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Conceptual Paper

Methodological tools and economic models to analyse the transition to a new development trajectory in China

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Abstract: The primary objective of this conceptual paper is to provide the reader with a methodological toolkit for analysing China's transition to a new economic trajectory based on qualitative production factors such as research and development and innovation, as well as highly skilled human capital, etc., which thereby could help the country in escaping the middle-income trap. The nature of the proposed methodology is impact assessment, i.e., the paper discusses the ways and means of assessing and predicting the impact of policy measures on the economy. The use of a specific set of indicators and the application of the DEA-SBM and the PSM-DID models is proposed for quantitative analyses amended by the Markov Chain Model for predictions. The main contribution of this paper to the existing body of knowledge is the proposition of a comprehensive model for evaluating economic development in general. By exploring the role of economic policies, a deeper understanding can be obtained of how the economy should be reformed and developed. It is a valuable and practical approach to compare differences and solve problems at the macro, mezzo, and microeconomic levels that can be applied to other regions and countries facing similar challenges.

Keywords: high-quality development; 14th Five-Year Plan; SBM-DEA model; PSM-DID model; Monte Carlo Markov chains

1. Introduction

This conceptual paper will form a part of a comprehensive thesis or monograph about China's transition to a new development path. This term refers to the exhaustion of former driving forces of GDP growth based primarily on the increase of the quantity of labour force and capital and the need to identify new driving engines by placing more emphasis on qualitative production factors. Such driving engines include research and development and innovation as well as highly skilled human capital, the upgrade of economic structures, the reduction of regional disparities and income inequalities, etc. Therefore, this report needs to discuss these factors and concepts in depth. Furthermore, a major part of previous literature focused on the issue of whether China will fall into the middle-income trap. This is a one-sided view because the country's development stage was assessed solely from the perspective of household income. There is still a research gap regarding the consideration of other factors.

Based on the theoretical and economic policy background described above, the primary objective of this paper is to elaborate a methodological concept and toolkit that enable the detailed analysis of this shift in China's development trajectory. The primary assumption behind this research objective is that the transition occurs spontaneously and along government policy measures. The effects of government measures (positive, negative, or neutral) on development trajectory change are assessed qualitatively and subsequently quantified. Consequently, the nature of the planned monograph is impact assessment in a broad sense with a combination of literature review and statistical figures, as well as modelling analysis. However, this report outlines only the impact assessment methodology without concrete statistical figures. This methodological framework lays the foundations of further work, more precisely the database analysis, which should be the next step of the research.

This report contains several scientifically novel elements. It is hoped that the results will assist in identifying the most appropriate options that are best suited for the general research objective of economic development by comparing a wide range of available statistical

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approaches, methods, and models. The conclusions may help those willing to quantify the impact of economic policy measures on the growth trajectory of countries facing the middle-income trap.

The central research questions of the paper are as follows.

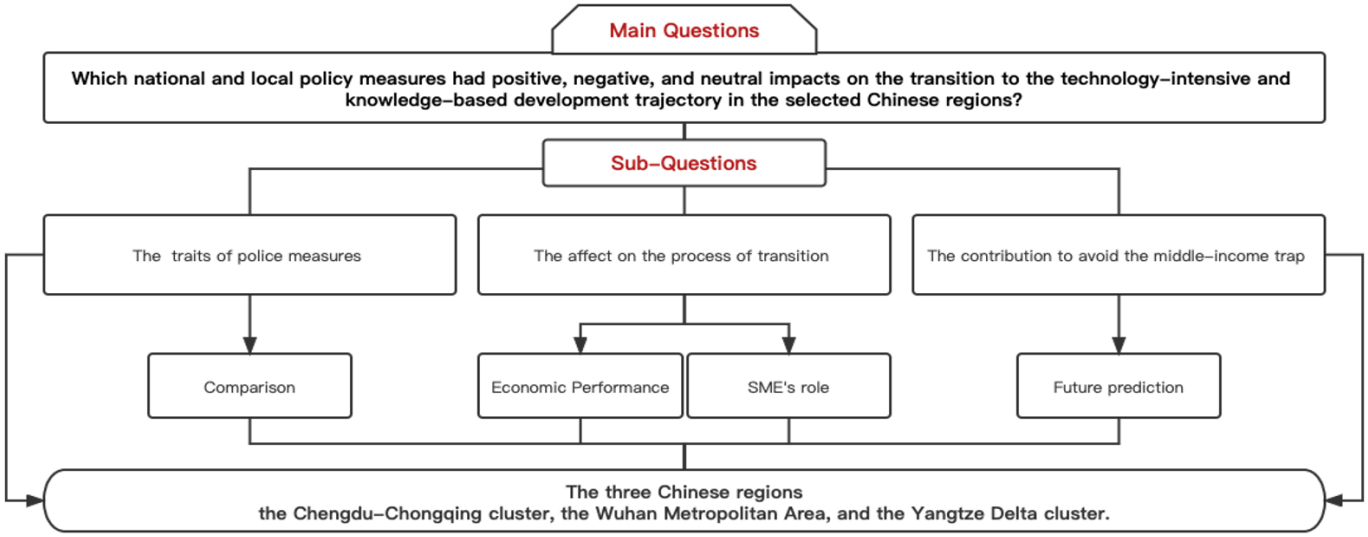

Figure 1. The mind map of research questions. *Source: Author's own work*

As regards the research approach, first, the relevant macro-level policy measures related to specific dates should identify. Second, the regional-level policies should be mapped. Third, the economic impacts of the policy measures should be analyzed. As far as these issues are concerned, on the one hand, the spillover of central policy measures should be examined, i.e., how policy measures are incorporated into local policies and what influence they exert on transition at the local level. The question is to what extent central policies are executed at the regional level and how significant the frictional losses are. On the other hand, the policy steps of regional and local authorities should be scrutinized and identified along with the analysis of their impact.

The research objective is to analyze the policy measures and their impact at the level of three specific Chinese regions: the Chengdu-Chongqing cluster, the Wuhan Metropolitan Area, and the Yangtze Delta cluster. The methodological frames are aligned with this regional approach. In addition, special attention is devoted to small- and medium-sized enterprises. It is assumed that they play an essential part in the emergence of the new development trajectory. The methodological frames reflect this focus. The time horizon is associated with China's policy framework. The analysis starts in 2021 with the launch of the 14th Five-Year Plan of China and ends in 2025. This planning document summarizes the primary policy objectives of the Chinese government for the subsequent years (see Annex).

The structure of this report is the following. The first chapter presents a short overview of the way of thinking in research philosophies and approaches. The second part is about research strategies and methodological choices. A brief comparative description analysis can better depict the differences among the regions since economic policies should be applied and adapted to local conditions. The third part contains the methodological and practical framework of data collection. Based on the assumption that economic policies can be measured, secondary data may be obtained from the National Bureau of Statistics of China, CSMAR, and the Wind-Data service database. The fourth part is the description of the methodology of data analysis. Policy assessment can be divided into two perspectives: the point of view of economic performance and the perspective of the role of SMEs. The fifth part is a robustness test-placebo test exercise to control the validity and reliability of the analyses, while the sixth one highlights the limitations of the methodology. The final parts of the report contain the summary, conclusions, and recommendations.

Further research will quantify the various effects based on actual statistical and survey data and identify the most critical elements of economic transformation and the most important policies that should be adopted based on comparisons.

2. Research philosophies and approach

2.1. Research philosophies

Policy judges are usually classified into two types: those basing their judgements on the current situation (positive economics) and those basing their judgements on assumptions of standards (normative economics). The former emphasizes the importance of objective laws. These persons focus on what is happening in the present and draw lessons and laws based on that (Voigt, 2011). The latter involves a prognosis for estimating the current state of the economy. Normative economics involves a process of prognostic verification (Friedman, 2009). It has many criteria that help establish standards and refine them.

In positive economics, facts are based on reality. Early economists such as John Neville Keynes (Keynes & Felix, 2017) and John Stuart Mill (Mill, 1875) first identified "what is" and "what should be". Because positive economics relies solely on facts and data, policymakers can develop appropriate measures to deal with any economic situation. Current macroeconomic indicators are used to calculate economic input-output efficiency and provide insights into a country's economic transformation. After being described by these indicators, the impact of policies can be more precise.

Positive and normative economics are inseparable from each other. Positive economics describes, explains, and predicts economic phenomena. However, it does not tell us which economic policy we should choose, nor does it provide advice or guidance. In normative economics, norms (standards) are established based on certain value judgments, and action steps to meet these standards are discussed (David, 1990; Jolls et al., 1998). Normative economics focuses on how to establish norms and how to apply them to economic behaviour. The logic of the approach is demonstrated in Figure 2.

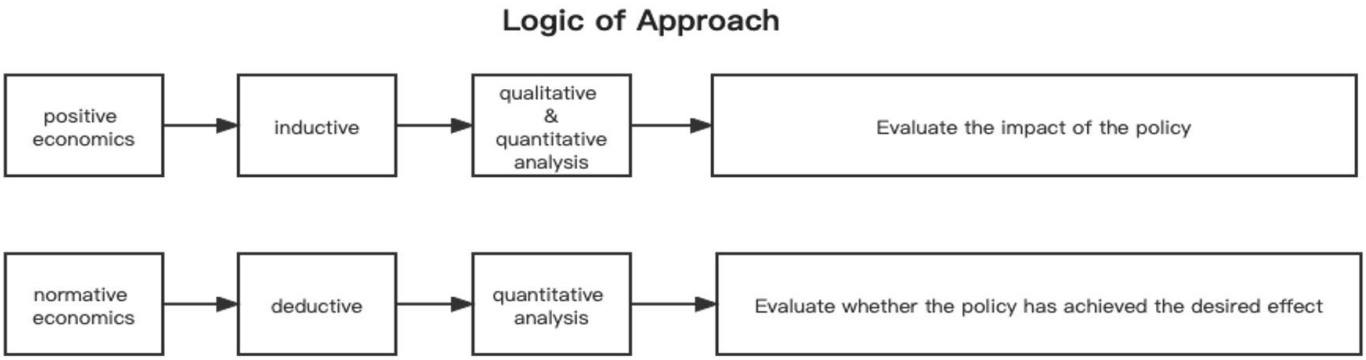

Figure 2. Logic of approach. *Source: Author's own work*

2.2. Research approaches

As far as approaches are concerned, inductive and deductive reasoning are concurrently applied in this paper. The *inductive method* has the advantage of identifying the causal relationship and logical reasoning (Thomas, 2006); (Prince & Felder, 2006). The conclusion is generally reliable and is based on the law of cause and effect as the objective basis, and is based on observation, experiment, and investigation as the means. However, when preparing for induction and collecting empirical materials, the analysis must be guided by certain theoretical principles, i.e., by the deduction method. Only in this manner can the collection be done consciously, and can the direction be established appropriately. Otherwise, the research direction will be lost (Elo & Kyngäs, 2008).

Before the theory can be tested, first it should be summarized and developed. Economic development takes place in real time. The government monitors and analyses macroeconomic data to understand the country's current economic situation and formulates a suitable national economic development strategy. Similar policies are implemented for the economy based on prior policy implementation and impacts to observe similarities and differences in effects. If a *hybrid research approach* is used, it can compensate for the shortcomings of deductive reasoning, which cannot be proved.

3. Research strategies and methodological choices

The main issue to be solved is the identification and quantification of the impact of policies on China's economic transformation. As the research deepens, this question can be described in two phases: first, by evaluating the effects of policies and, second, by judging the values of these effects on economic transformation.

3.1. Research strategies

In the process of discussing the effects of economic policies on economic transformation, the content of the economic policies of the three major regions in the Yangtze River Basin should be examined. Then the effects of economic policies on the local government's impact on the direction of economic development should be assessed by comparing the policies of different regions based on their local conditions. At the same time, the local policies of the Yangtze River Basin should be compared with the general guidelines of the 14th Five-Year Plan of the central government to determine the guiding role of central government policies on local policies. This is a descriptive investigation, also known as a narrative report, which refers to a study whose results accurately describe the qualities or the overall image of some general or specific occurrence (Sandelowski, 2000). It explains the main patterns and characteristics of the crowded phenomena by gathering data, discovering the situation, and delivering information.

Second, using 2021 as the observational node, the role of local government policies in fostering local economic development and SMEs should be assessed. From a top-down perspective, it is more straightforward to conduct such research.

The first approach uses Data Envelopment Analysis (DEA model) to measure regional economic performance. To measure the economic effects of a policy numerically, the DEA model analyses input and output ratios using a linear algebraic equation. The second approach is to use the PSM-DID model to assess the effectiveness of policies on SMEs in these regions. Propensity Score Matching (PSM) is a statistical method for processing data from observational studies (Rosenbaum & Rubin, 1983). Because there are many biases and confounding variables in the data in observational studies for various reasons, the Propensity Score Matching method is designed to reduce the effects of these biases and confounding variables in order to make a more reasonable comparison between the experimental and the control groups (Altmann, 1974).

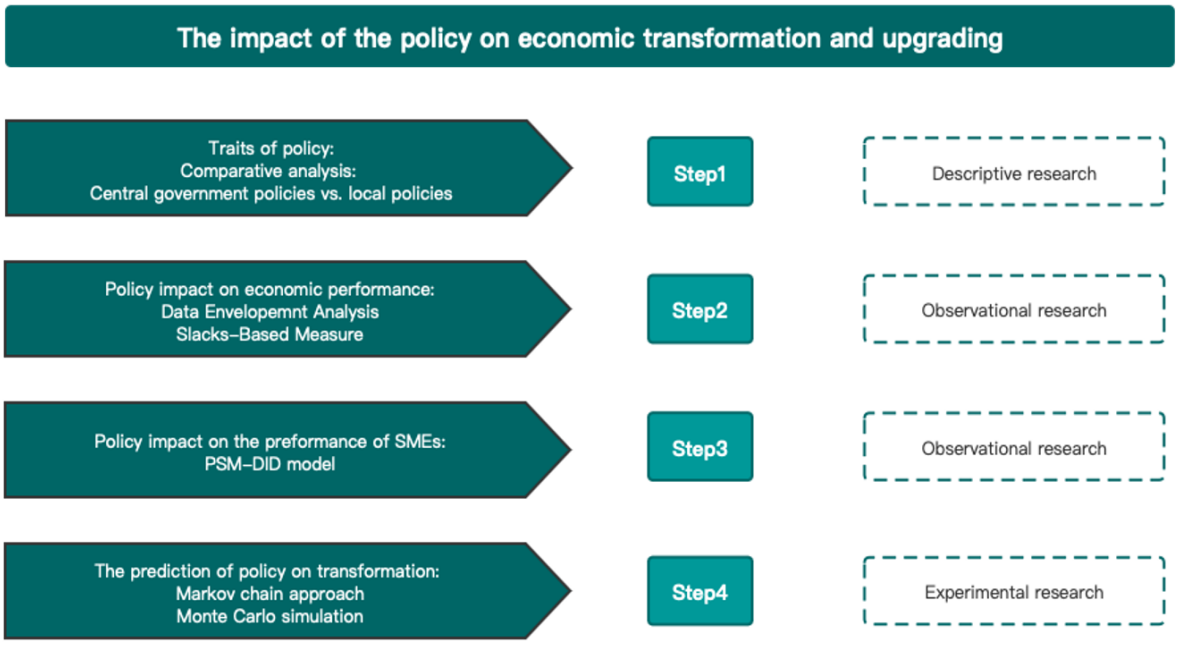

Figure 3. Strategies of research. *Source: Author's own work*

Finally, the function of policies in economic transformation should be explored. The probability of China's economic transformation into a technology and knowledge-based society should be predicted by gathering high-technology support from the economic policies of other countries worldwide. This should take the form of experimental research. It should start with a hypothesis, and then it should be tested randomly. A paper can include a large sample of data to determine whether the hypothesis is true or false (Ledyard, 2020).

Positive economics uses inductive reasoning to map the current situation of the economy. It usually gathers information and data to determine how the economy functions. With the information collected at this stage, the variables are divided into dependent and independent ones. It is impossible to detect the economic trajectory at the beginning of the process because many factors can present unexpected situations that may threaten and change the original growth path.

By conducting experimental research, one can find out how the economy is evolving and how it can be transformed. Therefore, the *Markov chain Monte Carlo (MCMC) approach* should be applied to calculate the probability of economic transformation and to predict the economy's future. In such an unexpected situation, multiple steps contribute to better prediction. Figure 3 contains the structured summary of the research strategy.

3.2. Methodological choices

A *qualitative analysis* considers contextual factors, making the research more complex (Elo & Kyngäs, 2008). The purpose of descriptive statistics is to generalize data using frequency and concentration trend analysis. Economic phenomena are analyzed based on their unique characteristics. As the demographic dividend disappears, China's GDP growth slows down. The road to economic recovery has encountered challenges due to the following factors:

- a localized multi-point distribution of domestic epidemics,
- frequent natural disasters such as heavy rains and floods,
- slowing global economic growth, and
- high raw material and energy prices.

Since science and technology are the current hot topic of economic development, the Chinese government will shift economic restructuring to promote science and technology innovation. A significant data source contributes to depicting the trend of the economic situation.

Comparative analysis is a necessary qualitative analysis for research. While the 14th Five-Year Plan's economic development goals are the same throughout the country, the development policies differ by region. By comparing the economic policies of different regions, one needs to find out the role of economic policies in promoting economic transformation at the level of the regions under survey.

The *quantitative method* focuses mainly on secondary data to assess the consequences of the execution of economic policies. Secondary data are derived from the National Bureau of Statistics of China, CSMAR, and the Wind-Data service database.

Popular methods of policy estimation include Instrumental-Variables, Regression-Discontinuity-Design, Data Envelopment Analysis (DEA), Difference-in-Differences (DID), and Propensity Score Matching (PSM), etc. Unlike traditional evaluation methods, *data envelopment analysis* eliminates the influence of subjective factors, reduces errors, and simplifies algorithms without sacrificing accuracy. The DEA is an empirical method for measuring the productivity efficiency of decision-making units (Charnes et al., 1978). There is no direct measure of the value or poorness of policy since this is highly subjective. Typically, the socioeconomic impact of policies is measured by comparing inputs and outputs. Since policy guidance will increase certain factors of production inputs, the productivity of output per unit of increased input will differ, so the DEA method can be used to track productivity in a more efficient way. For example, if the country strongly promotes science and technology innovation, the proportion of financial support for science and technology personnel will increase. This will raise social productivity.

Using the DID approach, unobservable factors can be included that can influence individuals' decisions about accepting the interventions of policies. Thus, the conditions for

policy evaluation can be relaxed, and policy evaluation can be made more realistic. With PSM, the treatment group, however, can find a control group with similar characteristics and determine the potential outcome of the treatment group in the opposite state through the non-treatment group in order to obtain an accurate estimate of the treatment effect (Cerulli, 2015). As a result, the analysis becomes more reliable and rigorous in the combination of DID and PSM methods. The PSM-DID model is mainly used to evaluate the effects of the 14th Five-Year Plan policies on SMEs after their implementation, with the Yangtze River Basin as the experimental group and other regions as the control group for comparative studies.

Based on the policy effects seen, an assessment with the Discrete-time Markov Chains can be made in response to whether the Yangtze River Basin region can achieve economic transformation successfully and avoid sliding into the middle-income trap. According to this paper's initial hypothesis, the current policy stimulus is assumed to assist the region in avoiding the middle-income trap and in transitioning to a new technology-intensive and knowledge-based economic trajectory.

Name	**Qualitative analysis**	**Quantitative method**		
Methods	Comparative Analysis	DEA-SBM	PSM-DID model	the Discrete-time Markov Chains
The reasons to select	Compare the economic policies of different regions and compare from a historical perspective.	1.The instrumental variables(IV) ignores the study subjects' heterogeneity, and the lagged variables' correlation problem cannot be removed. 2.The Regression Discontinuity Designor (RDD) has multiple breakpoints, which has fewer practice meaning. 3.Data Envelopment Analysis eliminates(DEA) measures the influence of subjective factors, reduces heterogeneity errors, and simplifies algorithms without sacrificing accuracy. It has more practical meanings.	The combination of PSM and DID, can firstly find a control group with similar characteristics and determine the potential outcome of the treatment group in the opposite state, and unobservable factors can also be included that can influence individuals' decisions about accepting policies' interventions.	Combine with the different stage outcomes before, the future predictions can be calculated by Markov Chains.

Figure 4. The comparison of methods. *Source: Author's own work*

4. Data collection

4.1. Data selection

In social research, questionnaires are frequently used to measure respondents' behaviours, attitudes, and social characteristics. People's perceptions and attitudes regarding economic changes are significant influencing factors when exploring the effects of policies. The implementation of a policy may have a variety of effects on people on various levels. For instance, quantitative easing measures (decreasing benchmark interest rates, etc.) will probably increase spending (the design of the survey is enclosed in the Appendix).

The data on economic indicators of different sectors are collected and sorted by the statistical offices in each region, which individuals cannot do. Thus, the data of the Main Bureau of Statistics are used as the primary data, and those deriving from the CSMAR databases and Wind databases as auxiliary data. Due to the limitations and other deficiencies of a single questionnaire, it is proposed to use secondary data. Data analysis will be conducted with the Stata software.

Quantitative second-hand information should be adjusted during use to ensure that research constructs can be quantified appropriately. The data collection should be based on the economic statistics of China's 14th Five-Year Plan, which are compared with the data of the 13th Five-Year Plan (from 2016 to 2021 vs. 2021 to 2025). Because the data types and requirements of the PSM and DID methods are different, the matching data should be adopted year by year, and then the DID results are calculated using the panel data. The next chapter describes the various indicators to be used in the subsequent model grouped according to criteria such as economic development, innovation, safety and security, people's welfare, and green ecology.

Since these models require a large amount of panel data, the collection process is rather specific. First, the data of 12 provinces in the Yangtze River basin are more comprehensive since provincial figures can be collected through the National Bureau of Statistics or statistical yearbooks. Second, if data are missing, this paper uses the mean-filling method. If there is a null value, the missing attribute value is filled based on the average of the values taken for that attribute in all other fields. This is due to regional differences in data. The conditional mean-filling method considers the mean of samples with the same characteristics as the absent sample. For the calculation of the conditional mean, we look for data of similar geographical locations and economic development levels. This can reduce data bias caused by missing regional data and will make the collected dataset more complete.

4.2. Description of proposed indicators

These indicators were mainly selected from the 14th Five-Year Plan. The questionnaire survey is a supplement for subjective assessment. Listed below are the definitions of these indicators (NDRC, 2021). Attached to the appendix is the expected data for the indicators in 2025. (See in the appendix).

Economic development indicators

Gross domestic product (GDP): a measure of the value added created by producing goods and services in a country.

Workforce productivity growth: a measure of a country's output per hour. It represents the amount of real GDP produced during one hour of labor.

Urbanization rate: population growth of an urban area is estimated over a given period.

Innovation-driven indicators

R&D spending growth: R&D expenditure will increase yearly in the 14th Five-Year Plan period in terms of its percentage share in GDP (hence referred to as R&D expenditure intensity). (NDRC, 2021)

The number of high-value invention patents (per 10,000 population): this is a newly proposed metric. By reviewing the number of patents possessed, the government will be able to promote the value of patents among intellectuals and raise public awareness of patents.

The added value of core industries in digit economy to GDP: digital transformation has enormous perspectives in emerging markets and developing countries. One country's technological ability can be measured through its values. The government should initiate relevant digital industry support policies when value-added decreases.

Safety & security indicators

Overall grain production capacity (hundreds of million tons): combined production capacity in a region's overall food output over a given period.

Overall energy production capacity (hundreds of million tons of standard coal): it includes coal, crude oil, natural gas, and non-fossil energy production capacity.

People's welfare indicators

The disposable income per capita (%): the portion of a resident's total household cash income that can be used to organize the household's everyday life.

Surveyed urban unemployment rate (%): aggregated data on urban employment and unemployment from a sample survey of the city's labour force status.

Years of education received by the working-age population on average: the number of years of study required to achieve a specific degree of education divided by the number of working-age people.

The number of certified (assistance) doctors (per 1,000 population): physicians have passed rigorous testing by the National Commission on Physician Assistant Certification.

Basic old-age insurance coverage: covered medical expenses for people over 60.

The number of nursery school places for infants under three years of age (per 1,000 people): an area for nursing and nurturing infants and toddlers under the age of 3 years. To develop health, it aims to support children's interaction and expression skills, self-knowledge, and responsibility.

Life expectancy per capita: the number of years an individual can expect to live.

Green ecology indicators

Energy consumption per unit of GDP decreases (%): all the energy used to act, create something, or inhabit a structure.

Carbon dioxide emission per unit of GDP decrease (%): the reduction of emissions resulting from the use of fossil fuels and the production of cement producing CO2.

Percentage of days with good air quality in cities at prefecture level and above: WHO defines "good and fresh air" as air with a concentration of negative oxygen ions above 1000-1500 per cubic centimetre in 2025 (WHO, 2017).

Percentage of surface water reaching grade III or above: people can drink and generally live with surface water that meets grade III standards (Su et al., 2017).

Forest coverage rate: an area where forests cover a certain proportion of the land in 2025.

People's perceptions indicators

Individual Life Change: researchers can see how people's lives have evolved in the three regions through the questionnaire. Whether there is a general increase or decrease trend, for instance, in the prices of clothing, food, housing, and transportation.

Life satisfaction: people's lives underwent a change in their level of social and economic participation and change, which resulted in a shift in how happy they felt.

Individual consumption expenditures: to feed the level of income and economic development through changes in consumer spending.

Figure 4 summarizes the macroeconomic indicators proposed to be used in the model in a specific, transparent format indicating the relationships among them.

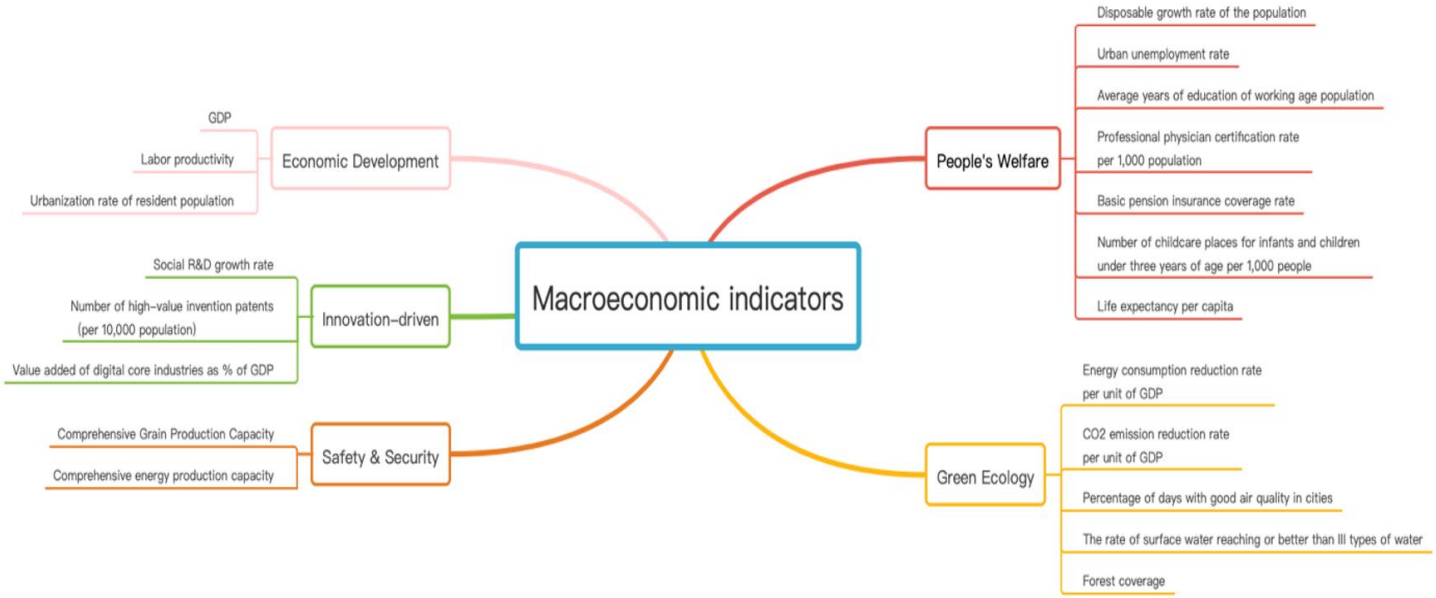

Figure 5. System of macroeconomic indicators. *Source: Author's own work*

5. Data analysis

5.1. Comparative analysis

Longitudinal comparisons

Time trend comparisons allow for assessing changes in metrics over time. The two periods of the five-year plans are compared to identify the core objectives of each cycle and the extent to which the objectives have been achieved over time.

Cross-sectional comparison

Comparison between regions: As mentioned before, three regions were selected based on the urban clusters, namely the middle and lower reaches of the Yangtze River. Because each region has different resources and cultures, the government's focus on developing the economy will differ. Therefore, comparing the development goals of each region and observing the differences in policy implementation and the effects of each region will help the region to develop better in the future.

Comparison of regional and central government policies: By identifying the similarities and the differences between the whole economy and the regions of the sample, one can come across other problems that arise when the central government implements policies for the regions and provides solutions to remedy them.

5.2. The DEA-SBM methods

Charnes et al.'s (1997) comparison of regional and central government policies: By identifying the similarities and the differences between the whole economy and the regions of the sample, one can come across other problems that arise when the central government implements policies for the regions and provide solutions to remedy them (Charnes et al., 1997).

Based on the DEA model, Tone (2001) proposed the SBM model as a non-radial measure of efficiency. In contrast to traditional CCR and BCC models, the SBM model does not require the input-output factors to grow simultaneously. It considers an input-output slackness problem, making its measurement of economic efficiency more realistic and accurate. Likewise, the factors of non-desired outputs are also taken into account. For example, the process of regional economic development not only produces goods and raises the income of people but also creates some environmental pollution, which is considered a non-desired output, as it does not contribute to the production, and it even has adverse effects.

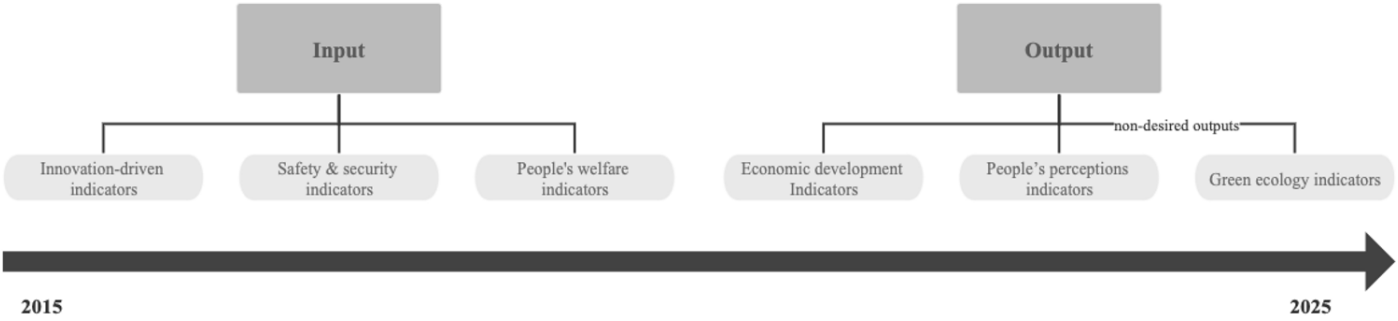

Figure 6. Design based on the DEA-SBM model. *Source: Author's own work*

The model setting of DEA-SBM

Step 1: Calculating the current year/ period standards efficiency from the non-angle. Decision-making units (DMU) are operational entities with m types of inputs and q types of outputs. In this case, the DMU is the economic performance of the digital economy. Based on the relevant data from 2015-2025, the SBM-DEA model could be used to calculate the overall efficiency value (TE), pure technical efficiency value (PTE), and scale efficiency value (SE) for urban agglomerations' economic performance during the 14th Five-Year Plan. With this technique, it is possible to calculate and analyze the operational efficiency of knowledge-based and technology-intensive economies.

$$\theta^* = \min_{\lambda, s^-, s^+} \frac{1 - \frac{1}{m}\sum_{i=1}^{m} \frac{S_i^-}{x_{i0}}}{1 + \frac{1}{q+h}\left(\sum_{r=1}^{q} \frac{S_r^+}{y_{r0}} + \sum_{k=1}^{h} \frac{S_k^-}{b_{k0}}\right)}$$

$$s.t\begin{cases} x_{i0} = \sum_{j=1}^{n} \lambda_j x_{ij} + S_i^-, \ i = 1, \ldots, m \\ y_{r0}{}^g = \sum_{j=1}^{n} \lambda_j y_{rj} - S_i^+, \ r = 1, \ldots, q \\ b_{k0}{}^b = \sum_{j=1}^{n} \lambda_j b_{kj} + S_k^-, \ k = 1, \ldots, h \end{cases}$$

θ^* : *The efficiency value of* $DUM(x_0, y_0)$

S_i^- : *Overload input*.

S_i^+ : *Insufficient output*.

$[x_{i0}]$ *is m input indicators, where*: $i = 1, 2, \ldots\ldots, m$.

$[y_{r0}]$ *is q output indicators, where*: $r = 1, 2, \ldots\ldots, q$.

$[b_{k0}]$ *is h non − desired output indicators, where*: $k = 1, 2, \ldots\ldots, h$.

Step 2: Calculate the whole period's super-efficiency from the non-angle. It is impossible to compare the efficiency of multiple decision-making units simultaneously if they are both efficient. Therefore, further measurement is done through super-efficiency. Super-efficiency can check the weak efficiency state in the process of calculation.

$$\theta^* = \min_{\lambda, s^-, s^+} \frac{1 + \frac{1}{m}\sum_{i=1}^{m} \frac{S_i^-}{x_{i0}{}^t}}{1 - \frac{1}{q+h}\left(\sum_{r=1}^{q} \frac{S_r^+}{y_{r0}{}^t} + \sum_{k=1}^{h} \frac{S_k^-}{b_{k0}{}^t}\right)}$$

$$s.t\begin{cases} x_{i0}{}^t \geq \sum_{t=1}^{T} \sum_{j=1}^{n} \lambda_j{}^t x_{ij}{}^t + S_i^-, \ i = 1, \ldots, m \\ y_{r0}{}^t \leq \sum_{t=1}^{T} \sum_{j=1}^{n} \lambda_j{}^t y_{rj}{}^t - S_i^+, \ r = 1, \ldots, q \\ b_{k0}{}^t \geq \sum_{t=1}^{T} \sum_{j=1}^{n} \lambda_j{}^t b_{kj}{}^t + S_k^-, \ k = 1, \ldots, h \end{cases}$$

$$When\ \theta^* = 1, the\ DEU\ is\ efficient.$$
$$When\ \theta^* < 1, The\ DEU\ is\ inefficient\ and\ there\ is\ a\ need\ to\ improve\ the\ output\ of\ the\ investment.$$

The current period's efficiency illustrates the productivity of different cities over time. By aggregating the productivity of the same city in different periods, the differences between the eastern and western regions can be compared, and the advantages and disadvantages of the eastern and western regions can be better determined. The individual regions' economic development policies and policy direction inputs are different. All other aspects, such as safety, innovation drive, etc. are similar. With all other highly identical aspects, policy implementation differences can be attributed to differences in policy orientation and local resources.

5.3. The PSM-DID methods analysis

The PSM-DID model

The Differences-in-Differences (DID) method is commonly used in policy evaluation impact studies, such as the analysis of 'incentive listing policies', 'epidemic-specific policies,' etc. to reveal the impact situation brought about by the effects (Cameron & Trivedi, 2005). The premise of the DID method is the "shock" assumption, in which every event that occurs during or after the intervention will equally affect both the treated and the control groups (Dimick & Ryan, 2014) and (Rubin, 1974).

$$treat_i = \begin{cases} 1, & \text{if } i \in \text{treatment group} \\ 0, & \text{if } i \in \text{control group} \end{cases} \qquad policies_i = \begin{cases} 1, & \text{if } i \in \text{post group} \\ 0, & \text{if } i \in \text{before group} \end{cases}$$

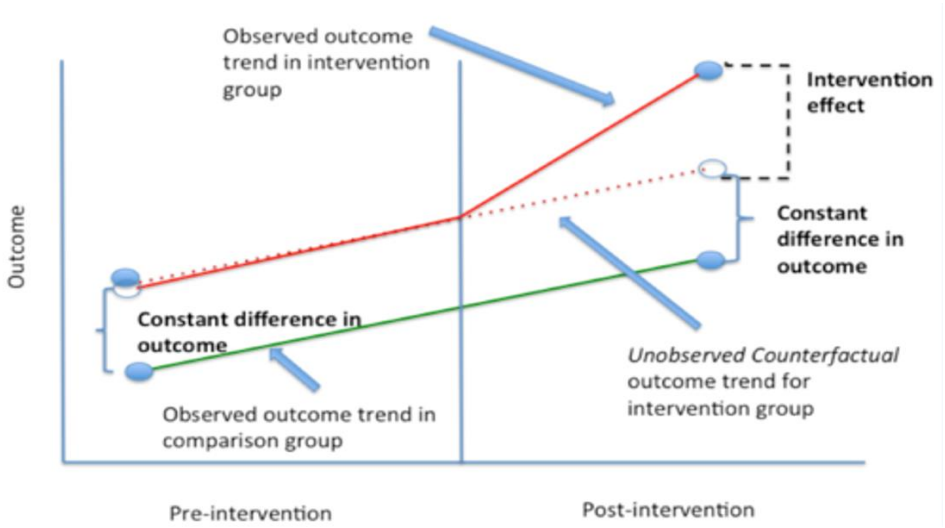

Figure 7. Differences-in-Differences (DID) design. *Source: Columbia University, n.d.*

Figures from panel data can be used to identify the two groups: the treatment group and the control group. Policy shock effects are realized by introducing dummy variables (Garrido et al., 2014), (Xin & Qu, 2019). The typical support assumptions and balancing assumptions of PSM must be satisfied. For any possible value of x, there is $0<p(x)<1$. The treatment and control groups overlap based on common support assumptions. This way, the treatment and control groups' propensity scores are equal. Given p (xi), Di is independent of xi. Based on the balancing assumption, the treatment is random for a given p (xi) (Heinrich et al., 2010). Propensity scores are obtained by logit regression, thereby reducing X from multidimensional to one-dimensional levels.

Unlike DID, PSM-DID considers personal differences between experimental and control groups. Also, compared to PSM, PSM-DID can accommodate unmeasured factors to include individual differences such as consumer preferences. The DID-PSM model was proposed by

Heckman (Heckman et al., 1998; Heckman et al., 1997). Based on the previous model, the PSM model looks for control groups that are feasible compared to the treatment group. The DID model is in charge of determining the impacts brought about by policy shocks. It is assumed that the treated team will have the same trends as the pre-treated group. In other words, no other factors will influence the outcomes (Dimick & Ryan, 2014). It was not easy to satisfy the parallel trend hypothesis under the basic study setting, so data processing by propensity score matching (PSM) was required.

Back to reality, there is no way to know what is happening on the other side of the parallel universe, so we can only list all the factors (confounders) that lead to the impact of SMEs and then find the SMEs where these factors are the same as the subject of the study (in the scope of a process called matching). If enterprise A enacts this policy and enterprise B does not, we subtract the effect of B from the effect of A to get the average treatment effect for the treated group (ATE).

To study the impact of policies on SMEs, we propose to use the PSM-DID model, which reflects the importance of SMEs to economic reforms. In the case of SMEs, the number of employees, business revenue, total assets, total liabilities, net profit, and income taxes constitute the internal factors, while policies can influence performance from outside.

The estimation steps of PSM-DID are roughly as follows.

Calculating Propensity Scores (PS) based on logits regression

$$
\begin{aligned}
Treat_{i,t} = & \\
& \beta_0 + \beta_1 Number\ of\ \ employees_{i,t} + \beta_2 Business\ revenue_{i,t} \\
& + \beta_3 Total\ assets_{i,t} + \beta_4 Total\ liabilities_{i,t} \\
& + \beta_5 Net\ profit_{i,t} + \beta_6 Income\ taxes_{i,t} \\
& + Policies + Year + \varepsilon_{i,t}
\end{aligned}
$$

The propensity matching score usually looks at the composition of the matched treatment and control group for comparison and requires a standard deviation of less than 10 per cent. It also looks at whether the matched sample has better-balanced data and shows a standard range of curvature. An individual's propensity to enter a treatment group (propensity value) can be calculated by using a "logit" model. A binary logit model was constructed with the study factor such as 'the treatment' as the dependent variable Y and other factors (business revenue, total assets, total liabilities, etc.) as independent variables X to confirm that all the selected variables affect treatment acceptance, which represents the overall level of confounding factors.

Matching

While matching data within a tolerable radius matching range (threshold), there are eight types of matching methods. In this paper, we use kernel matching. Heckman established superior sample qualities for a subset of ATET matching estimators (Cerulli, 2015; Heckman et al., 1998). The missing observation is estimated by the kernel types as follows.

Matching method	C(*i*)	*h*(*i*,*j*)
One-nearest-neighbor	$\{\text{Singleton } j : \min_j \|p_i - p_j\|\}$	1
M-nearest-neighbors	$\{\text{First}\, M\, j : \min_j \|p_i - p_j\|\}$	$\frac{1}{M}$
Radius	$\{j : \|p_i - p_j\| < r\}$	$\frac{1}{N_{C(i)}}$
Kernel	All control units (C)	$\frac{K_{ij}}{\sum_{j\in C} K_{ij}}$
Local-linear	All control units (C)	$\frac{K_{ij}L_i^2 - K_{ij}\hat{\Delta}_{ij}L_i^1}{\sum_{j\in C}\left(K_{ij}L_i^2 - K_{ij}\hat{\Delta}_{ij}L_i^1 + r_L\right)}$
Ridge	All control units (C)	$\frac{K_{ij}}{\sum_{j\in C} K_{ij}} + \frac{\tilde{\Delta}_{ij}}{\sum_{j\in C}\left(K_{ij}\tilde{\Delta}^2{}_{ij} + r_R h\|\tilde{\Delta}_{ij}\|\right)}$
Stratification	All control units (C)	$\frac{\sum_{b=1}^{B}\mathbf{1}[p(\mathbf{x}_i)\in I(b)]\cdot\mathbf{1}[p(\mathbf{x}_j)\in I(b)]}{\sum_{b=1}^{B}\mathbf{1}[p(\mathbf{x}_j)\in I(b)]}$

Figure 8. 8 methods of matching. *Source: Cerulli, 2015*

Using the DID model to compare the differences between the group

$$y_{it} = \alpha + \beta treat_i + \gamma policies_t + \delta treat_i \times policies_t + \sum_j \eta_j x_{i,t} + \varepsilon_{it}$$

β:captures group effects of treatment groups (inherent differences between treatment and control groups)

γ:controls for the time effect of the treatment period (inherent time trend before and after the treatment period)

x:for other control variables

δ:then represents the treatment effect (effect of exposure to policy shocks) for the treatment group during the treatment period

$$\widehat{ATET} = \frac{1}{N_1}\sum_{i\in\{D=1\}}\left\{Y_i - \widehat{Y_{0i}}\right\}$$

$$\widehat{ATENT} = \frac{1}{N_0}\sum_{i\in\{D=0\}}\left\{Y_{1i} - \widehat{Y_i}\right\}$$

$$\widehat{ATE} = \left(\frac{1}{N}\sum_i D_i\right)\times\widehat{ATET} + \left(\frac{1}{N}\sum_i (1 - D_i)\right)\times\widehat{ATENT}$$

$ATET = average\ treatment\ effect\ on\ treated$

$ATENT = average\ treatment\ effect\ on\ untreated$

$ATE = average\ treatment\ effect$

If the sample is in two timelines in parallel universes (all other conditions are identical), i.e., in treated one and in untreated one, this results in the following: a differential effect of one outcome is AE, and the average of this outcome is ATE.

We propose to address the SMEs that gain support from the policies as the treatment group and those that do not get the support as the control group. The control groups with similar situations are found through PSM, and then the 14th Five-Year Plan of the three cities is compared with other cities through DID. Therefore, a study of policy effects on SMEs can provide a deeper understanding of China's economic development and find the role of SMEs during the entire economic transformation.

5.4. Markov Chain Monte Carlo analysis

The most basic method is a Markov Chain Monte Carlo method based on Metropolis-Hastings. Markov Chain Monte Carlo (MCMC) is a Monte Carlo method that uses the Markov chain as a probabilistic model (Martin & Quinn, 2002). The Markov Chain Monte Carlo method constructs a Markov chain so that its smooth distribution is the distribution to be sampled. It then performs a random walk based on this Markov chain to generate a sequence of samples and then uses the samples from this smooth distribution to perform the approximate numerical computation. Hastings extended the original algorithm to its present form in 1970 (Hastings, 1970).

In previous studies, the income level was the only condition to predict future status. We added more conditions to the status by combining the previous results.

The estimation steps of MCMC are as follows.

Calculating the probability of distribution of income level

It is a stochastic process in state space that describes transitions from one state to another, and is named after Russian mathematician Markov, Andreĭ Andreevich (Markov, 1954).

From state *i* to state *j*, if one step is used:

$$p_{ij} = \Pr(X_1 = j \mid X_0 = i)$$

From state *i* to state *j*, if n steps are used:

$$p_{ij}^{(n)} = \Pr(X_n = j \mid X_0 = i) \quad i, j \in S$$

i status is set to $middle - income\ level$.

j state is set to $high - income\ level$.

The transfer probability satisfies:

$$\sum_{j=1}^{m} P_{ij} = 1 \quad i, j \in S$$

The set of states is denoted as *S* in this paper. The likelihood of being identical to a specific value *j* is determined solely by the most recent value and not by previous realizations.

Construct a Markov chain with a transfer matrix

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1m} \\ p_{21} & p_{22} & \cdots & p_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ p_{n1} & p_{n2} & \cdots & p_{nm} \end{bmatrix}$$

Status	Explanation
1st status	No economic performance efficiency (θ≠ 1) SMEs aren't significantly influncenced by the policies Low income level
2nd status	No/low economic performance efficiency(θ≠ 1,θ<0.5) SMEs are significantly influncenced by the policies Lower-middle income level
3rd status	No/low economic performance efficiency(θ≠ 1,θ>0.5) SMEs are significantly influncenced by the policies Higher-middle income level
4th status	High economic performance efficiency (θ= 1) SMEs significantly influncenced by the policies High income level

The classif ication of incomes level based on GNI per capita in current USD(dollers) :

Low income level: < 1046

Lower – middle income level: 1046 – 4095

Higher – middle income level: 4096 – 12695

Highe income level: > 12695

Figure 9. Divided by income level combined with the economic performance. *Source: Author's own*

By comparing each Chinese regional city's per capita GNI income levels, each region's state proportion of income level is determined, and the initial distribution of middle-income regions is given. A first-order Markov chain determines a country's per capita income level with time-invariant transition probabilities indicated as I = 1…, N and j = 1..., N. Each one reflects the likelihood that state i will be followed by state j. An analysis of the probability statistics of the transformation of all middle-income countries from industries dominated by labor income to high-technology-producing industries should be presented. The probability of economic transformation in China's Yangtze River Basin region is predicted by studying the probability of transfer in other middle-income countries.

Montel Carlo Simulation for prediction

If for any i, j, Detailed Balance Distribution (DBD) must satisfy:

$$\pi(i)\,P_{ij} = \pi(j)\,P_{ji}$$

P : *the transf er matrix of the Markov chain*.

$\pi(x)$:*the distribution of income level*.

However, the DBD cannot have perfect implications. Therefore, the equation introduces an acceptance probability $\alpha(i,j)$:

$$p(i)\,q(i,j)\,\alpha(i,j) = p(j)\,q(j,i)\,\alpha(i,j)$$

$$\alpha(i,j) = min\left\{\frac{p(j)\,q(j,i)}{p(i)\,q(i,j)}, 1\right\}$$

As a result of adding acceptance probabilities, the original Markov chain becomes a Markov chain with a new transfer matrix.

Spatial Markov Chain to predict the city cluster

Markov chains are used here to make predictions spatially as well as longitudinally. A spatial Markov chain method combines the characteristics of urban cluster development along the Yangtze River to find coherence and influence between the regions. Spatial Markov chains compensate for the shortcomings of the traditional Markov chain method by considering

spatial interaction between regional units. Therefore, regional economic growth differences and convergence should be examined.

Converting the traditional Markov chain from one-dimensional to two-dimensional, i.e., the $k \times k$ transfer probability matrix: Based on the product of regional attribute values and a spatial weight matrix, the spatial lag value is calculated as a spatially weighted average of the attribute values within the region (Koo, 2005).

$$The\ spatial\ lag\ value = \sum_j w_{ij} x_j$$

$$w_{ij} = \begin{cases} e^{\frac{1}{\varphi d_{ij}} + \frac{1}{\left|\overline{x_j} - \overline{x_i}\right|}}, i \neq j \\ 0,\ i = j \end{cases}$$

w_{ij}: *the elements in the spatial weight matrix* W.

x_j: *the observed values of the variables* (*etc*. *GDP values*) *in region* j.

φ: *the weight of coeffficient*.

d_{ij}: *the shortest linear distance from i city to j city*.

$\overline{x}$: $E(x)$

Consequently, Markov Chains should be used to calculate the probability of China's economic transformation based on the probability of each middle-income country's economic transformation. Monte Carlo Simulation gives detailed forecasts. It shows the possibility that each outcome will occur during the forecast period at a projected time.

6. Robustness Test--Placebo Test

A placebo test is derived from a randomized trial in medicine, such as testing the efficacy of a new treatment (Seabra et al., 2000). To avoid the experiment effect caused by subjective psychological effects, the population participating in the investigation can be randomly divided into two groups, one of which is the experimental group taking the actual drug. The other group is the control group taking a placebo (for example, useless sugar pills). The participants are not informed whether they are taking the actual drug or the placebo (placebo effect). It is a counterfactual test. In economics, it is often a test of a policy assuming whether any effect would be perceivable if the policy did not exist.

6.1. Cause-and-Effect Relationship

One of the main objectives of econometric analysis is to reveal causal relationships, and the endogeneity of the treatment is a significant key to accurate causal identification. There are three causes of endogenous bidirectional causality: missing variables, measurement mistakes, and measurement errors (Elwert & Winship, 2014). It is acceptable to worry about endogeneity when the research topic is the evaluation of policy effectiveness. In general, policy formulation and implementation are exogenous factors from the point of view of microeconomic entities: first, only omitted variables related to policy shocks affect the results; second, policy implementation and policy targeting are not significant.

$$y_t = c + \alpha y_{t-1} + \beta y_{t-1} + \ldots + \gamma y_{t-n} + e_t$$

y: *economic perfformace indicators*, *i*.*e GDP*.

t: *the preiods from* 2015 *to*2025.

Developed by Sims (1980), the vector autoregressive model (VAR) estimates the dynamic relationships between joint endogenous variables without any prior constraint (Bernanke et al., 1997). Analyzing the intrinsic patterns of economic operations can be used

to observe whether the economy would follow the given trajectory even without policy implementation. The policy has no natural effect if the economic forecast and actual economic indicators are consistent.

6.2. Change Time Window Test

One option is to adjust the point at which the policy takes effect. This includes the point at which the policy is implemented in the preceding treatment group. At this point, the placebo test serves the same purpose as the parallel trend test, which is to examine the coefficients of the time dummy variables in the regression of the base before the occurrence of policy and the interaction term of the treatment group for significance (F (-1), F (-2), F (-3),...). If this is not significant, the test passes. In addition, a more generic method is to randomize the time point at which the policy occurs, i.e., antecedent or posterior to the time point.

The fictional policy time was rolled back (Chen & Li, 2012). In this report, the implementation date of the 14th Five-Year Plan is shifted from 2021 to 2016, bringing the temporal effect ahead by five years. For this, we suppose the computed coefficients of the fictional policy variables are insignificant. In that case, the coefficients suggest no systematic difference in the economic development trajectory between the treatment and the control group provinces after omitting the effect of the 14th Five-Year Plan policy.

6.3. Randomizing the treatment group

The first method, the change time window test, has the disadvantage that if the sample period is short, resulting in too short a time interval for random sampling, the conclusions may not be accurate (Tucker, 2014). Even if the number of samples is large, the small sampling space will affect the robustness of the results.

Changes in the treatment and control groups are likely influenced by other policies implemented during the same period. When changing the time of policy implementation is not adequate, a placebo test on the treatment group should be performed this time (Liu & Zhao, 2015).

For example, if the innovative drive is taken as a random variable and its data is randomized, then the steps should be as follows:

- Individual samples of the core variables (innovative drive) should be eliminated from the original data set.
- The deleted core variables should be randomly disordered, and the randomized innovation drivers should be combined into the processed original dataset.
- The randomized data should be entered into the regression equation, and the procedure should be repeated 1,000 times.
- The coefficients and standard errors of the innovation drivers should be extracted from the 1,000 regressions. The kernel density distribution of the coefficients and t-values and the p-value coefficient scatter plot should be presented independently.

7. Research limitations

Concerning this research, nonetheless, many constraints should be mentioned. There needs to be more data from the Main Bureau of Statistics in specific periods, which puts tremendous pressure on data collection. The satisfaction data sample needs to be expanded for a more comprehensive evaluation.

The type of data matching could be a limiting factor of the research. The PSM model uses cross-sectional data, whereas the DID model uses panel data. Each cross-sectional period of the panel data is matched period by period. Period-by-period matching is an excellent solution to the “temporal mismatch” problem. However, it has one disadvantage: the control group’s instability (period-by-period matching cannot filter the DID model to a stable control group, and individuals in the treatment group may have different matches in each

period). Period-by-period matching can solve these matching mistakes. Therefore, efforts should be made to clear the data in the and change the method to evaluate the impact of the 14th Five-Year Plan policies.

Most economic policy models are measured indirectly. Policies are evaluated based on the performance efficiency of the socio-economy and their utility for different industries of SMEs. The functioning of a society is a complex system, and external factors affect the economy more than only through one policy. Therefore, it takes efforts to attribute economic efficiency to government policy directly.

8. Summary and conclusions

China's economic transformation as a research field is rich in relevant, challenging literature sources. This conceptual paper lays out the methodology for a quantitative study for China's new economic trajectory. In addition, it provides a methodological basis for further research based on secondary data (statistics) and primary data (questionnaires). Under the given conditions, China's 14th Five-Year Plan contains basic background information with its qualitative economic objectives and specific quantitative figures focusing on SMEs, which are assumed to be one of the main driving forces of changes. Based on some theoretical and practical considerations, this regional approach offers the chance of gaining a better view of the processes to be analyzed than a discussion on the macroeconomic level.

Research philosophies comprising the combination of positive and normative economics are recommended for the analysis of economic development. The 14th Five-Year Plan's economic indicators should be used to measure economic development in quantitative terms and changes in a comprehensive way, they also should be used to optimize the failure to achieve the expected economic value, and the economic indicators of the 14th Five-Year Plan should be used to lay the foundation for the economic indicators of the 15th Five-Year Plan. Normative economics predicts the process of implementing policies. Observing how regional economies change and develop under the influence of economic policies will assist in determining which policies are effective and which need to be improved.

The research methodology contains three main types of quantitative methods and one qualitative method to gain a full and comprehensive understanding of the economic growth trajectory. Comparative analysis helps identify the different traits of regions. Analyzing the impacts of policies can also be conducted using the DEA-SBM and the PSM-DID models. To maximize economic efficiency in a region, the DEA-SBM model compares its economic performance with that of a group of similar areas under the influence of the same policies. The PSM-DID methodology is closer to reality since it allows for the identification of visible policy repercussions and changes. Regarding the prediction, the Markov Chain Model primarily helps calculate the likelihood of the escape of these three regions from the middle-income trap.

The main contribution of this paper to the existing body of knowledge is the proposition of a comprehensive model for evaluating economic development. By exploring the role of economic policies, a deeper understanding could be obtained of how the economy should be reformed and developed. Despite this, some limitations should be considered. The first major limitation concerns the selection of indicators. The set of the current indicators is only in the exploratory stage; therefore, the construction of the indicator system could be better and should partially reflect the state of economic development. The problem may arise that a limited dataset can only partially reflect some phenomena. Second, there is the risk that the model's flaws will bias the conclusions.

This paper contains methodological foundation for further discussion and analysis. The most important future research direction is to apply this framework to qualitative analyses and impact assessments by filling the models and indicators with concrete figures.

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