of phosphate fertilizer to ensure domestic supply, the Chinese government has adopted more mandatory policies.

Table 9 Analysis on the Application of phosphorus fertilizer Industrial Policy Tools in China

Tool categories	Tool name	Stage 1		Stage 2		Stage 3	
		Amount	Proportion%	Amount	Proportion%	Amount	Proportion%
Voluntary tool							
Mandatory tool	Command line and authoritative tools	26	44	5	29	19	59
	Supervision	4	7			1	3
	Rules	7	12	2	12	1	3
Hybrid tool	Production subsidy	7	12	6	35	1	3
	Tax subsidy	6	10	1	6	1	3
	Information and advice	9	15	3	18	9	28

The Interviewee

After analyzing and sorting out the main policies of the phosphorus fertilizer industry since the founding of China, in order to understand the changes of the phosphorus fertilizer industry policies in the past ten years, several major phosphorus fertilizer companies in Yunnan were investigated by interview. Because China's phosphorus fertilizer industry has passed the supporting period, the planning management period and is now in the adjustment period, the policy support period and the capacity control period. The subsidy policies previously adopted by the government for a long time have been largely abolished. Since the Chinese government put forward the Action Plan for Zero Growth of Fertilizer Use by 2020 in September 2015, the policy has indeed reduced the consumption of phosphorus fertilizer, and the application of phosphorus fertilizer in China has decreased year by year.

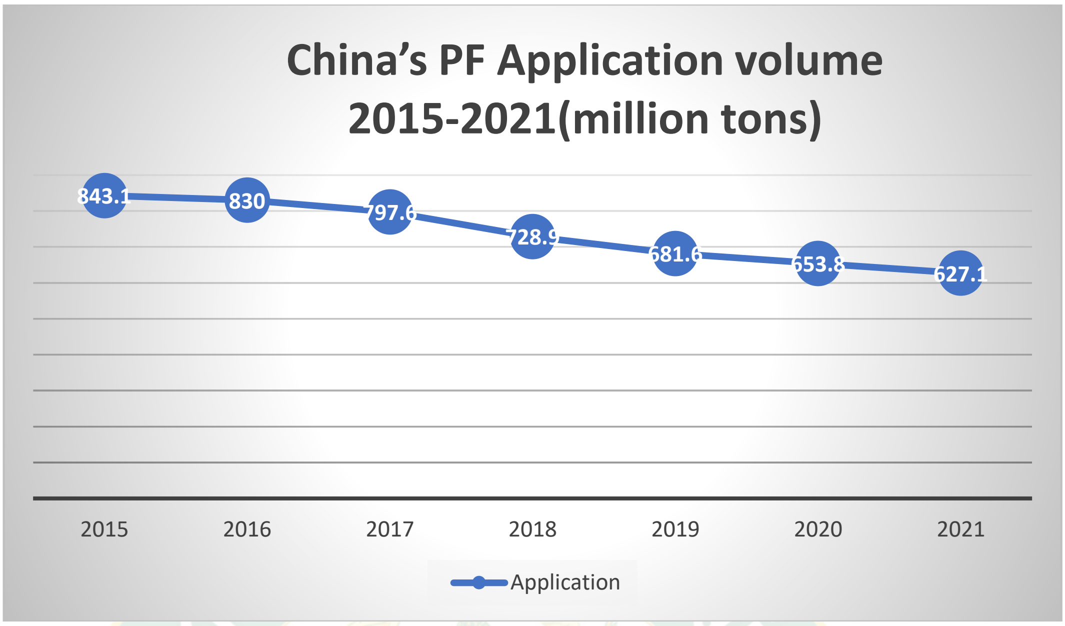

Figure 15 China's phosphorus fertilizer Application volume from 2017 to 2021

Data resource: China Statistical Yearbook

Based on the above research, an interview questionnaire was designed to investigate several major phosphorus fertilizer companies in Yunnan, including Yunnan Yuntianhua Group Co., Ltd., Qinghai Yuntianhua International Fertilizer Co., Ltd., Yunnan Golden Field Fertilizer Co., Ltd., Yunnan Xingkun Chemical Co., Ltd., Yunnan Xuanwei Dongsheng Chemical Co., Ltd., Yunnan Lufeng Qinpan Phosphorus Chemical Co., Ltd Kunming Hongteng Chemical Co., Ltd. understands the current situation of phosphorus fertilizer industry affected by policies in recent years, and obtains the main policies that affect the production plan of phosphorus fertilizer producers and the profit of phosphorus fertilizer companies.

Questions of the interview

1. What do you think of the change of phosphorus fertilizer production in the last 10 years?
2. Do you think the overcapacity of phosphorus fertilizer still exists?

3. Do you think the zero growth policy of chemical fertilizer application has an impact on the yield of phosphorus fertilizer? Why?

4. How do you view the impact of fertilizer storage in off-season policy on phosphorus fertilizer production?

5. How do you view the impact of the value-added tax (VAT) policy on phosphorus fertilizer production?

6. How do you view the impact of the tariff policies in foreign trade on phosphorus fertilizer production, including import tariffs policy and export tariff policy?

7. Do you think Phosphate rock resource policies have an impact on the yield of phosphorus fertilizer, including phosphorus export license and export quota policy, phosphorus resource tax policy? Why?

8. What policies can make impact on the phosphorus fertilizer industry in China in the last 10 year? And why?

9. What phosphorus fertilizer industrial policies do you think the government should adjust to optimize the phosphorus fertilizer production capacity ? Why?

Analysis of interview results

For most enterprises, due to the reduction of domestic demand, expanding exports has become an inevitable choice to resolve the domestic surplus phosphorus fertilizer production capacity. Faced with the dilemma of overcapacity, respondents from several companies said that the policies that will have a significant impact on the phosphorus fertilizer industry in the past five years mainly include export policy, value-added tax policy and phosphorus rock resource tax policy. Among them, the export policy has a significant impact on the phosphorus fertilizer industry in the past five years, directly affecting whether enterprises can resolve excess capacity and improve the profitability of phosphorus fertilizer enterprises.

Figure 16 China's phosphorus fertilizer export volume and export earnings from 2017 to 2021

Data resource: China Statistical Yearbook

Export restriction policy

In terms of export tariffs, according to the Notice of the Tariff Commission of the State Council on the Interim Tariff Adjustment Scheme for Import and Export in 2019 issued by the Tariff Commission of the State Council, since January 1, 2019, China will no longer impose export tariffs on potassium chloride, potassium sulfate, compound fertilizer and other chemical fertilizer commodities. The complete elimination of export tariffs is conducive to reducing the pressure of domestic overcapacity by increasing exports. Many phosphorus fertilizer manufacturers have also begun to make profits through export.

However, according to the information fed back by the respondents, it is understood that in recent years, due to the large price difference between the value of phosphorus fertilizer in China and overseas markets, many phosphorus fertilizer enterprises have found that increasing exports can greatly improve their profits. However, under the situation that the Chinese government attaches great importance to "food security", in order to ensure the supply of phosphorus fertilizer to domestic agriculture, the macro-control goal of the phosphorus fertilizer industry is first to ensure domestic demand, so from 2021, the Chinese government began to control the export of phosphorus fertilizer and began to implement a series of strict export restrictions. As a result, the overall operating rate of the phosphorus fertilizer industry is not high and the supply is limited.

Legal inspection policy for phosphorus fertilizer export

On October 11, 2021, the General Administration of Customs of the People's Republic of China issued the Announcement of the General Administration of Customs on Adjusting the Catalogue of Import and Export Commodities Subject to Inspection (No. 81, 2021). According to the Law of the People's Republic of China on Import and Export Commodity Inspection and its implementing regulations, the General Administration of Customs decided to adjust the catalogue of import and export commodities subject to inspection. From October 15, 2021. The customs supervision condition "B" is added to the 29 10-digit customs commodity numbers involved in the export of chemical fertilizers, and the customs carries out export commodity inspection on relevant commodities. Among them, the export chemical fertilizer belonging to hazardous chemicals shall also be subject to the export chemical inspection and the export hazardous chemical packaging inspection in accordance with the relevant regulatory provisions of hazardous chemicals. The unqualified chemical fertilizer shall not be exported according to relevant regulations.

According to the interview, due to the complicated legal inspection procedures for phosphorus fertilizer export, the export of phosphorus fertilizer enterprises has been subject to many restrictions, and even caused the general shutdown of enterprises. Medium and low concentration phosphorus fertilizer enterprises in Yunnan are facing a life-and-death situation, and enterprises urgently appeal to speed up customs clearance. The enterprise said that if it goes on like this for a long time, the enterprise will inevitably lose money and close down. Finally, the international market will lose money and the domestic market will not be guaranteed.

Export quota system

On July 12, 2022, China's phosphorus fertilizer export quota was basically determined. This is the first time that a quota system has been adopted to allow the export of phosphorus fertilizer since October 16, 2021, when the export of phosphorus fertilizer was restricted by law in order to ensure domestic supply.

The export quota of phosphorus fertilizer is basically determined, and the price of phosphorus fertilizer will improve in the following or peak season of agricultural demand. Due to the high price of domestic phosphorus rock, the price of phosphorus fertilizer products continued to rise, leading to the tightening of domestic phosphorus fertilizer export policy. The total export quota of phosphorus fertilizer is about 3.6 million tons, including monoammonium, diammonium, heavy calcium, super phosphorus and nitrogen-phosphorus binary compound fertilizer. The quota amount of production enterprises includes the total amount of phosphorus fertilizer outcome that the enterprise needs to export. The known export quota producers are concentrated in Hubei Province, Guizhou Province and Yunnan Province, and the enterprises include Yuntianhua, Xingfa Group, Hubei Yihua, etc. At present, due to the uncertain export process, the export of phosphorus fertilizer is suspended, and the price of phosphorus fertilizer has dropped due to the low season of domestic agricultural demand. With the arrival of the autumn agricultural peak season and the determination of export policy, the demand will warm up and the price of phosphorus fertilizer is expected to rise.

Value added tax

Value-added tax is a kind of turnover tax levied on the added value or added value of goods in the production, circulation, labor service and other links. China adopts the tax deduction method commonly used internationally, that is, according to the sales volume of goods or services sold, the outcome tax is calculated at the prescribed tax rate, and then the value-added tax paid when the goods or services are obtained is deducted, that is, the input tax. The difference is the tax payable on the value-added part.

Respondents said that the value-added tax policy would affect the cost of phosphorus fertilizer enterprises, and also the production scheduling plan of phosphorus fertilizer production, thus affecting the price and outcome of phosphorus fertilizer. Before 2000, in order to support the development of phosphorus fertilizer industry, the Chinese government exempted value-added tax on phosphorus fertilizer. Since 2000, because phosphorus fertilizer products have become self-sufficient, in order to cooperate with the domestic policy of "production for production", phosphorus fertilizer will no longer be exempt from value-added tax, but will be taxed at 13%. By January 1, 2008, the Chinese government has exempted value-added tax on phosphorus fertilizer. In 2015, the Chinese government issued the Notice on the Policy of Resuming the Levy of Value-added Tax on Chemical Fertilizers, which changed from VAT exemption to VAT collection. The sales and import of chemical fertilizers will be subject to domestic and import value-added tax at a uniform rate of 13%.

However, the interviewees believed that the levy of VAT had no obvious impact on the long-term cost of the industry, but would have an impact on the local market before and after the starting point of the levy due to the uncertainty of the buffer period and the different adjustment speed of enterprises. Some interviewees believed that the resumption of VAT meant a substantial step forward in the marketization of chemical fertilizer products and helped to eliminate backward production capacity in the industry to a certain extent. Value-added tax generally results in a cost increase of 1% to 3.5% for phosphorus fertilizer products.

Based on the result of objective 1, the research can get a conclusion as follow. By listing a list of policy documents issued by a large number of Chinese governments and analyzing sufficient literature, it is concluded that there are main eight phosphorus fertilizer industry policies in China since 1950 to the present. These eight industrial policies have profoundly affected the development of Chinese phosphorus fertilizer industry in terms of phosphorus raw materials, freight, prices, environmental protection costs, demand, application volume and foreign trade phosphorus industrial policy in China has experienced three historical periods: “supporting period, planning management period and adjustment period” .At present, phosphate fertilizer industry policy is in the third stage of historical adjustment, facing the contradiction of overcapacity in the phosphate fertilizer industry. The subsidy policies previously adopted by the government for a long time have been largely abolished. Since the Chinese government put forward the Action Plan for Zero Growth of Fertilizer Use by 2020 in September 2017, the policy has indeed reduced the consumption of phosphate fertilizer, and the application of phosphate fertilizer in China has decreased year by year. The policies that had a significant impact on the phosphate fertilizer industry in the past ten years mainly include export policy, value-added tax policy and phosphate rock resource tax policy.

Objective 2 To simulate the appropriate capacity allocation policy model for phosphorus fertilizer industry in China

CGE model is a policy analysis and policy evaluation model based on economic theory This research uses the CGE policy simulation model that has been constructed and assumed to be a good theoretical structure, based on literature review, policy list, interview, real economic data to analyze phosphorus fertilizer industrial policy in China, which is incorporated into the appropriate modules of the model, and the major industrial policies that may have an impact are designed as exogenous variables .Finally this research will design the CGE model for phosphorus fertilizer industry in China, which may affect The development phosphorus fertilizer industry, especially the rational allocation of phosphorus fertilizer capacity in China. Through the policy simulation of the model, the main policy framework for phosphorus fertilizer industrial capacity management policy capacity management in China will be finally obtained. This is a deductive research approach.

CGE Models for phosphorus fertilizer industrial policy in China

2.1 Modeling principle of CGE (computable general equilibrium) model

2.1.1 Logistics and capital flows in economic operations

The operation of the social economy can be summarized as commodity transactions and capital flows between different economic entities.

Enterprises invest in raw materials (from the market), capital and labor, then produce goods into the market for sale. Some of these products are purchased by other enterprises s as raw materials, and some are consumed as consumer goods by government departments, household, or partially exported to foreign countries. Commodities that are not sold remain in various sectors in the form of inventory. Therefore, domestic commodity markets include both domestically produced and imported goods, which constitute a composite commodity in the commodity market. The government collects various taxes and fees from businesses, residents, and imported goods and uses them for various financial expenses. Consumers(household) receive income and remuneration from labor income, capital gains, etc. They use their part of revenue as consumption expenditure, and the rest as household savings. Labor, capital, etc. are put into the market as production factors, forming a factors market.

The entire social economy can be summarized as the unity of capital flow and real logistics shown as Figure 19. It describes the cycle of logistics and capital flows in a real economical society. The so-called general equilibrium state is devoted to maximize consumer utility and maximize corporate profits meanwhile. In the general equilibrium state, If the entire economy has N markets, M production factors, all commodities and factors are required to be cleared in the market (Zhang Xin, 2010).

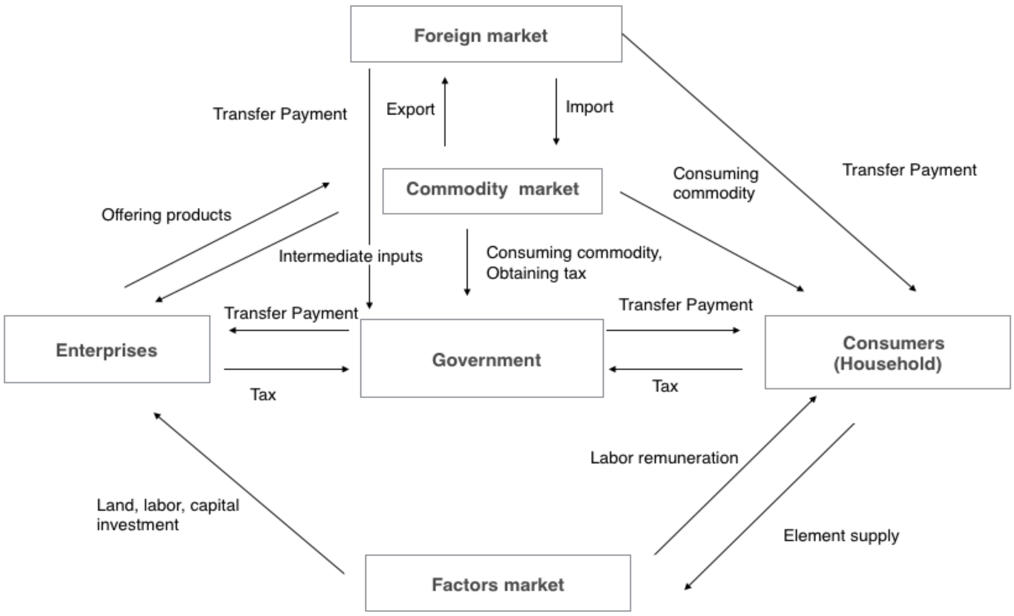

Figure 17 Logistics and capital flow cycle in economical society

2.1.2 Basic modeling principles of CGE model

The CGE model, also known as the Applied General Equilibrium Model, is used to describe the interlinkages between national economic sectors. This model can describe, simulate, and predict the relationships and interactions between policies and economic activities. The CGE model is built on the foundation of a class of economic mathematical models based on the complex causal relationship of the economic system. It devotes to find equilibrium prices in all markets that make up the economic system, under certain resource constraints and codes of conducts following Walras's law. The CGE model specifically uses the supply and demand equations in the various markets that form the economic system, which together describe the interdependence of economic systems.

The variables in the model are divided into exogenous and endogenous variables. Endogenous variables refer to the variables to be determined by the model. Exogenous variables are known variables determined by factors other than the model, which are external conditions on which the model is based. Endogenous variables can be described in the model system, and exogenous variables themselves cannot be described in the model system. Parameters are usually determined by factors outside the model and are therefore often seen as exogenous variables.

Exogenous variables are generally variables used to simulate policy shocks. Endogenous variables are those that can be automatically changed and equalized after changes in exogenous variables through the intrinsic relationship of the equations. The model makes the economic system reach a new equilibrium state from the original equilibrium state through the impact of exogenous variables.

The basic principle of the model has two steps as shown in Figure 20.

Step 1: Model calibration

Applying the equation system, based on the actual exogenous variable values and parameter values of the known base year, each endogenous variable is solved. The value of the endogenous variable solved must be consistent with the actual value to indicate that the solution is successful.

Step 2: Simulation calculation

According to the research needs to change the exogenous variables and parameter values of the model, and solve. By comparing the simulation results with the basic solutions, the policy impact effect can be obtained.

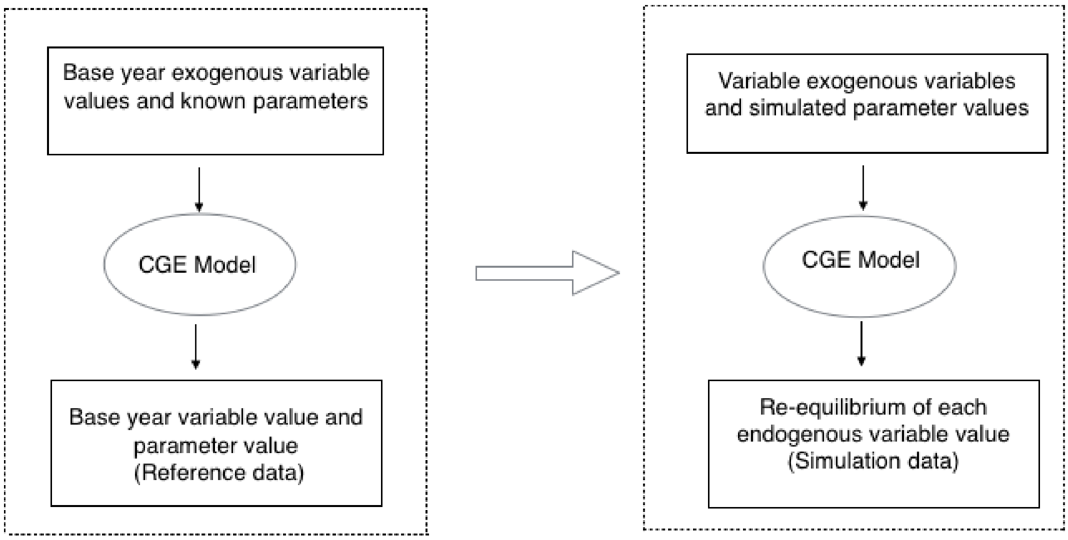

Figure 18 Modeling principle of CGE model

2.2 Construction of CGE model for phosphorus fertilizer industry in China

This model is centered on the LHR model (the standard CGE model developed by the International Food Policy Institute, Lofgren, Hariss and Robinson 2002) and consists of four components including the production market, the commodity market, the economic entity, and the macro equilibrium.

Based on the characteristics of developing countries in China, this research constructs a CGE model for China's phosphorus fertilizer industry policy analysis based on the standard CGE-LHR (Lofgren, Hariss and Robinson) model. The CGE-LHR model belongs to the neoclassical traditional model. It is a static CGE model in a single country. The producers and consumers pursue the maximization of production profit and the maximization of consumption utility, while promoting the balance of supply and demand of the entire economic system. The consumption equation is derived from nonlinear first-order optimization conditions.

The main features of the CGE-LHR model are: allowing flexible division of departments, elements, etc., which can be applied to different levels of research in rural areas, towns, and countries; models, data separation, and different base period data can be easily applied in models; The SAM table distinguishes activities and commodities, allows one production activity to produce multiple commodities; allows domestic and foreign trade and generates transaction costs; the model considers the self-sufficient economy of some commodities in developing country residents; and can flexibly choose the model's macro .The closing rule and the way the element market is closed.

2.2.1 Description of social and economic relations and market composition of phosphorus fertilizer industry

The CGE model for phosphorus fertilizer industry should focus on the relationship between the phosphorus fertilizer industry, the consumer market, land and labor factors inputs, and government policies. The economic closed relationship is shown in Figure 21.

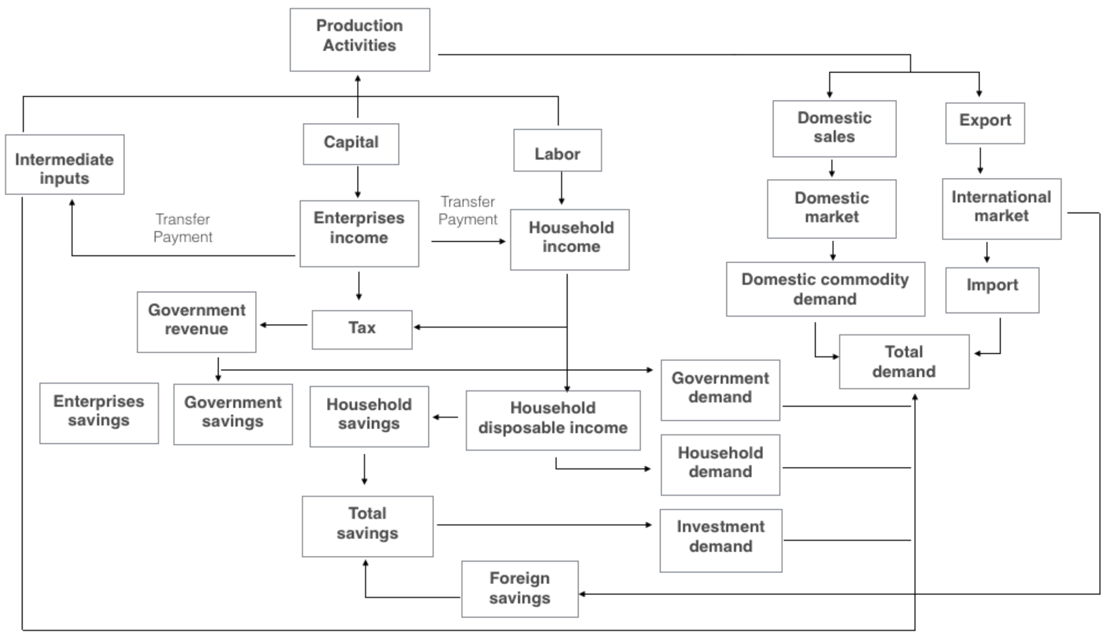

Figure 19 Economic closure of CGE model for phosphorus fertilizer industry

The model used in this research is based on the standard CGE model developed by Lofgren, Hariss and Robinson (2002) (hereafter referred to as the LHR model). The LHR model is a neoclassical traditional model and belongs to a single country static model. Its basic principle is to maximize the producer's production profit and optimize the consumer's utility, so that the entire economic system reaches equilibrium. Differentiating activities and commodities in the SAM table allows a production activity to produce multiple commodities. However, the assumption that a department produces only one commodity is used in this model (Zhang Xin, 2010); the macro closure rules of the model and the closure of the factor market need to be selected according to the macroeconomic realities of the target country.

This research aims to control and influence the phosphorus fertilizer industry from phosphorus mining to production process through policy shocks, to research the impact of industrial policy under different scenarios on macroeconomics, household consumption, and agricultural product prices. The basic structure of the CGE model of this research is shown in Figure 22.

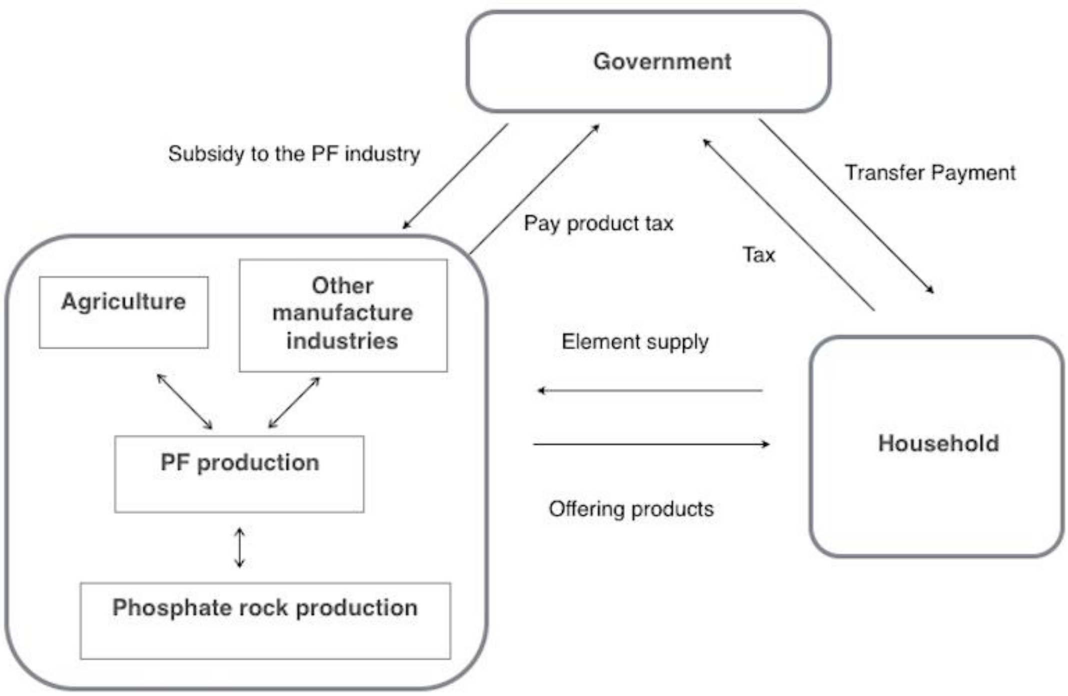

Figure 20 Structure of CGE model for phosphorus fertilizer industry

2.2.1 The assumptions of the CGE model for phosphorus fertilizer industry in China

The construction of the model is based on a series of assumptions. The assumptions for the CGE model constructed in this research are as follows.

1) Assuming that the Chinese economy is based on a perfectly competitive market, producers are recipients of market prices. Producers also use technology with the same scale and return. The product price is the unit production cost of the product. The optimal result of the production activity is zero production profit.

2) The factors of production in the economic system are limited. Labor is homogenous: the labor skills of the same kind of residents are the same, the unit labor gets the same income, the labor is owned by the resident department, and it can flow freely between industries and does not flow between countries. Capital is homogenous: producers only decide the amount of use based on the rent rate of capital, and do not distinguish the source of capital. Capital is owned by households, businesses and foreign sectors and can flow between industries and countries.

3) Assume that the economic operation conforms to the Walras theorem.

4) One production industry produces only one product.

5) Currency is neutral. In the model, relative prices affect the decision-making of economic operations.

6) The market demand function represents a summary of all consumer demand functions, with continuous, non-negative, and a function of price.

2.2.2 Modules in the CGE model for phosphorus fertilizer industry in China

The equations of this model are used to describe the relationship between different economic entities and prices. All the equations of the model are divided into four modules: price module, production trade module, economic entity module, macro closure module.

The meanings of the variables in the CGE model for phosphorus fertilizer industry in China are shown as Table 10 and Table.11.

Table 10 Endogenous Variables and meanings in the CGE model

Variables	Meaning	Variables	Meaning
PA(a)	Production activity price	QA(a)	Quantity of production activities
PVA(a)	Value-added part price	QVA(a)	Quantity of Value-added part
PINTA(a)	Intermediate input total price	QINTA(a)	Quantity of Intermediate input
WL	Labor price	QLD(a)	Labor demand
WK	Capital price	QKD(a)	Capital demand
PX(c)	Production activity outcome commodity price	QX(c)	Quantity of production activity outcome commodity
PD(c)	Domestic production of domestically used commodity prices	QD(c)	Quantity of domestic production of domestically used commodity
PE(c)	Domestically produced commodity export price	QE(c)	Quantity of domestically produced commodity export
PQ(c)	Domestic market price of composite commodity	QQ(c)	Domestic market quantity of composite commodity
PM(c)	Price of imported commodity	QM(c)	Quantity of imported commodity
YH(h)	Household income	QH(c,h)	Quantity of commodity consumed by residents
ENTSAV	Enterprise savings	QINT(c,a)	The demand quantity of production department for commodity c
YG	Government revenue	EINV	Total investment
GSAV	Government savings	EG	Government expenditure
PGDP	GNP price index	FSAV	Foreign savings
GDP	Actual gross national product	YENT	Enterprise income
QINV(c)	Investment in the final demand for commodity	WALRAS	Virtual variable

Table 11 Exogenous variables meanings in the CGE model

Variables	Meaning	Variables	Meaning
QG(c)	Quantity of government consumption commodity	EXR	Exchange rate
QLSAGG	Total labor supply	QKSAGG	Total capital supply
$transfr_{h,g}$ (h)	Government transfer of income to the household	$transfr_{h,row}$(h)	Foreign transfer of household
transfrrow	Foreign transfer payments to enterprises	$transfr_{g,row}$	Foreign transfer payments to the government
$transfr_{h,ent}$ (h)	Enterprises-to-resident transfer	$transfr_{ent,g}$	Government-to-enterprises transfer income
$transfr_{row, f}$	Transfer of factor income to foreign countries	$transfr_{row, g}$	Government transfer payments to foreign countries
pwe(c)	Price of export commodity	pwm(c)	Price of imported commodity

2.3.1 The price module

The price module assumes that different types of goods in the same place of production and consumption, that is, imports, exports, and domestically produced and domestically consumed goods are not completely replaceable. In the equation consisting of price modules, endogenous price variables are linked to endogenous or exogenous other price and non-price variables. The module includes the following equations:

$$PA_a \cdot QA_a = (PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a) \cdot (1 + ta_a), a \in A$$ Equation 1

Equation 1 represents the income and cost of production activities. The post-tax income of each production activity consists of two parts: the cost and the added value of the intermediate input.

$$PVA_a \cdot QVA_a = WL \cdot QLD_a + WK \cdot QKD_a, a \in A$$ Equation 2

Equation 2 represents the determination of the value of the added value of the production activity is determined by the labor price and the capital price.

$$PINTA_a = \sum_c ica_{ca} \cdot PQ_c, c \in C$$ Equation 3

Equation 3 is the calculation method of the total total input price. The price is determined by the composite commodity price and the intermediate input share factor.

$$PX_c = \sum_a sax_{ac} \cdot PA_a \qquad a \in A$$ Equation 4

Equation 4 indicates the outcome price of domestic production activities.

$$PM_c = pwm_c \cdot (1 + tm_c) \cdot EXR \qquad c \in CM(\subset C)$$ Equation 5

Equation 5 indicates how the import price of the commodity is determined.

$$PE_c = pwe_c(1 - te_c) \cdot EXR \qquad c \in CE(\subset C)$$ Equation 6

Equation 6 indicates how the price of the export goods is determined.

2.3.2 Production and trade module

The production trade module contains four categories of equations, namely domestic production and use, distribution of domestic outcome levels (including domestic consumption, domestic market and exports), and total domestic market supply (including imports and domestic production and domestic consumer goods). Composite and the definition of trading inputs in the distribution process. The equation for this module is as follows

$$QA_a = \alpha_a^A [\delta_a^A QVA_a^{\rho_a^A} + (1-\delta_a^A) QINTA_a^{\rho_a^A}]^{\frac{1}{\rho_a^A}}, a \in A$$ Equation 7

$$\frac{PVA_a}{PINTA_a} = \frac{\delta_a^A}{1-\delta_a^A} \left(\frac{QINTA_a}{QVA_a}\right)^{1-\rho_a^A}, a \in A$$ Equation 8

The constant alternative elastic production function (CES, Constant Elasticity of Substitution) is used at the top of production (Li Shantong, 2010). Such as equation 7 and equation 8. The reason is that under the condition that the factors market is completely competitive, producers need to choose the optimal input that minimizes production cost under the established production technology.

The second level of nesting of production functions concludes equation 9 and equation 10 as followed.

$$QVA_a = \alpha_a^{va} [\delta_{La}^{va} QLD_a^{\rho_a^{va}} + (1-\delta_{La}^{va}) QKD_a^{\rho_a^{va}}]^{\frac{1}{\rho_a^{va}}}, a \in A$$ Equation 9

Equation 9 represents value-added departments use CES functions.

$$\frac{WL}{WK} = \frac{\delta_{La}^{va}}{1-\delta_{La}^{va}} \left(\frac{QKD_a}{QLD_a}\right)^{1-\rho_a^{va}}, a \in A$$ Equation 10

Equation 10 represents a function that minimizes cost.

$$QINT_{ca} = ica_{ca} \cdot QINTA_a, a \in A, c \in C$$ Equation 11

Equation 11 is used to describe the production function of the intermediate input as the Leontief production function.

$$QX_c = \alpha_c^t [\delta_c^t QD_c^{\rho_c^t} + (1-\delta_c^t) QE_c^{\rho_c^t}]^{\frac{1}{\rho_c^t}}, \rho_c^t > 1, c \in C$$ Equation 12

Equation 12 represents the calculation of the number of manufactured goods for domestic production activities.

$$QA_a = \sum_c sax_{ac} \cdot QX_c$$ Equation 13

Equation 13 shows that the outcome commodities of domestic production activities are divided into two parts: domestic sales and exports, and the CET function is used in the mutual substitution relationship.

$$\frac{PD_c}{PE_c} = \frac{\delta_c^t}{1-\delta_c^t} \left(\frac{QE_c}{QD_c}\right)^{1-\rho_c^t}, c \in C$$

Equation 14'

$$QX_c = QD_c, c \in C$$

Equation 14 represents the first-order optimization condition for domestic sales and exports. This equation applies to the productions which have exported market. Equation 14' can apply to the commodities completely sale in domestic market.

$$QQ_c = \alpha_c^q(\delta_c^q QD_c^{\rho_c^q} + (1-\delta_c^q)QM_c^{\rho_c^q})^{1/\rho_c^q}, c \in C$$ Equation 15

Equation 15 shows that the production price of the active sector is weighted by two prices, domestic sales and exports.

$$QQ_c = \alpha_c^q(\delta_c^q QD_c^{\rho_c^q} + (1-\delta_c^q)QM_c^{\rho_c^q})^{1/\rho_c^q}, c \in C$$

Equation 16

$$QQ_c = QD_c, c \in C, \quad QM_C=0$$

Equation 16 shows that domestic market goods consist of domestically produced goods and imported goods. If there is no import, Equation 16 applies.

$$\frac{PD_c}{PM_c} = \frac{\delta_c^q}{1-\delta_c^q}\left(\frac{QM_c}{QD_c}\right)^{1-\rho_c^q}, c \in C, \quad QM_c > 0$$ Equation 17

Equation 17 represents the first-order optimization conditions for domestic sales and imports.

$$PQ_c = PD_c, c \in C, \quad QM_C=0$$ Equation 17’

Equation 17' represents the first-order optimization condition for domestic sales and imports.

$$PQ_c \cdot QQ_c = PD_c \cdot QD_c + PM_c \cdot QM_c, c \in C$$ Equation 18

Equation 18 indicates that domestically sold goods consist of domestically produced and imported goods.

Figure 23 shows the production input-outcome structure of this model. Figure 24 shows the production structure of this model.

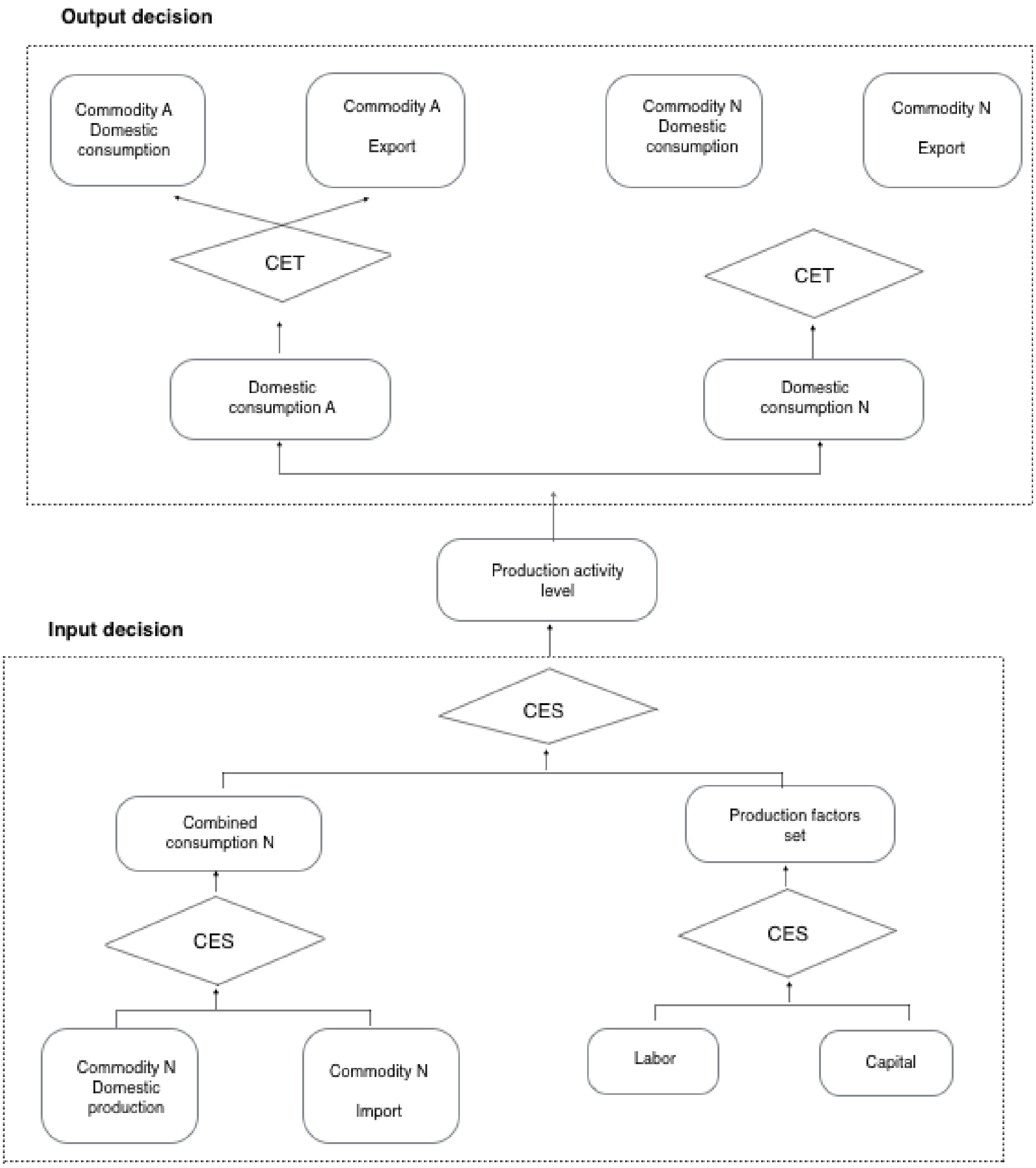

Figure 21 Input and outcome decision for commodities

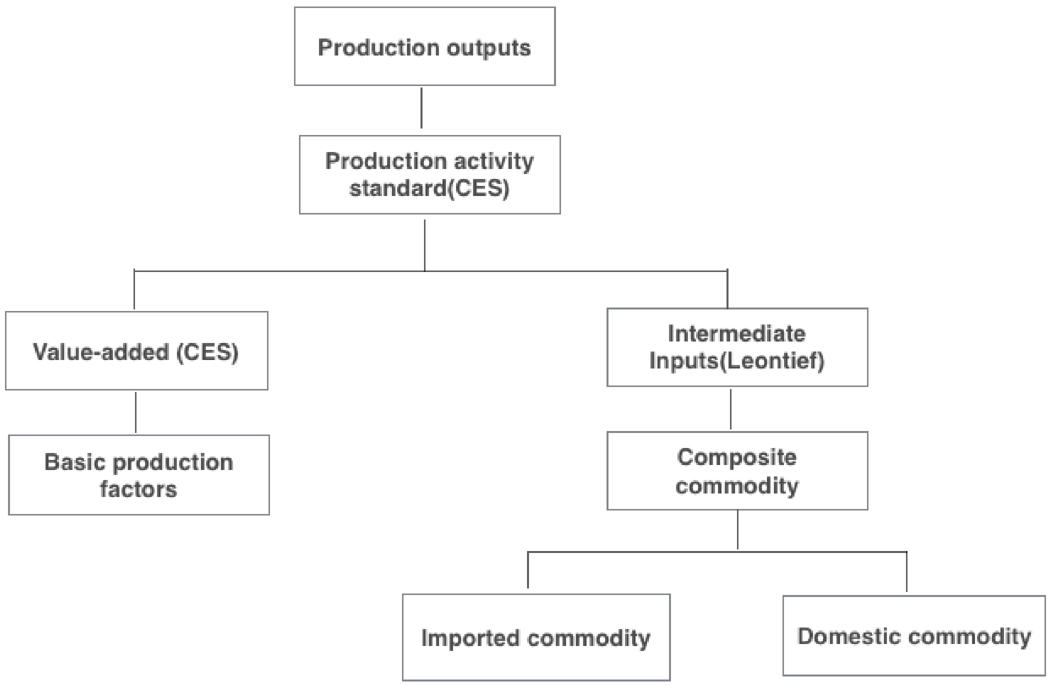

Figure 22 Production structure

2.3.3 The economic entity module

The economic entity module in this CGE model has four economic entities: household, enterprises, government and other regions of the world. The equations in this module mainly describe the income, payment and transfer payment of each entity.

2.3.3.1 For the entity of household

$$YH_h = WL \cdot shif_{hl} \cdot QLSAGG + WK \cdot shif_{hk} \cdot QKSAGG + \overline{transfr_{h,ent}} + \overline{transfr_{h,gov}} + \overline{transfr_{h,row}} \cdot \overline{EXR} \qquad h \in H$$

Equation 19

Equation 19 is the equation for the revenue of household in this model.

$$PQ_c \cdot QH_{ch} = shrh_{ch} \cdot mpc_h \cdot (1 - ti_h) \cdot YH_h, c \in C, h \in H$$ Equation 20

Equation 20 is the equation for the consumption of household in this model, in which the consumption expenditure of the household is consistent with the Cobb-Douglas utility function. The household's consumption structure of this model is shown in the Figure 25.

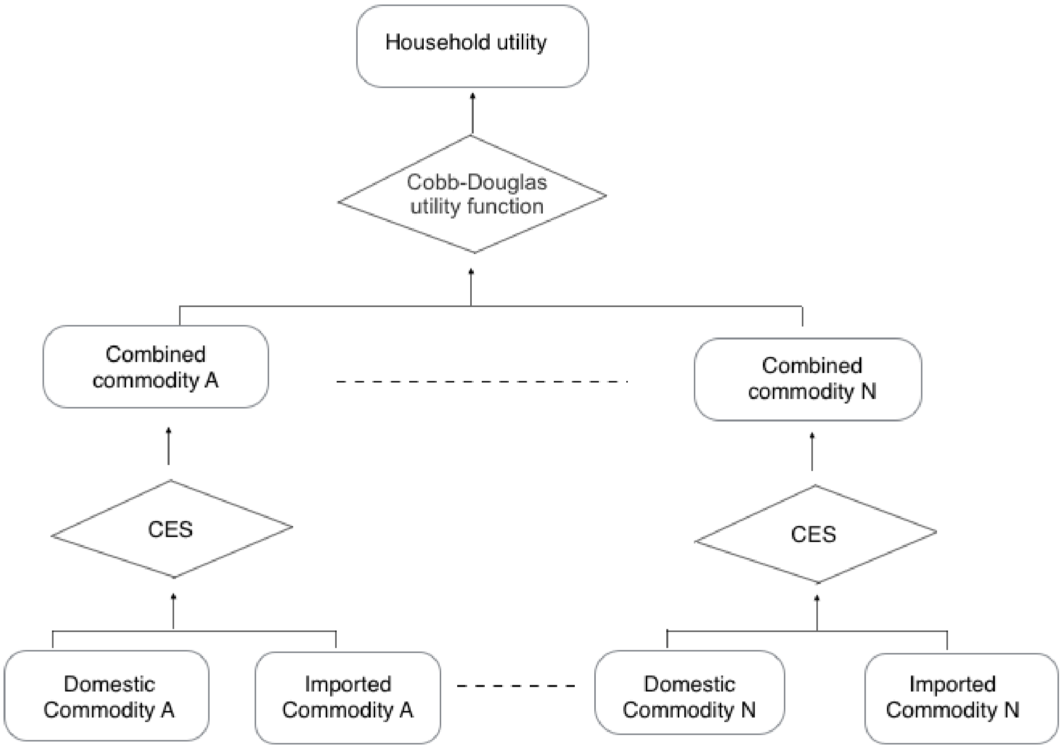

Figure 23 Household's consumption structure

2.3.3.2 For the entity of enterprises

$$YENT = shif_{ent,k} \cdot WK \cdot QKSAGG + transfr_{ent,gov}$$ Equation 21

$$ENTSAV = (1 - ti_{ent})YENT$$ Equation 22

Equation 21 and Equation 22 describe the formation of enterprises' revenue and savings in this model.

$$EINV = \sum_{c} PQ_c \cdot QINV_c, c \in C$$ Equation 23

Equation 23 represents the total investment of each department.

2.3.3.3 For the entity of government

$$YG = \sum_{a} \frac{ta_a}{1+ta_a} \cdot PA_a \cdot QA_a + \sum_{h} ti_h \cdot YH_h + ti_{ent} \cdot YENT + \sum_{c} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c} te_c \cdot pwe_c \cdot QE_c \cdot EXR + \overline{tranfr_{g,row}} \cdot \overline{EXR}$$ Equation 24

Equation 24 represents the government's revenue.

$$EG = \sum_{c} PQ_c \cdot \overline{QG_c} + \sum_{h} \overline{tranfr_{hg}} + \overline{transfr_{ent,g}}$$ Equation 25

Equation 25 represents government's expenditure.

Equation 26

$$GSAV = YG - EG$$

Equation 26 represents the government's savings.

2.3.3.4 For the entity of foreign countries

$$QQ_c = \sum_{a} QINT_{ca} + \sum_{h} QH_{ch} + QINV_c + \overline{QG_c}, c \in C$$ Equation 27

Equation 27 represents the system equilibrium condition, indicating that all domestic supplies equal domestic demand. Take the "small country" assumption.

2.3.4 The constraint module of system

$$\sum_a QLD_a = QLSAGG + WALRAS$$ Equation 28

$$\sum_a QKD_a = QKSAGG$$ Equation 29

Equations 28 and 29 indicate that the factors market is clear。

$$\sum_c pwm_c \cdot QM_c = \sum_a pwe_c \cdot QE_c + \sum_h \overline{tranfr_{h,row}} + \overline{transfr_{ent,row}} + \overline{transfr_{g,row}} + FSAV$$
$$= \sum_a pwe_c \cdot QE_c + \sum_h \overline{tranfr_{h,row}} + \overline{transfr_{g,row}} + FSAV$$ Equation 30

Equation 30 represents the international foreign exchange balance.

$$ENIV = \sum_h (1 - mpc_h) \cdot (1 - tih_h) YH_h + ENTSAV + GSAV + FSAV \cdot EXR$$ Equation 31

$$GDP = \sum_{c \in C} (QH_c + QINV_c + \overline{QG_c} + QE_c - QM_c)$$ Equation 32

Equation 31 represents an investment-savings equilibrium.

Equation 32 represents the calculation of the nominal GDP used to research the need for macroeconomics.

$$PGDP \cdot GDP = \sum_{c \in C} PQ_c \cdot (QH_c + QINV_c + \overline{QG_c}) + \sum_{c \in C} PE_c \cdot QE_c$$
$$- \sum_{c \in C} PM_c \cdot QM_c + \sum_{c \in C} tm_c \cdot pwm_c \cdot EXR \cdot QM_c$$ Equation 33

Equation 33 represents the calculation of the actual GDP used to research the need for macroeconomics.

2.3.5 The macro closure module

$$QLSAGG = \overline{QLSAGG}$$ Equation 34

$$QKSAGG = \overline{QKSAGG}$$ Equation 35

Equations 34 and 35 form a macroscopic closure module.

2.3.6 Price benchmark

$$WL = 1$$ Equation 36

Equation 36 represents the selection of the laborer's price as a price basis.

According to the needs of the research industry fiscal policy, this model adopts neoclassical macro closure. The exchange rate is exogenous.

2.4 Determination of parameters in the model

Various elastic values are used in the CGE model, and these elastic values have a great influence on the simulation results (Arndt et al., 2002). Therefore the determination of the parameters is actually the determination of the key elastic values.

The essential elasticity used in the CGE model for Chinese phosphorus fertilizer industry policy includes production elasticity, demand elasticity, trade elasticity, and elasticity of factor inputs. The production elasticities used in the production equations are: the elasticity of substitution between commodities in the intermediate input, the elasticity of substitution between the total intermediate demand and added value, the elasticity of substitution between labor and capital in the factors, the elasticity of substitution between land capital and non-land capital, and substitution elasticity between marginal land and cultivated land. The demand elasticity mainly involved in the demand function refers to the Arminton substitution elasticity between the domestically produced commodities and the import commodities. The trade elasticity used in the trade functions refers to the elasticity of substitution between domestic sales and domestic sales for domestic produced commodities, called CET elasticity of substitution.

Usually there are three types of elasticities require exogenous settings in the CGE model. There are two methods for setting the elasticity coefficient. One is to use the econometric method to calculate based on historical data. More scholars set the elasticity coefficient based on the results of other researchers. This research also uses the methods of research using other research scholars to give the elasticity needed in the model.

The top-level production function in this model uses the CES elasticity which describes the elasticity of substitution between the intermediate input and the basic production factors input. The elasticity adopt 0.3 Mi Cuicu i(2011) refers to all departments. The substitution elasticity in the CES production function of each department adopts the elastic value of Zhao Yong and Wang Jinfeng (2008).

Table 12 Various types of elasticity in the model

Elasticity type		Comment
Production	Total outcome	Elastic value on the total outcome level of domestic commodities
	Factors replacement	Alternative elasticity between basic input factors in production function
	Production factors and intermediate inputs	Alternative elasticity between basic elements and intermediate inputs in production function
Commercial trade	Armington elasticity	Alternative elasticity between imported and national products in consumer goods
	CET elasticity	Alternative elasticity between domestic exports and internal sales
Consumption	Cobb-Douglas utility function	

2.5 Sensitivity analysis of parameters

Many parameters should be applied in the CGE model. Many parameters in this research can be obtained by model calibration. The other parameters in this research are derived from existing literature results. For this part of the parameters, the choices face many uncertainties. Therefore the sensitivity analysis of parameters is often required, in order to determine the impact of the choice of different parameters on the model results.

There are five types of methods in the CGE model literature currently: unconditional system sensitivity analysis, conditional sensitivity analysis, Harrison-Vinod method, Harrison-Vinod improvement method, and Monte Carlo experiment method. Among these methods, Unconditional system sensitivity analysis, Harrison-Vinod method, Harrison-Vinod improvement method and Monte Carlo experiment method are more complicated. So these three are not widely applied in large CGE models.

This research tries to use the conditional system sensitivity analysis to analyze the parameter by simulation results. If the direction and size of the variables are still consistent, the symbol direction has not changed, the simulation results are credible as a whole higher degree.

So far, the model construction of the phosphorus fertilizer industry policy simulation has been completed. There are 34 sets of endogenous variables and 14 sets of exogenous variables. There are 33 sets of equations in Equations 1 to 33. In addition, 34 and 35 are macro-closed modules, and 36 is a price base designation. In fact, WL is fixedly assigned. In this model, the variable QLSAGG and the variable QKSAGG actually belong to exogenous variables. Thus there are 34 sets of endogenous variables, from Equations 1 to 33, plus Equation 36, for a total of 34 sets of equations. The number of equations is equal to the number of endogenous variables. The virtual variable WALRAS can guarantee that the number of variables is equal to the number of equations, and can also be used to verify the consistency of the model solution.

Data sources

According to the research objective and research methods of this research, the key data will be gathered from secondary data mostly obtained from public information release. Capacity allocation policies need to be formulated and implemented nationwide by the government, and the data of individual companies are not representative. Therefore, the data sources of this research are mainly based on the macroeconomic data of phosphorus fertilizer industry in China.

The macroeconomic data of phosphorus fertilizer industry in China mainly come from the "China Statistical Yearbook", "China Industrial Statistical Yearbook", "China Economic Census Yearbook", "China Energy Statistical Yearbook" , The input-outcome table", "China Financial Yearbook", "China Tax Yearbook". The main data resource comes from National Bureau of Statistics of China.

Data Analysis

1. Build the Data base of CGE Model for phosphorus fertilizer industry : Chinese Social Accounting Matrix

In order to achieve the computability of the general equilibrium model, firstly it is necessary to assign values to the exogenous variables and parameters in the model. This is also a prerequisite for simulation implementation. The Social Accounting Matrix (SAM) can meet the requirements of the CGE model data set. Therefore, the preparation of the SAM table needs to be based on the basic assumptions of the CGE model. Firstly, the supply and demand of commodities are equal. Secondly, all industries have zero profits; thirdly, they meet the requirements of budgetary constraints; Finally, international needs remain balanced. In fact, the SAM has become the most common form of standard data organization for the CGE model (Qu Fan, 1997).

1.1 Principle and Structure of the Social Accounting Matrix

1.1.2 Principles of Social Accounting Matrix

In order to achieve the computability of the general equilibrium model, firstly it is necessary to assign values to the exogenous variables and parameters in the model. This is also a prerequisite for simulation implementation. The Social Accounting Matrix (SAM) can meet the requirements of the CGE model data set. Therefore, the preparation of the SAM table needs to be based on the basic assumptions of the CGE model. Firstly, the supply and demand of commodities are equal. Secondly, all industries have zero profits; thirdly, they meet the requirements of budgetary constraints; Finally, international needs remain balanced. In fact, the SAM has become the most common form of standard data organization for the CGE model (Qu Fan, 1997).

In the beginning, the SAM framework was established and developed in the middle of the last century to link the data of both social and economic aspects (Pyatt, 1985). The first real world-recognized SAM was established by Professor Richard Stone, which was designed to build a British economic model. Professor Stone is also known as "the great architect of SAM." For the definition of SAM, different scholars have different understandings, which can be roughly classified into the following categories: The first one is to use the SAM table as in the form of a matrix, reflecting the supply table ,to reflect he relationship among the system of national accounts (SNA) ,the demanding -supplying tables ,the utility tables and the departmental accounts (UNSO, 1993); the second one is that a complete SAM system, which must encompass all economic systems and also need to be classified (Pyatt et al., 1976). The third one is that SAM is a tabular sample of economic identity (Taylor, 1983); The fourth one is proposed by Round, which considers SAM as a single-entry accounting system, whose rows accounts record expenditures, and corresponding columns accounts records revenue to represent a macro account in the matrix. In addition, some scholars use SAM as a data set that includes social and economic data (Chowdhury et al., 2017). This research uses the definition of Round.

The most important function of SAM is for policy analysis (Lange, 2004). Pyatt and Thorbecked et al. (1976) continued Stone’s research and the SAM table was widely used in research on poverty issues and income distribution issues. The Development Research Center of the State Council and the National Bureau of Statistics were committed to compile SAM tables of China since 1980s. (Li Shan et al., 1996).

Compilation of the SAM is closely linked to input-outcome analysis and is an extension of its application (Chowdhury et al., 2017). This research uses a SAM table in a checkerboard format. This type of SAM table has the same number of rows and columns, and the rows and columns correspond one-to-one. The row and column are cross-recorded once. The credit of the account (column accounts) records the revenue, and the debit (raw accounts) records the expenditure. Each piece of data in the table has a double meaning: Any data represents both the credit of the row and the debit of the column. The SAM table follows the accounting rules of “accounting with loans and borrowing must be equal”. The sum of added up row accounts in the SAM table equals to the sum of added up column accounts.

$$y_i = \sum_{j=1}^{n} t_{ij} = \sum_{j=1}^{n} t_{ji}, i = 1,2 \dots \dots n$$

Where yi is the total revenue or total expenditure of account i, and n is the dimension of the square matrix, that is, the number of accounts of SAM.

Meanwhile, the compilation of the SAM table reflects the economic balance relationships: Total investment in production activities should be equal to the total outcome of production activities; Total institutional income should be equal to total expenditure; And total supply should be equal to total demand (Robinson et al., 1990).

The SAM table also describes the socio-economic linkages in the CGE model. So the SAM describes the entire relationship between production activities, factor markets, enterprises, households, governments, and other parts of the world in the economic system. In addition, savings-investment accounts Contact with the commodity market has formed a closure together. The complex relationship can be represented by the following Figure 26. (Lofgren et al., 2001).

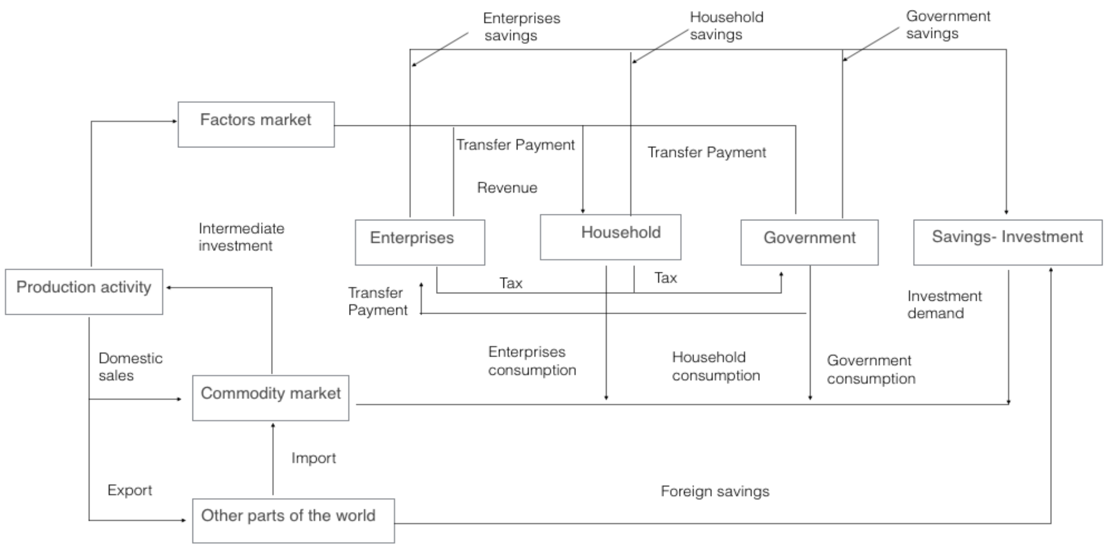

Figure 24 Major socio-economic links in SAM

1.1.2 Structure of Social Accounting Matrix

According to the classification method of Seung et al. (1998), accounts in SAM can be divided into production factor accounts, institutional department accounts, production activity accounts, commodity accounts, trade accounts and capitals accounts, according to the nature of the accounts and the role played in the system. As shown in the Table.11, among them, the production activity account and the commodity account comprise different industries or industry parts, and the production factor accounts include labor and capital. Capital can be further subdivided into land accounts based on research needs. There are three main types of accounts in institutional accounts: enterprises, household, and government; commodity accounts correspond to production accounts; trade refers to the rest of the world, and is generally represented by ROW. The savings-investment account reflects the accumulation and use of capital.

Since China's input-outcome table is updated every five years, an updated extension table will be prepared in the middle year. As of now, the input-outcome extension table 2017 has been released. The macro SAM provides a total control reference for the microscopic SAM of the segment (Thorbeeke, 2003). The accounts in table 1 are properly classified depending on the this research, and finally a macro SAM with an open economy covering 9 categories of accounts is generated.

The specific access methods of the data are listed as followed. In the process to compile the SAM, most of the data can be obtained by some public data resource, but some data can only be determined by the scientific method of approximated estimation and margin calculated. Finally the data resources of Chinese macro SAM in 2017 are shown in the Table 13.

Table 13 Standard SAM framework for CGE models

	1 Activity	2 Commodity	3 Factors	4 household	5 Enterprises	6 Government	7 Saving-investment	8 ROW	9 Total
1 Acticity		Total outcome of the market		Self-produced by household					Total outcome
2 Commodity	Intermediate Input	Transaction cost		Household consumption		Government consumption	Total investment	Export	Total demand
3 Factor	Added value							Factors' foreign revenue	Total factors' revenue
4 Household			Household revenue			Government transfer to household		Foreign transfer to household	Total household revenue
5 Enterprises			Factors' revenue			Government transfer to enterprise		Foreign transfer to enterprises	Total enterprises revenue
6 Government	Production tax, Added value tax	Sales tax, Tarrif, Export tax	Factors tax	Direct tax	Enterprises tax			Foreign transfer to government	Total government revenue
7 Saving-investment				Household saving	Enterprises saving	Government savings		Foreign savings	Total savings
8 ROW		Import	Foreign factors' revenue		Transfer to foreign countries	Transfer to foreign countries			Total foreign expenditure
9 Total	Total Input	Total supplement	Total labor expenditure	Total household expenditure	Total enterprises expenditure	Total government expenditure	Total Investment	Total foreign revenue	

2. Compilation of the Chinese Macro SAM in 2017

Table 14 Data resources of Chinese macro SAM in 2017

Row account	Column account	Data resource
Activity	Total outcome	Input-outcome extension table 2017
Commodity	Intermediate investment	Input-outcome extension table 2017
	Household consumption	Input-outcome extension table 2017
	Government consumption	Input-outcome extension table 2017
	Investment	Input-outcome extension table 2017
	Export	Input-outcome extension table 2017
Labor	Laborer's remuneration	Money Flow Statement table 2017
Capital	Capital gains	Input-outcome extension table 2017
Household	Household labor income	Input-outcome extension table 2017
	Transfer payment from enterprises to household	Balance item
	Transfer payment from government to household	China Financial Yearbook 2018
	Foreign income of household	Balance of payments 2017
Enterprises	Investment income	The sum of capital gains and foreign net transfers to enterprises
	Transfer payment from government to enterprises	Balance item

Table 14 (Cont.)

Row account	Column account	Data resource
Government	Net production tax	Input-outcome extension table 2017
	Import tariffs	China Financial Yearbook 2018
	Direct tax	Money Flow Statement table 2017
	Enterprises tax	China Financial Yearbook 2018
	Foreign transfer to the government	Balance of payments 2017
Capital account	Household savings	Money Flow Statement table 2017
	Enterprises savings	Money Flow Statement table 2017
	Government savings	Money Flow Statement table 2017
Foreign	Net capital inflows abroad	Money Flow Statement table 2017
	Import	Input-outcome extension table 2017
	Foreign capital investment earnings	Balance of payments 2017
	Government payment to foreign countries	China Financial Yearbook 2018

2.1 Activity Account

The active account mainly accounts for the total input and total outcome of the enterprises' production activities. The line of active accounts reflects the total outcome of domestic firms, where the total outcome is derived from the total domestic outcome of the commodity account. The column of the activity account reflects the total investment of domestic enterprises, including factor inputs, intermediate inputs and net production taxes.

Table 15 Activity account of Chinese Macro SAM in 2017

Total input			Total output	
Intermediate investment		1434518	**Total outcome**	2257734
	Laborer's remaineration	423268		
	Capital gains	304969.1		
Net production tax		94978.6		
Total		**2257733.7**	**257734**	

2.2 Commodity account

Commodity accounts are used to reflect the total supply and total demand for commodities for the domestic market. The revenue item of the commodity account comes from the intermediate input, final consumption, export and capital formation. The expenditure items include the total outcome of domestic commodities, import commodities and tariff.

Table 16 Commodity account of Chinese Macro SAM in 2017

Domestic market total supply		Domestic market demand		
Total domestic outcome	2257734	Intermediate investment		1434518
Import	14385.42	Final consumption	456518	
Tariff	149268.4		Household consumption	320426.7
			government consumption	123750.3
		Export		163846.8
		Capital formation		357886
			Fixed capital formation	348300
			Net increase in inventory	5309.13
Total	**2421387.82**			**2341919.3803**

2.3 Factors (Labor) account

The labor account in the factor account is used to reflect the input and the distribution of the labor factors. The row of labor accounts represents revenue from labor remuneration generated by factor inputs. The column of labor accounts represent the distribution of element revenue. This is a relatively simple account. According to the principle of double-entry bookkeeping, the laborer's remuneration is equal to the household's labor remuneration. The data comes directly from the summary of labor remuneration in the China Input-Outcome Table (2017), which in fact is two aspects of the same problem reflected.

Table 17 Factors (Labor) account Account of Chinese Macro SAM in 2017

Expenditure				Revenue	
Distribution of capital gains	423268			**Capital gains**	423268
		Capital gains of the household	118993.4		
		Capital gains of the enterprise	220487.2		
		Investment gains of foreign investors	1467.6		
Total	**423268**		**340948.2**		**423268**

2.4 Factors (Capital) account

This account mainly accounts for the revenue and distribution of capital factors. The row of the account is used to reflect the revenue of the capital factors, which is exactly equal to the "capital gains" account of the activity account. The column of the account is used to reflect the distribution of capital factors revenue, including the profit distribution of household and enterprises, and investment gains of foreign investors.

Table 18 Factors (Capital) account of Chinese Macro SAM in 2017

Expenditure		Revenue	
Household's labor income	304969.1	Laborer's remuneration	304969.1
Total	**304969.1**	**304969.1**	

2.5 Household account

Household account is used to reflect the revenue and expenditure of household. Household's revenue comes from labor remuneration, transfer payments from enterprises and government, and gains from abroad. Household's expenditure items mainly include household's consumption, personal income tax and household savings.

Table 19 Household Account of Chinese Macro SAM in 2017

Expenditure		Revenue	
Household's consumption	320426.7	Laborer's remuneration	423268
Personal income tax	11966.37	Household's capital gains	30627.82
Household's savings	180564.1	Transfer payment from enterprises to household	33436.12
		Transfer payment from government to household	24611.68
		Foreign gains of household	1013.51
Total	**512957.17**	**512957.13**	

2.6 Enterprises Account

Enterprises account reflects the Enterprises' revenue and expenditure. Revenue includes revenue after the distribution of factors, specifically capital gains and government transfers to enterprises. Expenditure mainly includes direct taxes paid to the government, transfer payments to household, and ultimately formed enterprises savings.

Table 20 Enterprises Account of Chinese Macro SAM in 2017

Expenditure		Revenue	
Transfer payment from enterprises to household	33436.12	Capital gains of the enterprise	304969.1
Direct taxes paid to the government	32117.29	Transfer payment from government to enterprises	17501.1
Enterprises savings	173636.6		
Total	**239190.01**	**322470.2**	

2.7 Government Account

This account mainly accounts for government revenue and expenditure. Revenue includes tariffs, various production taxes, personal income taxes, enterprises direct taxes, and government's foreign transfer revenue. Expenditure includes transfer payment from government to household and enterprises, government consumption, government payment to foreign countries, and ultimately formed government savings. Government savings is the balance of the account.

Table 21 Government Account of Chinese Macro SAM in 2017

Expenditure		Revenue	
Transfer payment from government to household	24611.68	Tariff	14385.42
Transfer payment from government to enterprises	17501.1	Various production taxes	94978.6
Government savings	123750.3	Personal Income Tax	11966.37
Government payment to foreign countries	9279.2	Enterprises direct tax	32117.29
Government savings	27943.2	Government's foreign transfer revenue	11347.6
Total	**203085.48**	**142100.08**	

2.8 Foreign account

This account reflects the external economic relationship of China. The revenue items of the account include import, foreign capital investment gains, government payment to foreign countries or interest of the debts abroad. Expenditure items include exports, foreign revenue of household, government’s foreign transfer gains, and foreign net savings. Foreign net savings is a balance item.

Table 22 Foreign Account of Chinese Macro SAM in 2017

Expenditure		Revenue	
Export	163846.8	Import	149268.4
Foreign revenue of household	1013.51	Foreign capital investment gains	337005.7
Government's foreign transfer gains	-11347.6	Government payment to foreign countries	9279.2
Foreign net savings	-13120.1		
Total	**140392.61**	**495553.3**	

2.9 Savings - Investment Account

The savings-investment account accounts for total investment and total savings. The total savings reflects the balance of payments for each account, which are already described in the previous accounts. This account is naturally balanced after the previous account balanced.

Table 23 Savings - Investment Account of Chinese Macro SAM in 2017

Expenditure		Revenue	
Fixed capital	359151.1	Household savings	180564.1
Stock	30492.72	Government savings	27943.2
		Enterprises savings	173636.6
		Net capital inflows abroad	-13120.1
Total	**389643.82**	**369023.8**	

According to the above steps, the final Chinese Macro SAM in 2017 was compiled as shown in Table 24.

Table 24 Chinese Macro SAM in 2017

	1 Activity	2 Commodity	3 Labor	4 Capital	5 Household	6 Enterprises	7 Government	8 Saving-investment	9 Row	10 Total
1 Acticity		1434518	423268	304969.1			94978.6			2257733.7
2 Commodity	2257734						14385.42		149268.4	2421387.82
3 Labor					423268					423268
4 Capital					30627.82	304969.1			337005.5	672602.62
5 Household		320426.7					11966.37	180564.1		512957.17
6 Enterprises					33436.12		32117.29	173636.6		239190.01
7 Government		123750.3			24611.68	17501.1		27943.2	9279.2	203085.48
8 Saving-investment		359151.1					30492.72			394952.95
9 Rows		163846.8			1013.51		-11347.6	-13120.1		140392.61
10 Total	2257734	2401692.9	423268	304969.1	512957.13	322470.2	172592.8	369023.8	495553.3	

The nine accounts in macro SAM are properly classified depending on the this study, and finally a Chinese macro SAM with an open economy covering 9 categories of accounts is generated. The macro SAM table constructs a comprehensive and consistent framework for Chinese social macroeconomic system in 2017 by scientific data. This study collects all the data from public data resources, including China input-outcome table in 2017, China Statistical Yearbook, China Industrial Statistical Yearbook, China Financial Yearbook and China Tax Yearbook. The main data resource comes from National Bureau of Statistics of China. Finally, China macro SAM table constructs a comprehensive and consistent framework for Chinese social macroeconomic system and a database for the CGE model.

3. Compilation of subdivision micro Social Accounting Matrix

The macro SAM table constructs a comprehensive and consistent framework for Chinese social macroeconomic system. But for the needs of industry policy analysis, more detailed data is needed. So this research needs a subdivision SAM based on the Chinese macro SAM 2017. In order to be consistent with the division of the 2017 input-outcome table, and taking the possibility of actually data collection into account, if the division is too detailed, data collection cannot be achieved.

The refined SAM is mainly subdivided into production departments, institutions, production factors, and taxes. Firstly, according to the functional department of phosphorus fertilizer, the agriculture, forestry, animal husbandry and fishery in the input-outcome table should be divided into agriculture, forestry, animal husbandry, fishery, agriculture, forestry, animal husbandry and fishery services according to the national economic industry classification criteria. This corresponds to the 2017 input-outcome table (section 41) of the agriculture, forestry, animal husbandry and fishery subdivided into six departments. In addition, the phosphorus fertilizer industry was separated from the chemical products (No. 12) in the input-outcome table. Specifically, the "2622 phosphorus fertilizer manufacturing", which is the terminal production department of phosphorus fertilizer, is separated from the "26 chemical raw materials and chemical products manufacturing industry" in the national economic industry classification (2015). The remaining departments in the "26 Chemical Materials and Chemicals Manufacturing Industry" are listed as "Other Chemical Materials and Chemicals Manufacturing". The raw material phosphorus rock of phosphorus fertilizer was separated from the "1020 non-metallic mining and mining industry" department from "1020 chemical mining" and became the "phosphorus ore mining industry", as a new additional department of input-outcome table. The other "10 non-metallic mining and mining industry" departments will be regarded as the "other non-metallic mining and mining industry" department.

After splitting and merging, the 21 departments Chinese micro SAM table of this research was formed as is shown in Table 22. The key phosphorus rock production costs of this research are based on the input-outcome table, the phosphorus fertilizer industry statistics table, and the balance data from the GTAP database.

Table 25 The subdivision department in the micro SAM and the departments in the corresponding Input-output table (Abbreviated as IO table)

Serial number	Subdivision in the micro SAM	Correspondence with IO of 41 departments
A01	Agriculture	Agriculture, forestry, animal husbandry, fishery and service
A02	Forestry, animal husbandry, fishery and service	Agriculture, forestry, animal husbandry, fishery and service
A03	Coal mining products	Coal mining products
A04	Oil and gas extraction products	Oil and gas extraction products
A05	Metal mining products	Metal mining products
A06	Phosphor rock mining products	Non-metallic minerals and other mining products
A07	The other non-metallic minerals and other mining products	Non-metallic minerals and other mining products
A08	Food and tobacco	Food and tobacco
A09	phosphorus fertilizer	Phosphorus fertilizer
A10	The other chemical raw materials and chemical manufacturing	Chemical raw materials and chemical manufacturing
A11	The other manufacturing	From exile to research industry to crafts and all other manufacturing, including scrap
A12	Electricity and heat production and supply	Electricity and heat production and supply
A13	Gas production and supply industry	Gas production and supply industry

Table 25 (Cont.)

Serial number	Subdivision in the micro SAM	Correspondence with IO of 41 departments
A14	Water production and supply industry	Water production and supply industry
A15	Building industry	Building industry
A16	Transportation and postal industry	Transportation and postal industry
A17	Financial industry	Financial industry
A18	Real estate	Real estate
A19	Education	Education
A20	Health, social security and social welfare	Health and social work, Culture, sports and entertainment, Public administration, social security and social organization
A21	Service industry	Information transmission, computer services and software industry; wholesale and retail trade; accommodation and catering; leasing and business services; research and experimental development; integrated technical services; water conservancy, environment and public facilities management; Service industry; culture, sports and entertainment; public management and social organization a total of 10 departments.

Table 26 CES factors production elasticity in various departments

Serial number	Departments in the CGE model	Alternative elasticity (σ)
A1	Agriculture	0.427
A2	Forestry, animal husbandry, fishery and service	0.427
A3	Coal mining products	2.182
A4	Oil and gas extraction products	2.182
A5	Metal mining products	2.182
A6	Phosphor rock mining products	2.182
A7	The other non-metallic minerals and other mining products	2.182
A8	Food and tobacco	0.435
A9	Phosphorus fertilizer	0.435
A10	The other chemical raw materials and chemical manufacturing	0.435
A11	The other manufacturing	0.435
A12	Electricity and heat production and supply	2.541
A13	Gas production and supply industry	2.541
A14	Water production and supply industry	2.541
A15	Building industry	0.262
A16	Transportation and postal industry	0.727
A17	Financial industry	0.727
A18	Real estate	0.727
A19	Education	0.727
A20	Health, social security and social welfare	0.727
A21	Service industry	0.727

Table 27 Armington elasticity and CET elasticity

Serial number	Department in the CGE model	Armington elasticity	CET elasticity
C01	Agriculture	3	3.6
C02	Forestry, animal husbandry, fishery and service	1.805	3.4
C03	Coal mining products	3.7	3.6
C04	Oil and gas extraction products	3.7	3.6
C05	Metal mining products	3.7	4.6
C06	Phosphor rock mining products	3.7	4.6
C07	The other non-metallic minerals and other mining products	3.7	4.6
C08	Food and tobacco	3.8	4.6
C09	Phosphorus fertilizer	3.8	4.6
C10	The other chemical raw materials and chemical manufacturing	3.8	4.6
C11	The other manufacturing	3.8	4.6
C12	Electricity and heat production and supply	4.4	4.6
C13	Gas production and supply industry	4.4	4.6
C14	Water production and supply industry	4.4	4.6
C15	Building industry	1.9	3.8
C16	Transportation and postal industry	1.9	2.8
C17	Financial industry	1.9	2.8
C18	Real estate	1.9	2.8
C19	Education	1.9	2.8
C20	Health, social security and social welfare	1.9	2.8
C21	Service industry	1.9	2.8

4. Balance of Social Accounting Matrix

In the process of compiling social accounting, there are some problems about diversification of data sources, Especially when the macro SAM is decomposed into micro-SAM tables according to the research needs. The methods of proportional decomposition, estimation, calculation, etc. will be used in this process. It is inevitable that each statistical data will have a statistically inconsistent situation, which will make the sum of the corresponding rows and columns of the original micro-SAM not equal, and it is necessary to properly use a certain method to balance the SAM.

Among the techniques for balancing SAM, the classic and most commonly used are the RAS method and the CE method. The RAS method applies to the case of known row and column sums, and some element values need to be fixed in the SAM compilation process in this research, which is suitable for the CE method.

The Chines micro-Social Accounting Matrix in 2017 including 21 departments then can be balanced by CE method.

Statistical Tool

As the scale of the CGE model increases, the description of the model object becomes more detailed, and the implementation of the CGE model calculation problem has higher requirements. There are more new computational theories and procedures systems to solve problems by CGE model science 1980, after the efforts of a large number of economists and mathematicians , coupled with the rapid development of computer information technology, such as the general equilibrium mathematical programming system (MPSGE), Rutherford (1987), the General Mathematical Modeling System (GAMS), and the General Equilibrium Modeling Toolkit (GEMPACK).These systems make it possible to build large-scale or ultra-large-scale CGE models. GAMS is the most commonly widely used in practice among them. As a general-purpose modeling system, GAMS is especially suitable for solving large-scale and complex mathematical models that can be established through many steps of adjustment or processing. It can describe the various characteristics of the model object in a concise and accurate manner. The auto-generation feature allows the modeler to easily debug and debug based on the errors and types indicated by the GAMS system. There are four main algorithms for solving general equilibrium models including Johansen-Euler algorithm, Newton algorithm, fixed point algorithm and planning algorithm.

The most commonly used of the various algorithms is the Johansen-Euler method. The algorithm and policy changes are closely combined and are simple and flexible. The basic principle of the Johansen-Euler algorithm is that equilibrium is the condition when demand and supply are equal.

The advantage of the Johansen-Euler approach is that system modelers can easily change the closure or the division of endogenous and exogenous variables without having to rewrite their computer programs, and without limiting the size of their models, so the model can be large. The disadvantage of this method is that it is not free to add inequalities.

In this research, the Johansen-Euler method is used in the model calculation. After passing the necessary test of the model, the simulation is realized under the static under-adjustment and solved by GAMS software.

Policy simulation

The purpose of the CGE model in this research was to conduct a policy simulation of the phosphorus fertilizer industry policy. Evaluation In order to fulfill the goal of realizing the capacity of China's phosphorus fertilizer industry to de-capacity, the implementation of various policies of the phosphorus fertilizer industry. Use the CGE model of China's phosphorus fertilizer industry policy constructed in to carry out policy shocks, and then evaluate and analyze the results of policy shocks. This research will conduct policy simulations in three phases and several scenarios.

Scenario design

Stage 1: Policy simulation of phosphorus mining and production of phosphorus fertilizer production raw materials. Mainly to control the production of phosphorus rock resources and the production of phosphorus rock products.

Scenario simulation of the phosphorus rock resource tax and the import and export quota of phosphorus rock, and the import and export tax of phosphorus rock.

Stage 2: Simulation of the financial subsidy policy for the phosphorus fertilizer production process. Mainly to reduce or cancel existing subsidies or preferential policies. Including coal discounts, natural gas discounts, electricity tariffs, and transportation price concessions

Stage 3: Conduct a policy simulation of the phosphorus fertilizer circulation. It mainly includes price limit policy, phosphorus fertilizer application policy, import and export tax policy, and import and export quota policy simulation.

This study uses GAMS software to run and solve the CGE model for China's phosphate fertilizer industry. After converting the CGE model constructed in this study into GAMS code, the policy simulation results were compared with the benchmark solution through policy simulation, and the change rates of relevant variables were obtained and analyzed. Finally, the results of the policy simulation shock are obtained through GAMS calculation results.

This study focus on the impact of industrial policies on the outcome of the phosphorus fertilizer industry, and the impact on the macro economy and the impact on the income of residents. Among them, this study selects total absorption, household consumption, government consumption, total investment, export value, import value, nominal GDP as macroeconomic indicators.

These macroeconomic indicators can comprehensively reflect China's macroeconomic situation. The base period values of macroeconomic indicators set in GAMS software are real data, which is consistent with the actual macroeconomic data of China in 2017 and reflects the actual economic situation of China in 2017. The data is sourced from publicly available data released by the Chinese government and is consistent with the values in the China Macro SAM Table constructed in this study.

Table 28 Base period value of the macroeconomic indicators in GAMS (Unit: 100 million yuan)

Macroeconomic indicators	Base period value
Total absorption	825016
Resident consumption	435000
Government consumption	135828.7
Total investment	495553.3
Export	163846.8
Import	149268.4
Nominal GDP	832035.9

The analysis of industrial effects mainly analyzes the impact of relevant policies on various industries mainly through the price, outcome volume, factor price and factor input of the production sector and the commodity sector.

Through the analysis of the results of the policy scenario simulation, it is concluded which industrial policies will have an important impact on phosphorus fertilizer production. Through the combined simulation of policy scenarios at different stages, the macro-effects and industrial effects of industrial policies are comprehensively evaluated. Finally, the industrial policy combination proposal for constructing rationally optimized phosphorus fertilizer production capacity control is obtained.

In conclusion, this study design a static standard CGE model for China's phosphorus fertilizer industry to finish objective 2. This model consists of four components: the production market, the commodity market, the economic entity, and the macro equilibrium. There are 34 sets of endogenous variables and 14 sets of exogenous variables in the model. This study constructed the China macro SAM table and subdivision micro SAM in 2017 to be the database of the model. Finally, based on the qualitative research in objective 1, two macro policies of the government that have a great impact on the phosphate fertilizer industry in recent years are set to policy scenarios.

Objective 3 To propose the appropriate capacity allocation management policy model for phosphorus fertilizer industry in China.

3.1 Policy simulation and result analysis

The purpose of this research is to find out the policy model of phosphorus fertilizer capacity allocation that is suitable for China at present. Based on the qualitative research in this research, the macro policies of the government that have a great impact on the phosphorus fertilizer industry in recent years are simulated. First, the model is run to obtain the baseline scenario without any policy disturbance until 2017. Then simulate each policy adjustment scenario, and compare the policy scenario results with the baseline scenario results, so as to obtain the dynamic changes of indicators under various policy scenarios, and analyze the effects of different policy adjustments on the phosphorus fertilizer industry. This research is divided into three scenarios for policy simulation. Focus on the impact of policies on the outcome of the phosphorus fertilizer industry, the impact of macroeconomic and the impact of residents' income.

3.1.1 Industrial value-added tax policy simulation

The value-added tax policy may control the outcome of phosphorus fertilizer, or increase the production and sales costs of phosphorus fertilizer products. So this research simulates the value-added tax policy of phosphorus fertilizer products, and adjusts it from the current 10% value-added tax rate to 13%.

The value-added tax accounted for more than 60% of China's total tax revenue and is the largest tax. The value-added tax is levied by the State Administration of Taxation. 50% of the tax revenue is the central fiscal revenue, and 50% is the local income. The value-added tax on the import link is levied by the customs, and the tax revenue is all the central fiscal revenue. At present, China implements the quasi-production value-added tax levied on various enterprises, units and individuals that sell goods, process, repair and repair services within the territory in the production, circulation and import links. From the perspective of input-outcome table, it is mainly levied on industrial, commercial and import sectors. Since May 1, 2018, China's value-added tax rate on pesticides, fertilizers and other goods has been reduced from 11% to 10%. The reduction of value-added tax rate may be of limited benefit to phosphorus fertilizer enterprises, because the factory price of compound fertilizer enterprises has mostly been close to the cost line, plus the deduction of water, electricity, freight, etc., the 1% reduction has little impact. The sales standard is adjusted to 5 million yuan. From the current price of compound fertilizer, compound fertilizer enterprises can meet the tax standard if their annual sales exceed 2300 tons. This is what most compound fertilizer factories can achieve, so the impact on the market price of compound fertilizer may not be too large. Value-added tax has become one of the most important taxes in China.

The level of value-added tax has a direct impact on the sales price of phosphorus fertilizer products and the profits of enterprises. This will affect the production and capacity changes of the phosphorus fertilizer industry.

3.1.1.1 Changes in macroeconomic indicators

Through the calculation results of policy simulation using GAMS, the simulated values of macroeconomic indicators can be obtained when the value-added tax increases to 13% in the simulated policy scenario. Comparing the base period values and simulated values of macroeconomic indicators, it was found that increasing value-added tax would have a policy impact on macroeconomic indicators, as shown in the following figure.

Table 29 Changes in macroeconomic indicators

	Base period value	Simulation value	Rate of change
Total absorption	825016	824809.7	-0.00025
Resident consumption	435000	434647.7	-0.00081
Government consumption	135828.7	135861.3	0.00024
Total investment	495553.3	495394.7	-0.00032
Export	163846.8	163763.2	-0.00051
Import	149268.4	149393.8	0.00084
Nominal GDP	832035.9	831852.9	-0.00022

Data source: Collated by GAMS calculation results

It can be seen from the table that with the increase of value-added tax, the production price of phosphorus fertilizer products has increased correspondingly, and the total consumption has increased as a whole. Government revenue increased and government consumption increased. The increase in value-added tax and government taxation will lead to a certain degree of decrease in both national income and GDP. But as product costs rise, corporate income will be affected, leading to a decrease in household consumption and a decrease in total investment. The consumption of residents decreased by 0.00008%, and the total investment decreased. As the price of products in related industries rises after the increase, the export decreases correspondingly and the import volume increases.

3.1.1.2 Industrial effect analysis

After simulating the value-added tax to 13% in the phosphate fertilizer industry, then it's possible to observe and analyze the policy impact of this policy change on various industrial sectors through the results of GAMS operation. This study mainly simulates the impact of policy changes on various industries by examining prices, outcome, factor prices, and factor inputs in the production and commodity sectors.

Table 29 reflects the changes in outcome prices, intermediate input prices and value-added prices of various industrial sectors. It can be seen from the table that the agricultural sector is the most affected by the policy. The increase in the price of phosphorus fertilizer will correspondingly increase the cost of agricultural products and thus affect the price of agricultural products. In domestic sales prices and composite commodity prices, the price change trend of each department directly related to the phosphorus fertilizer industry is the same as that of the phosphorus fertilizer industry.

Table 30 Impact on the micro sector: commodity prices

Serial number	Subdivision in the micro SAM	Base period value	Outcome price		Intermediate product price		Value added price	
			Simulation value	Rate of change	Simulation value	Rate of change	Simulation value	Rate of change
A01	**Agriculture**	**1**	**1.0128**	**0.0128**	**1.0132**	**0.0132**	**1.0029**	**1.0029**
A02	Forestry, animal husbandry, fishery and service	1	1.9984	-0.004	1	0	1.0001	0.0001
A03	Coal mining products	1	0.9900	-0.0100	0.987	-0.013	0.9901	-0.0099
A04	Oil and gas extraction products	1	0.9901	-0.0099	0.9901	-0.0099	1	0
A05	Metal mining products	1	1	0	0.0099	0.0099	1	0
A06	Phosphor rock mining products	1	1.0017	0.0017	1.0006	0.0006	1.0017	0.0017
07	The other non-metallic minerals and other mining products	1	1.0001	0.0001	0.9901	-0.0099	0.9978	-0.0022
A08	Food and tobacco	1	1.0019	0.0019	1.0023	0.0023	1.0012	0.0012
A09	Phosphorus fertilizer	1	1.0132	0.0132	1.0084	0.0084	1.0156	0.0156

Table 30 (Cont.)

Serial number	Subdivision in the micro SAM	Base period value	Outcome price		Intermediate product price		Value added price	
			Simulation value	Rate of change	Simulation value	Rate of change	Simulation value	Rate of change
A10	The other chemical raw materials and chemical manufacturing	1	1	0	0.0099	0.0099	1	0
A11	The other manufacturing	1	1.0001	0.0001	1	0	0.9901	-0.0099
A12	Electricity and heat production and supply	1	1.0001	0.0001	0.9901	-0.0099	0.9901	-0.0099
A13	Gas production and supply industry	1	0.9908	-0.0092	-0.8923	-0.1077	1.0001	0.0001
A14	Water production and supply industry	1	0.9901	-0.0099	0.9901	-0.0099	1	0
A15	Building industry	1	1	0	0.0099	0.0099	1	0
A16	Transportation and postal industry	1	1.0001	0.0001	1	0	1.0922	0.0922
A17	Financial industry	1	1.0001	0.0001	0.9901	-0.0099	0.9978	-0.0022

Table 30 (Cont.)

Serial number	Subdivision in the micro SAM	Base period value	Outcome price		Intermediate product price		Value added price	
			Simulation value	Rate of change	Simulation value	Rate of change	Simulation value	Rate of change
A18	Real estate	1	0.9908	-0.0092	-0.8923	-0.1077	0.9908	-0.0092
A19	Education	1	1	0	1	0	1	0
A20	Health, social security and social welfare	1	1.0021	0.0021	1.0011	0.0011	1.0029	1.0018
A21	Service industry	1	1	0	1	0	1	0

Data source: collated by GAMS calculation results

Table 30 reflects the Impact on the micro sector through changes in outcome quantity, total intermediate outcome quantity, and value-added outcome quantity of the 21 production department. The base period data is sourced from the 2017 economic data publicly released by the Chinese government, which is consistent with the 21 sector SAM table constructed by merging the 2017 China input-outcome table in this study. It can be seen from the table that in the change of outcome, in addition to the reduction of phosphorus fertilizer outcome, the outcome of the agricultural sector also decreased, and the outcome of the upstream phosphorus rock industry decreased. It can be found that the phosphorus fertilizer industry is directly affected, while other industries are mainly indirectly affected. it should be noted that, the decrease in product production in the agricultural sector is also transmitted to the food sector, and the constant decrease in food products may endanger the development of agriculture, thereby affecting the country's food security.

Table 31 Impact on the micro sector: Outcome quantity

Serial number	Subdivision in the micro SAM	Outcome quantity			Intermediate input quantity			Value added investment quantity		
		Base period value	Simulation value	Rate of change (%)	Base period value	Simulation value	Rate of change (%)	Base period value	Simulation value	Rate of change (%)
A01	**Agriculture**	**59391.6**	**58209.7**	**-0.0199**	**42762.0**	**41911.0**	**-0.0199**	**16629.7**	**16298.7**	**-0.0199**
A02	Forestry, animal husbandry, fishery and service	44803.5	44624.3	-0.004	32258.6	32129.5	-0.004	12545.0	12494.8	-0.004
A03	Coal mining products	46564.7	46187.5	-0.0081	33526.6	33255.0	-0.0081	13038.1	12932.5	-0.0081
A04	Oil and gas extraction products	69182.7	69127.4	-0.0008	49811.5	49771.7	-0.0008	19371.2	19355.7	-0.0008
A05	Metal mining products	18168.8	18168.8	0	13081.6	13081.6	0	5087.3	5087.3	0
A06	Phosphor rock mining products	73113.6	72397.1	-0.0098	52641.8	52125.9	-0.0098	20471.8	20271.2	-0.0098
A07	The other non-metallic minerals and other mining products	11833.7	11834.8	0.0001	8520.2	8521.1	0.0001	3313.4	3313.8	0.0001
A08	Food and tobacco	182876.7	181194.2	-0.0092	131671.2	130459.8	-0.0092	51205.5	50734.4	-0.0092
A09	Phosphorus fertilizer	823227.8	815077.8	-0.0099	592724.0	586856.0	-0.0099	230503.8	228221.8	-0.0099
A10	The other the mical raw materials and chemical manufacturing	658061.0	654573.3	-0.0053	473803.9	471292.8	-0.0053	184257.1	183280.5	-0.0053
A11	The other manufacturing	1268365.4	1268492.3	0.0001	913223.1	913314.4	0.0001	355142.3	355177.8	0.0001
A12	Electricity and heat production and supply	86853.9	86671.5	-0.0021	62534.8	62403.5	-0.0021	24319.1	24268.0	-0.0021
A13	Gas production and supply industry	4537.1	4495.4	-0.0092	3266.7	3236.7	-0.0092	1270.4	1258.7	-0.0092
A14	Water production and supply industry	1975.0	1955.5	-0.0099	1422.0	1407.9	-0.0099	553.0	547.5	-0.0099
A15	Building industry	62704.5	62535.2	-0.0027	45147.2	45025.3	-0.0027	17557.3	17509.8	-0.0027
A16	Transportation and postal industry	79393.9	79640.0	0.0031	57163.6	57340.8	0.0031	22230.3	22299.2	0.0031
A17	Financial industry	74050.7	73947.0	-0.0014	53316.5	53241.9	-0.0014	20734.2	20705.2	-0.0014
A18	Real estate	135081.2	135783.6	0.0052	97258.4	97764.2	0.0052	37822.7	38019.4	0.0052
A19	Education	37045.8	37131.0	0.0023	26673.0	26734.3	0.0023	10372.8	10396.7	0.0023
A20	Health, social security and social welfare	410937.6	414594.9	0.0089	295875.1	298508.4	0.0089	115062.5	116086.6	0.0089
A21	Service industry	141165.9	141067.0	-0.0007	101639.4	101568.3	-0.0007	39526.4	39498.8	-0.0007

Data source: collated by GAMS calculation results

3.1.2 Simulation of phosphorus fertilizer export policy

In terms of export tariffs, before 2009, the country's policy in all aspects of fertilizer production and marketing was basically based on fertilizer to ensure food production. In order to ensure the domestic demand for chemical fertilizers, the country has set a high export tariff of chemical fertilizers, which can be levied up to 110%. According to the Notice of the Tariff and Tariff Commission of the State Council on the Interim Tariff Adjustment Scheme for Import and Export in 2019 issued by the Tariff and Tariff Commission of the State Council, since January 1, 2019, China will no longer impose export tariffs on potassium chloride, potassium sulfate, compound fertilizer and other chemical fertilizer commodities. The complete elimination of export tariffs is conducive to reducing the pressure of domestic overcapacity by increasing exports. Because China's phosphorus fertilizer industry has been in a state of overcapacity for a long time, and the proportion of heavy super phosphorus consumption in China's phosphorus fertilizer consumption structure is less than 10%, China's international trade in phosphorus fertilizer mainly focuses on the export of heavy super phosphorus. According to the data, China's phosphorus fertilizer export volume reached 2048000 tons in 2021, with a year-on-year increase of 38.4%; The export value was US $616 million, up 100% year on year. In 2017, 1.8413 million tons of phosphorus fertilizer were exported. According to the adjustment of China's export tariff on phosphorus fertilizer in recent years, in order to alleviate domestic overcapacity, the export area has been relaxed year by year. However, the strict export law and inspection policy of phosphorus fertilizer started in 2021 has restricted the export of phosphorus fertilizer products. In order to ensure the domestic supply of phosphorus fertilizer, China has long implemented a phosphorus fertilizer export quota system, which also greatly limits the quantity of phosphorus fertilizer exports. However, the phosphorus fertilizer export legal inspection policy implemented since October 2021 has again restricted the phosphorus fertilizer export, and the Chinese government has a limited phosphorus fertilizer export quota every year. The strict export policy currently implemented has caused many phosphorus enterprises to be unable to resolve serious overcapacity through export, and the possibility of enterprise losses is increased.

In order to analyze the impact of phosphorus fertilizer export policy on the phosphorus fertilizer industry and macroeconomic, the phosphorus fertilizer export quota was simulated. In 2017, 1.8413 million tons of phosphorus fertilizer were exported. A policy simulation scenario was set to reduce the export volume of phosphorus fertilizer to 1.4 million tons.

3.1.2.1 Changes in macroeconomic indicators

The simulated values of macroeconomic indicators can be obtained by GAMS calculation results when the export volume of phosphorus fertilizer was reduced to 1.4 million tons. Comparing the base period values and simulated values of macroeconomic indicators, it was found that decreasing the export volume of phosphorus fertilizer would have different policy impact on macroeconomic indicators, as shown in the following table 31.

Table 32 Changes in macroeconomic indicators (Data source: collated by GAMS calculation results)

	Base period value	Simulation value	Rate of change
Total absorption	825016	824727.2	-0.00035
Resident consumption	435000	434717.3	-0.00065
Government consumption	135828.7	135728.2	-0.00074
Total investment	495553.3	495632.6	0.00016
Export	163846.8	163741.9	-0.00064
Import	149268.4	149316.2	0.00032
Nominal GDP	832035.9	831802.9	-0.00028

It can be seen from table 31 that with the reduction of the export volume of phosphorus fertilizer, the production price of phosphorus fertilizer products has decreased correspondingly, and the total consumption has declined as a whole. Government tax revenue and government consumption decreased. Residents' consumption and total investment decreased. As the price of products in related industries rises after the increase, the export decreases correspondingly and the import volume increases. The impact on GDP and national income have decreased to some extent.

3.1.2.2 Industrial effect analysis

Through the analysis of GAMS calculation results, it was found that implementing stricter export policies and reducing the export volume of phosphate fertilizer will also have an impact on other industrial sectors. This study mainly simulates the impact of policy changes on various industries by examining prices, outcome, factor prices, and factor inputs in the production and commodity sectors.

Table 32 reflects the changes in outcome prices, intermediate input prices and value-added prices of various industrial sectors. It can be seen from the table that phosphorus rock has been greatly impacted by the policy and the price has declined. Due to the increase in domestic supply, the decreasing price of phosphorus fertilize leads to a decrease in agricultural product prices. The agricultural sector was impacted by policies and prices fell. In domestic sales prices and composite commodity prices, the price change trend of each department directly related to the phosphorus fertilizer industry is the same as that of the phosphorus fertilizer industry reflects the changes in outcome prices, intermediate input prices and value-added prices of various industrial sectors. It can be seen from the table that the agricultural sector is the most affected by the policy.

Table 33 Impact on the micro sector: commodity prices(Data source: collated by GAMS calculation results)

Serial number	Subdivision in the micro SAM	Base period value	Outcome price		Intermediate product price		Value added price	
			Simulation value	Rate of change	Simulation value	Rate of change	Simulation value	Rate of change
A01	**Agriculture**	**1**	**0.9801**	**-0.0199**	**0.9711**	**-0.0288**	**0.9872**	**-0.0128**
A02	Forestry, animal husbandry, fishery and service	1	1.9984	-0.004	1	0	1.0001	0.0001
A03	Coal mining products	1	0.9900	-0.0100	0.987	-0.013	0.9901	-0.0099
A04	Oil and gas extraction products	1	0.9901	-0.0099	0.9901	-0.0099	1	0
A05	Metal mining products	1	1	0	0.0099	0.0099	1	0
A06	Phosphor rock mining products	1	0.9353	-0.0647	0.9211	-0.0789	0.9422	-0.0578
A07	The other non-metallic minerals and other mining products	1	1.0001	0.0001	0.9901	-0.0099	0.9978	-0.0022
A08	Food and tobacco	1	0.9902	-0.0098	0.9809	-0.0191	0.9709	-0.0291
A09	Phosphorus fertilizer	1	0.901	-0.099	0.932	-0.068	0.9752	-0.0248
A10	The other themical raw materials and chemical manufacturing	1	1	0	0.0099	0.0099	1	0
A11	The other manufacturing	1	1.0001	0.0001	1	0	0.9901	-0.0099

Table 33 (Cont.)

Serial number	Subdivision in the micro SAM	Base period value	Outcome price		Intermediate product price		Value added price	
			Simulation value	Rate of change	Simulation value	Rate of change	Simulation value	Rate of change
A12	Electricity and heat production and supply	1	1.0001	0.0001	0.9901	-0.0099	0.9901	-0.0099
A13	Gas production and supply industry	1	0.9908	-0.0092	-0.8923	-0.1077	1.0001	0.0001
A14	Water production and supply industry	1	0.9901	-0.0099	0.9901	-0.0099	1	0
A15	Building industry	1	1	0	0.0099	0.0099	1	0
A16	Transportation and postal industry	1	1.0001	0.0001	1	0	1.0922	0.0922
A17	Financial industry	1	1.0001	0.0001	0.9901	-0.0099	0.9978	-0.0022
A18	Real estate	1	0.9908	-0.0092	-0.8923	-0.1077	0.9908	-0.0092
A19	Education	1	1	0	1	0	1	0
A20	Health, social security and social welfare	1	1	0	1	0	1	0
A21	Service industry	1	1	0	1	0	1	0

Implementing stricter export policies and reducing the export volume of phosphorus fertilizer also had an impact on the outcome quantity of other industrial sectors. Table 33 reflects the Impact on the micro sector through changes in outcome quantity, total intermediate outcome quantity, and value-added investment outcome quantity of the 21 production department. The base period data is sourced from the 2017 economic data publicly released by the Chinese government, which is consistent with the 21 sector SAM table constructed by merging the 2017 China input-outcome table in this study.

It can be seen from table 33 that in the change of outcome, that implementing strict export policies for phosphate fertilizers will prevent phosphate fertilizer enterprises from resolving excess production capacity through export channels, leading to a reduction in phosphate fertilizer production. It also leads to operational difficulties and even bankruptcy for phosphate fertilizer enterprises. In addition to a significant decrease in production in the upstream phosphate rock industry, the agricultural sector has been significantly impacted by policy. The production of agricultural products has significantly decreased. The production of other related departments such as food and transportation has also decreased. It should be noted that phosphate fertilizer companies may reduce production and ensure profits in their future production scheduling plans, which may affect the supply of phosphate fertilizer in the future and significantly affect the supply of phosphate fertilizer in the agricultural sector.

Therefore, overly strict export policies are not only detrimental to the healthy development of phosphate fertilizer enterprises, but may also endanger the agricultural sector and food security.in addition to the reduction of the outcome of the upstream phosphorus rock industry decreased. In the long run, strict control over the export of phosphorus fertilizer products will not be conducive to ensuring sufficient supply of agricultural products, and will also pose a threat to food security.

Table 34 Impact on the micro sector: Outcome quantity (Data source: collated by GAMS calculation results)

Serial number	Subdivision in the micro SAM	Outcome quantity			Intermediate input quantity			Value added investment quantity		
		Base period value	Simulation value	Rate of change (%)	Base period value	Simulation value	Rate of change (%)	Base period value	Simulatio n value	Rate of change (%)
A01	**Agriculture**	**59391.6**	**59160.0**	**-0.0039**	**42762.0**	**42595.2**	**-0.0039**	**16629.7**	**16564.8**	**-0.0039**
A02	Forestry, animal husbandry, fishery and service	44803.5	44489.9	-0.007	32258.6	32032.7	-0.007	12545.0	12457.2	-0.007
A03	Coal mining products	46564.7	46280.6	-0.0061	33526.6	33322.0	-0.0061	13038.1	12958.6	-0.0061
A04	Oil and gas extraction products	69182.7	69265.7	0.0012	49811.5	49871.3	0.0012	19371.2	19394.4	0.0012
A05	Metal mining products	18168.8	18188.8	0.0011	13081.6	13096.0	0.0011	5087.3	5092.9	0.0011
A06	Phosphor rock mining products	73113.6	69633.4	-0.0476	52641.8	50136.0	-0.0476	20471.8	19497.4	-0.0476
A07	The other non-metallic minerals and other mining products	11833.7	11868.0	0.0029	8520.2	8544.9	0.0029	3313.4	3323.0	0.0029
A08	Food and tobacco	182876.7	184668.9	0.0098	131671.2	132961.6	0.0098	51205.5	51707.3	0.0098
A09	Phosphorus fertilizer	823227.8	802317.8	-0.0254	592724.0	577668.8	-0.0254	230503.8	224649.0	-0.0254
A10	The other themical raw materials and chemical manufacturing	658061.0	652928.1	-0.0078	473803.9	470108.3	-0.0078	184257.1	182819.9	-0.0078
A11	The other manufacturing	1268365.4	1268492.3	0.0001	913223.1	913314.4	0.0001	355142.3	355177.8	0.0001
A12	Electricity and heat production and supply	86853.9	87218.7	0.0042	62534.8	62403.5	-0.0021	24319.1	24268.0	-0.0021
A13	Gas production and supply industry	4537.1	4556.2	0.0042	3266.7	3236.7	-0.0092	1270.4	1275.7	0.0042
A14	Water production and supply industry	1975.0	1970.3	-0.0024	1422.0	1418.6	-0.0024	553.0	551.7	-0.0024
A15	Building industry	62704.5	62760.9	0.0009	45147.2	45187.9	0.0009	17557.3	17573.1	0.0009

Table 34 (Cont.)

Serial number	Subdivision in the micro SAM	Outcome quantity			Intermediate input quantity			Value added investment quantity		
		Base period value	Simulation value	Rate of change (%)	Base period value	Simulation value	Rate of change (%)	Base period value	Simulatio n value	Rate of change (%)
A16	Transportation and postal industry	79393.9	80132.3	0.0093	57163.6	57695.2	0.0093	22230.3	22437.0	0.0093
A17	Financial industry	74050.7	74191.4	0.0019	53316.5	53417.8	0.0019	20734.2	20773.6	0.0019
A18	Real estate	135081.2	135878.1	0.0059	97258.4	97832.3	0.0059	37822.7	38045.9	0.0059
A19	Education	37045.8	37045.8	0	26673.0	26673.0	0	10372.8	10372.8	0
A20	Health, social security and social welfare	410937.6	411060.9	0.0003	295875.1	295963.8	0.0003	115062.5	115097.0	0.0003
A21	Service industry	141165.9	141250.6	0.0006	101639.4	101700.4	0.0006	39526.4	39550.2	0.0006

In conclusion, to finish objective 3, this study used GAMS software to run the CGE model designed for objective 2 in two different policy simulation scenarios. The model is run to obtain the baseline scenario without any policy disturbance until 2017. Then simulate each policy adjustment scenario, and compare the policy scenario results with the baseline scenario results, so as to obtain the dynamic changes of indicators under various policy scenarios, and analyze the effects of different policy adjustments on the f phosphorus fertilizer industry. This study is divided into two scenarios for policy simulation. Focus on the impact of policies on the outcome of the phosphorus fertilizer industry, the impact of macroeconomic and the impact of residents' income. By observing and analyzing the results of model calculations, it can be concluded that changing these two policies may have similar and different impacts and impacts on China's macroeconomic and related industrial sectors, thus evaluating the policies of the f phosphorus fertilizer industry. Based on the results of policy simulation operation, it can be found that using the CGE model is a useful policy analysis tool for effectively predicting the impact of f phosphorus fertilizer industry policies on macroeconomic and micro industrial sectors.

Discussion

The application of phosphorus fertilizer is an important symbol of modern agriculture, and chemical fertilizer is the "grain" of grain, which plays a key role in increasing crop production and ensuring national food security. This research focuses on the key policies of China's phosphorus fertilizer industry in the production and sales links. It comprehensively explains the design of the phosphorus fertilizer industry policy framework and policy scenario design from two aspects of theoretical analysis, policy design and policy simulation evaluation, and carries out policy simulation and evaluation of the two scenarios. Finally, according to the analysis of the simulation results, the policy recommendations to promote the optimization of China's phosphorus fertilizer production capacity are given.

This research simulated China's industrial value-added tax and phosphorus fertilizer export quota policies respectively, and analyzed the impact of phosphorus fertilizer production capacity policy on our economic and social development from the perspective of macroeconomic effects, industrial effects and social welfare effects. The research found that further limiting the export volume of phosphorus fertilizer, China's GDP fell, the price of phosphorus fertilizer fell, and the outcome of phosphorus fertilizer fell, which had the largest impact on the price of the primary industry, the smallest impact on the price of the tertiary industry, and the income of rural residents and urban residents increased. Therefore, implementing policies blindly that only control the production and production capacity of phosphorus fertilizers may endanger the development of agriculture, thereby affecting the country's food security and healthy GDP growth.

CHAPTER 5
CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

Conclusion

This research takes China's phosphorus fertilizer industry policy as the research object, uses the policy tool theory to sort out and summarize China's phosphorus fertilizer industry, uses the policy cycle theory to study the industrial policy cycle, uses the qualitative analysis interview method to study the main industrial policies affecting phosphorus fertilizer enterprises in recent years, and then uses the Computable general equilibrium model (CGE) to conduct policy simulation based on the above research results, The CGE policy model of China's phosphorus fertilizer industry is designed, and suggestions for further optimizing China's phosphorus fertilizer industry policy are put forward.

The main research results and innovations of this research are as follows.

1. The externality theory is applied to build the theoretical basis for the policy demand on the phosphorus fertilizer industry chain. Innovatively apply the policy tool theory of Howlett and Ramesh to sort out and analyze the relevant policies that have been issued by China's biofuel ethanol industry in three stages according to voluntary policies, mandatory policies and hybrid policies. Based on the theoretical basis, this research systematically analyzes the factors that affect the design of industrial policies. There are eight main phosphorus fertilizer industry policies in China. Phosphorus fertilizer industry industrial policy in China has experienced three historical periods: “supporting period, planning management period and adjustment period”. At present, phosphorus fertilizer industry policy is in the third stage of historical adjustment.

2. The influencing factors of China's phosphorus fertilizer industry policy selection are systematically analyzed. Based on the result of interview, the policies that have a significant impact on the phosphorus fertilizer industry in the past ten years mainly include export policy, value-added tax policy and phosphorus rock

resource tax policy. This research systematically analyzes the factors that affect the design of industrial policies.

3. The static CGE model of China's phosphorus fertilizer industry was designed for policy simulation and evaluation. Based on the China national input-outcome table in 2017, the 2017 China's social macro-social accounting matrix (SAM) and detailed 21-department SAM table for the CGE model was formed through reasonable splitting and merging. Then the value-added tax in sales and the export policy in international trade were set as the policy scenarios, and the CGE model is used for policy simulation and evaluation.

4. Based on analyze of policy shocking results of the CGE model, the research found that increasing value-added tax during the sales phase of phosphate fertilizer products and further increasing export trade restrictions to reduce phosphate fertilizer exports will both reduce phosphate fertilizer production. Based on analyze of policy shocking results of the CGE model, the study has found that increasing value-added tax during the sales phase of phosphate fertilizer products and further increasing export trade restrictions to reduce phosphate fertilizer exports will both reduce phosphate fertilizer production. These tow policies have similar impacts on China's phosphorus fertilizer industry, but have different impacts on the macroeconomic indicators and other micro industry sectors. They have the similar certain negative impact on GDP, and can cause a slight decrease in the income of residents too. These tow policies have different impacts on the micro industry sectors. The agricultural sector has been most significantly impacted by these two policies simulation. Therefore, when implementing the policy of reducing phosphate fertilizer production capacity, it is necessary to strengthen the agricultural subsidy policy for farmers and focus on the food security.

In a word, constructing a CGE model for phosphorus fertilizer industry is a useful policy analysis tool that can simulate policy changes in advance and predict the impact of policy implementation on macroeconomic and micro industrial sectors.

Implications

The influencing factors of phosphorus fertilizer industry policy selection are systematically analyzed. Based on the theoretical basis, this paper systematically analyzes the factors that affect the design of industrial policies. The CGE model of phosphorus fertilizer industry was designed. Based on the data, the Chinese social macro-social accounting matrix (SAM) in 2017 was constructed. According to the macro SAM, a detailed 21 department subdivision SAM was formed through reasonable splitting and merging. Then the value-added tax in sales and the export policy in international trade are set as the policy scenarios, and the CGE model is used for policy simulation and evaluation. Based on the research results, industrial policy recommendations for further optimizing phosphorus fertilizer capacity are put forward. The study found that the use of tax and export policies will have different impacts on phosphorus fertilizer industry, and also have different impacts on the macroeconomic.

1. To Improve the quality of China's phosphorus fertilizer industry

1.1 Changing the development mode of phosphorus fertilizer industry

The phosphorus fertilizer industry should fundamentally change the past model of relying solely on capacity expansion. The industry and enterprises should realize that the linear development model of quantity expansion alone cannot continue. In the future, the focus of development should be shifted to improving its own quality. By improving the utilization rate of resources, increasing the concentration of industries, accelerating the merger and reorganization and joint development, focusing on the global market, cultivating transnational enterprises and seeking effective, quality and sustainable development with the purpose of enriching the product structure, combining fertilizer and chemical, strengthening agrochemical services and promoting internationalization.

1.2 Strict industry accessing

Strict industry access, elimination of backward production capacity and further improvement of industrial concentration are the necessary conditions to control and solve overcapacity. Since 2011, the Chinese government has issued and implemented the "Conditions for Access to the Ammonium Phosphorus Industry", which clearly stipulates that in order to accelerate industrial restructuring, strengthen environmental protection, comprehensively utilize resources, regulate industrial investment behavior, stop blind investment and low-level repetitive construction, and promote the healthy development of the phosphorus fertilizer industry, in accordance with relevant national laws, regulations and industrial policies, no new ammonium phosphorus enterprises will be built within three years in principle, and the energy consumption Put forward strict requirements for environmental protection. At the same time, the existing ammonium phosphorus enterprises were reorganized through the access announcement management method. This policy has played a certain role in limiting the increase in the number of phosphorus fertilizer enterprises. From the perspective of the development of the phosphorus fertilizer industry, we should further implement the industry access conditions and announcement management in the future, eliminate enterprises that do not meet the relevant energy consumption and environmental protection requirements, and control the impulse of repeated investment in the phosphorus fertilizer industry.

1.3 Promoting the merger and reorganization of phosphorus fertilizer enterprises

After years of development, China's phosphorus fertilizer industry has formed leading enterprises such as Yuntianhua, Wengfu, Kaihua, Yihua, Xinyangfeng and Liuguo Chemical. The phosphorus fertilizer production capacity is mostly more than 1 million t/a, and most of them are mineral fertilizer integration enterprises. Their own phosphorus ore can meet the production demand. The time is ripe for China's phosphorus fertilizer industry to speed up mergers and reorganization and increase industrial concentration. Since 2012, the Chinese government issued the "Twelfth Five-Year Plan" for the fertilizer industry, which proposed to accelerate the concentration of basic fertilizer production to competitive enterprises and gradually form a production and operation pattern dominated by large fertilizer enterprises. Encourage large enterprises to further expand their business scale and strength through mergers and acquisitions, elimination of backward and construction of fertilizer bases. The phosphorus fertilizer industry should continue to promote merger and reorganization, establish several large enterprises with relatively complete industrial chain, obvious scale advantage and leading technology level, reflect the "power of the company", which is conducive to restraining the blind expansion of production capacity, improving the overall technical level and international competitiveness of the industry, and also conducive to external coordination in the import of raw materials and export products to form the group advantage.

Due to the decisive impact of phosphorus rock resources on the development of the phosphorus fertilizer industry, the future route of merger and reorganization of the phosphorus fertilizer industry will be carried out simultaneously in the upstream and downstream. Upstream large mineral fertilizer combination enterprises, sulfur resource advantage enterprises and other enterprises have gradually integrated the downstream small and medium-sized enterprises, and also extended to the phosphorus resource producing areas. While promoting merger and reorganization, we should encourage strong alliances among large enterprises. For example, the cooperation between Xingfa Group and Wengfu Group is typical. The two enterprises have conducted extensive cooperation in the refining of wet-process phosphoric acid, the recovery of associated fluorine and iodine resources and other aspects, breaking the industry boundary, and improving the competitiveness of both parties in the field of phosphorus fertilizer and phosphorus chemical industry.

During the "Fourteenth Five-Year Plan", China's fertilizer industry will focus on improving industrial quality, boosting agricultural modernization and improving international competitiveness as its strategic priorities for high-quality development. The essence of high-quality development of fertilizer is consumption-oriented supply-side structural reform, focusing on the value-added of fertilizer products, the transformation of development fields, the upgrading of production models, and the expansion of strategic layout.

2. Promote international development

2.1 Moderate export of phosphorus fertilizer policy

We will allow proper export of phosphorus fertilizer and digest some excess capacity. The current tariff policy should be integrated with agricultural subsidies. With the continuous strengthening of agricultural subsidies, the tariff policy should be adjusted in a timely manner. Properly increase the export quota of phosphorus fertilizer and further implement zero tariff for phosphorus fertilizer export. Appropriate exit mechanism for the legal inspection policy of phosphorus fertilizer export.

2.2 Building an international layout

Large enterprises and groups in the fertilizer industry should actively promote the pace of industrial internationalization, and pay more attention to international new fertilizer products when carrying out capacity cooperation "going out". Timely carry out overseas cooperation and connect foreign brand advantages and technical advantages with China's cost advantages, which is conducive to improving the quality of China's fertilizer and promoting the popularization and promotion of advanced fertilizer technology in China.

Under the current situation of low domestic fertilizer demand potential and excess capacity of phosphorus fertilizer, it is an inevitable choice for phosphorus fertilizer enterprises to go international. Domestic phosphorus fertilizer enterprises should further expand the degree of internationalization, establish overseas bases on the basis of product export and technology export, and purchase and build production plants abroad.

phosphorus fertilizer and phosphorus chemical enterprises are developing abroad. After more than 50 years of development, China's phosphorus fertilizer industry has not only greatly increased its outcome, but also diversified its products. In addition, it has mastered a set of technologies from the design and construction of the plant, and has laid a foundation for future development. Therefore, we can use our technology to go abroad and carry out technology export, including the design and general contracting of new equipment abroad, as well as new technology transfer. Foreign markets are still large, such as Australia, Africa, Southeast Asia, India, etc., which are still short of phosphorus fertilizer, providing us with a rare opportunity to develop abroad. Others, such as Jordan, the United Arab Emirates, Türkiye, Ethiopia, and Southeast Asian countries, are optimistic about China's technology and technical talents and hope that China will support them to build phosphoric acid and phosphorus chemical plants. Therefore, going out of China's phosphorus fertilizer and phosphorus chemical enterprises is one of the current industry development strategies. This can not only solve the domestic fertilizer overcapacity, but also promote the development of relevant countries. This is a systematic project, which is expected to take a lot of effort.

3. Optimize and strengthen the policy of reducing production capacity

The policy of eliminating backward production capacity and promoting the reduction of production to improve the comprehensive utilization rate of phosphonyls. The development and utilization level of phosphonyls will be raised by 40% in 2015. By 2020, the comprehensive utilization of phosphonyls will increase from 30% of the current annual production to 50%. Support technical transformation and orderly exit and transfer. Set up a special fund for the transfer and transformation of phosphorus fertilizer (or fertilizer) production capacity to drive uncompetitive enterprises or enterprises with inadequate environmental protection to transfer production capacity, or transform devices, or adjust product structure, or exit the industry.

3.1 Establishing an exit mechanism for capacity transfer

Small and medium-sized phosphorus fertilizer enterprises have relatively low resource utilization rate and inadequate environmental protection facilities. In addition to merger and reorganization, these phosphorus fertilizer enterprises should establish a capacity transfer exit mechanism. Enterprises that are not located in the phosphorus resource producing areas will shift from the production of basic fertilizer to the production of secondary processing fertilizer, cooperate with agrochemical services, produce special fertilizer for regional users, or withdraw from the industry. Enterprises in phosphorus resource producing areas should strengthen upgrading and transformation, and those who cannot meet the requirements of environmental protection and qualified personnel should withdraw from the industry.

4. Product structure should be developed towards fine phosphorus and organic phosphorus chemicals.

Actively develop functional fine phosphorus and specialized fine organophosphorus chemicals. The development of phosphorus chemical industry to high-end products is a more important way. That is, industrial grade phosphoric acid and phosphorus are prepared by purification of wet-process phosphoric acid. at present, the majority of phosphorus in China is produced by thermal process, and the wet process will be adopted in the future. Phosphoric acid purification to reduce energy consumption and save costs. Adjust the industrial structure and focus on developing high-end phosphorus chemical industry. High-end phosphating industry is an important support for the development of high and new technology, and is China's phosphorus chemical industry. It is necessary to realize the transformation from a large phosphorous chemical country to a powerful one. Its products include: 1) ultra-high purity yellow phosphorus; 2) Ultra-high purity phosphoric acid (e.g. electronic grade, phosphoric acid, high-tech material phosphoric acid, etc.); 3) phosphorus series electronic chemicals; 4) Chiral phosphorus ligands and phosphorus catalysts; 5) Lithium battery materials; 6) phosphorus series new functional materials; 7) phosphorus-containing drugs and intermediates.

None of the world's famous large companies today is taking the development path of refinement and vigorously developing the leading products of fine chemicals through their own patented technologies to improve the competitiveness of core technologies. For example, Israel Chemical Group (ICL) is the largest phosphorous flame retardant manufacturer in the world; Nippon Chemical Industrial and ROSA are the world's largest producers of high purity electronic grade phosphoric acid; Thermos is the largest phosphorus manufacturer for food and medicine in the world. These enterprises have provided valuable experience for the development of phosphorus fertilizer and phosphorus chemical enterprises in China.

5. Strengthen resource guarantee

Sedimentary phosphorus rock (colloidal phosphorus rock) accounts for about 85% of the proven reserves of phosphorus rock in China, and most of them are medium-low grade phosphorus rock. The content of harmful impurities in this kind of ore is generally high. The ore is fine, tightly embedded, difficult to dissociate and difficult to separate. The development and utilization of medium-low grade phosphorus rock resources is a major strategic issue related to the sustainable development of China's phosphorus chemical industry and phosphorus fertilizer industry and the national food security. At present, Yuntianhua Group, Wengfu Group, Hubei Yihua, Hubei Dayukou, Hubei Huangmailing Chemical and other enterprises have made great progress in the utilization of medium-low grade phosphorus ores and built a number of beneficiation plants. In the future, we should continue to improve the medium-low grade phosphorus ore processing industry on the basis of industry access, mergers and reorganization, and realize the sustainable utilization of phosphorus ore resources.

6. Strengthen support for waste treatment and recycling

Preferential policies in terms of finance, tax and land will be given to waste treatment and environmental protection facilities construction projects. The export of fluorine recovery products, such as hydrogen fluoride and fluoride salts, which are by-products of phosphorus fertilizer, can be given tariff preference. It is suggested to refer to the energy saving subsidies of household appliances and automobile industries and give subsidies to phosphonyls comprehensive utilization products, so that the comprehensive utilization industry can be profitable and can increase profits for enterprises, change the subsidies for enterprises to simply expand production capacity as comprehensive utilization products, make the comprehensive utilization industry profitable and can increase profits for enterprises, and change the traditional mode of enterprises to simply expand production capacity as the focus of investment.

Recommendations

Recommendations For Policy Makers

The government should revise the export policy every year according to the economic form, appropriately adopt the legal inspection quota system, and flexible the export quota system.

On the one hand, the implementation of the quota policy is conducive to the relevant enterprises to arrange the production of domestic supply and overseas shipment in a more planned way. On the other hand, based on the situation of domestic phosphorus fertilizer overcapacity, phosphorus fertilizer really needs to maintain a certain proportion of exports, maintain a relatively reasonable operating rate and achieve a balance between production and sales, which is conducive to the long-term healthy and stable development of the industry. The implementation of legal inspection measures on the export of chemical fertilizers has indeed played an important role in ensuring the supply and price stability of domestic chemical fertilizers, and is an important means of regulation and control to ensure the sufficient supply of domestic chemical fertilizers and meet the needs of agricultural production. The performance data of several fertilizer listed companies show that the performance of some industry leaders, especially phosphorus fertilizer listed companies, increased significantly in the first half of the year. This shows that the legal inspection measures for chemical fertilizer export play a role in ensuring the supply and price stability of domestic chemical fertilizer, while the actual impact on the leading enterprises is not obvious.

The agricultural means subsidy can effectively offset the cost of agricultural means invested by farmers for grain planting, promote farmers to actively grow grain, stabilize grain area and grain yield, and ensure national food security. It has improved the efficiency of grain production and restored the enthusiasm of farmers to grow grain to a certain extent.

Recommendations For phosphorus fertilizer manufacturer

1. To change the development mode of phosphorus fertilizer industry.

The phosphorus fertilizer industry should fundamentally change the past model of relying solely on capacity expansion. The industry and enterprises should realize that the linear development model of quantity expansion alone cannot continue. In the future, the focus of development should be shifted to improving its own quality.

2. To change the product structure.

Product should be developed towards fine phosphorus and organic phosphorus chemicals. And it's very necessary to continuously adjust the structure of phosphorus fertilizer products based on changes in domestic and international market demand. Although China has a large export volume of phosphate fertilizers, most of them are mid to low-end products with lower prices. Therefore, the competitiveness of high-end products in China needs to be further improved.

3. To promote international development

Large enterprises and groups in the fertilizer industry should actively promote the pace of industrial internationalization, and pay more attention to international new fertilizer products when carrying out capacity cooperation "going out". Timely carry out overseas cooperation and connect foreign brand advantages and technical advantages with China's cost advantages, which is conducive to improving the quality of China's fertilizer and promoting the popularization and promotion of advanced fertilizer technology in China.

Recommendations for Further Research

The problem of overcapacity in the phosphorus fertilizer industry has not appeared for a long time in China. So there are few literatures on the research of the fertilizer industry using CGE model. In addition, the outcome value of the phosphorus fertilizer industry is relatively low relative to the share of the gross domestic product of all industries in China. Although the required research results and conclusions can be analyzed, the impact effect is not very obvious.

This study constructed a static standard CGE model for the China's phosphorus fertilizer industry. However, this study did not update the base year data forward. If we want to analyze the impact of policy shocks in future years, we need to further dynamize the model. If economic data may be available in the future, it will get more useful policy simulation shocks and comparations to establish a dynamic CGE model for China's phosphorus fertilizer industry. Therefore a dynamic CGE model is also constitutes the next research direction.

REFERENCES

Bai Letang. 2016. Research on the Exit of State-owned SMEs and the Problem of "De-capacity" under the Supply-side Structural Reform. **Economics**, 7, 65 -74.

Basu N, Pry & R, Quint T. 1998. ASPEN: A microsimulation model of the economy. **Computational Economics**, 12, 223 241.

Beroggi, G. 2001. Visual-interactive decision modeling (VIDEMO) in policy management: Bridging the gap between analytic and conceptual decision modeling. **European Journal of Operational Research**, 128(2), 338-350.

Chen Wenling. 2014. Resolving excess capacity requires new ideas and new breakthroughs. **Economic Research Reference**, 7, 94- 96.

Chen Zhenming. 2018. Retrospect and Prospect of Disciplinary Development of Public Policy in China's 40 Years of Reform and Opening – up. **Southeast Academic Research**, 4, 52-59.

Chowdhury, R. B., Moore, G. A., Weatherley, A. J. & Arora, M. 2017. Key sustainability challenges for the global phosphorus resource, their implications for global food security, and options for mitigation. **Journal of Cleaner Production**, 140, 945-963.

CGE. 19689. A computable general equilibrium model applied to Chinese economy. **System Engineering—Theory and Practice**, 4, 32-39.

Cong xiaolan. 2014. Multi-regional CGE simulation of carbon tariffs under the geopolitical economic framework. **Word regional studies**, 3(23).

Cordell, D., Drangert, J.-O. & White, S. 2009. The story of phosphorus: Global food security and food for thought. **Global Environmental Change-human and Policy Dimensions**, 19, 292-305.

Gao Hongye. 2007. **Western Economics**. Beijing: China Renmin University Press.

Gao Yua, & Zhang Sheng. 2011. Thought on adjustment and optimization of phosphorus fertilizer industrial distribution in China under the current situation. **Phosphorus & Compound Fertilizer**, 26(2), 1-4.

Gao Yuqiang. 2011. **Research on Optimization of Agricultural Subsidy System**.

Dalian: Dongbei University of Finance and Economics.

Geissler, B., Mew, M. C., Weber, O. & Steiner, G. 2015. Efficiency performance of the world's leading corporations in phosphorus rock mining. **Resources, Conservation and Recycling**, 105, 246-258.

Han Han. 2009. The impact of China's tariff policy adjustment on the fertilizer industry and its countermeasures - take Yifu International Trade Co., Ltd. as an example.

Hillman. 2005. **Political Economy in Trade Protection**. USA: Peking University Press.

Howlett, M., Ramesh, M. & Perl, A. 2003. **Studying Public Policy Principles and Processes**. 4th ed. Oxford: Oxford University Press.

Huang Qunhui. 2016. On the supply side structure of China's industry Reform. **China Industry Economy**, 9, 2-23.

Iba T, Hiro kane M , Takenaka H, et al. 2000. Boxed economy model : fundamental concepts and perspectives. pp. 941-944. In **First International Workshop on Computational Intelligence in Economics and Finance (CIEF' 2000)**. Atlantic City, New Jersey, USA: Association for Intelligent Machinery.

Lerner, D. & Lasswell, H. D. 1951. **The Policy Sciences; Recent Developments in Scope and Method**. Stanford: Stanford University Press.

Li, G., van Ittersum, M. K., Leffelaar, P. A., Sattari, S. Z., Li, H., Huang, G. & Zhang, F. 2016. A multi-level analysis of China's phosphorus flows to identify options for improved management in agriculture. **Agricultural Systems**, 144, 87-100.

Li Yuxuan. 2014. **Research on the impact of China's fertilizer industry policy on food production**. Beijing: China Agricultural University.

Li, Zhang Jie. 2014. The fundamental causes and outlets of overcapacity in China: non-market factors and its three-step strategy. **Reform**, 2, 40-51.

Lin Ke, & Lu Zhen. 2017. Under the background of overcapacity in China Research on capacity withdrawal mechanism. **Economist**, 3, 63-69.

Liu Bing. 2016. Grab "go Key issues of production capacity. **Macroeconomic Management**, 7, 42-44.

Liu Jianjiang, Luo Shuangcheng, & Ling Silian. 2015. International experience and enlightenment to resolve overcapacity. **Economic Aspect**, 6, 111-114.

Mei Shuwen. 2008. Policy Cycle of National Intellectual Property Strategy, **Intellectual**

Property, 18(1), 37-42.

Mohr, S. & Evans, G. 2013. Projections of Future Phosphorus Production. **PHILICA.COM**. Article number 380. Available https://www.resilience.org/wp-content/uploads/articles/General/2013/09_Sep/peak-phosphorus/Phosphorus%20Projections.pdf

Nijkamp, P., Wang, S. & Kremers, H. 2005. Modeling the impacts of international climate change policies in a CGE context: The use of the GTAP-E model. **Economic Modelling**, 22(6), 955-974.

Pan Dan. 2014. Analysis of the factor analysis of the intensity of chemical fertilizer application in China. **Journal of Agricultural Science of South China : Social Science Edition**, 13(2), 24 - 31.

Pan Wenxuan. 2016. Overall Thinking and Countermeasure Framework for Resolving Negative Capacity Impacts. **Journal of Finance and Economics**, 5, 63-73.

Qu Fan. 2007. **China Computable General Equilibrium Model and Simulation**. PhD. thesis. Wuhan: Huazhong University of Science and Technology.

Qu Jidong. 2008. Analysis the development trend of the same fertilizer industry from the evolution of the fertilizer policy. pp. 49-52. In **AgriGoods Herald, The second China agricultural development forum·proceedings**.

Sarah Connors. 2016. **GeoPolicy: Science and the policy cycle. EGU Blogs**. [Online]. Available https://blogs.egu.eu/geolog/2016/09/14/geopolicy-science-and-the-policy-cycle/.

Sheng Chao Xun. 2013. International experience and strategy to resolve overcapacity. **Reform,** 8, 94-99.

Shi Wei. 2014. International experience of overcapacity governance and its enlightenment to China. **Economic System Reform**, 4, 154-158.

Shihui Zhang et al. 2017. How shale gas will shape China’s future? An evaluation based on dynamic Energy-CGE model. **Energy Procedia**, 105, 3349 – 3354.

Springer, N. P. 2017. Physical, technical, and economic accessibility of resources and reserves need to be distinguished by grade: Application to the case of phosphorus. **Sci Total Environ**, 577, 319-328.

Suh, S. & Yee, S. 2011. Phosphorus use-efficiency of agriculture and food system in the US. **Chemosphere**, 84(6), 806-813.

Wang Li, al et. 2008. Historical envolvement and development trend of fertilizer circulation policies in China. **Phosphorus & Compound Fertilizer**, 2(23).

Wang Liguo, & Gao Yueqing. 2014. Establish and improve the market exit mechanism to effectively resolve overcapacity. **Macroeconomic Research**, 10, 8-21.

Wang Min. 2013. Discussion on measures to improve industrial quality by overcapacity in China's phosphorus fertilizer industry. **phosphorus fertilizer & Compound Fertilizer**, 28(4), 6-11.

Wu, H., Zhang, Y., Yuan, Z. & Gao, L. 2016. A review of phosphorus management through the food system: identifying the roadmap to ecological agriculture. **Journal of Cleaner Production**, 114, 45-54.

Zhang Chunyu, & Tang Jun. 2015. The negative impact of measures to reduce excess capacity by establishing a long-term mechanism-Taking Hebei Province as an example. **Development Research**, 5, 83-87.

Zhang Junxuan, & Zhao Changwen. 2014. **Analysis of China's Current Overcapacity Problem--Policy, Theory, Case**. Beijing: Tsinghua University Press.

Zhang Shihui, Wang, C. & Cai, W. 2017. How Shale Gas will Shape China's Future? an Evaluation Based on Dynamic Energy-CGE Model. **Energy Procedia**, 105, 3349-3354.

Zhang Tao, & Xu Wei. n.d. **phosphorus fertilizer: returning to the origin to open the industry "knot knot".** [Online]. Available http://www.sino-nz.com/html/2016/04/15/42297.html (January, 5, 2020).

Zhang Weifeng, et al. 2017. **China Fertilizer Development Research Report 2016**. Beijing: China Agricultural University Press.

Zhang Xin. 2010. **The Basic Principles and Programming of the General Equilibrium Model Can Be Calculated**. Shanghai: Shanghai People's Publishing House.

Zheng Liangyong, & Du Liqing. 2013. The countermeasures of agricultural fertilizer pollution and environmental protection in China. **China 's hot belt agriculture**, 2, 76-78.

Zhou Heping. 2016. The price of gas is released, and the influence of fertilizer market on geometry?. **PetroChina and Chemical**, 12, 26-27.

Zhao Tianyu. 2015. **Research on Market Allocation Mechanism of China's Manufacturing Investment and Capacity under Transition Economy.** Jilin University.

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