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# Development and Elucidation of a System Dynamics Approach for Modeling National Production Growth

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**Abstract**

*This study seeks to develop and explicate a system dynamics model for national production growth. The validation of a simulated model and the evaluation of a designed model's structure and behavior were carried out. University experts familiar with the research topic were selected through snowball sampling for the qualitative phase. The quantitative sample included senior managers, supervisors, production managers, and sales managers from active companies in Yazd, obtained through convenience sampling. Thematic coding using MAXQDA software was employed for qualitative data analysis, while Vensim software was used with a 95% confidence level for the quantitative analysis. The research findings demonstrate that economic, technological, social, environmental, cultural, and political indicators significantly influence national production growth within the system dynamics framework. Furthermore, the simulation of the designed model reveals the most influential factors in specific production indicators: production quality improvement (dynamic coefficient: 0.933) for technological production, knowledge-based production culture improvement (dynamic coefficient: 0.931) for cultural production, production leap policies (dynamic coefficient: 0.884) for political production, employment rate improvement (dynamic coefficient: 0.862) for economic production, social welfare enhancement (dynamic coefficient: 0.847) for social production, and green supply chain management (dynamic coefficient: 0.816) for environmental production.*

***Keywords:*** *Model, National production growth, System dynamics.*

## 1. Introduction

One of the primary goals of governments in the economic realm is to actively work towards increasing per capita production and improving societal well-being. It is considered crucial for governments to identify the factors that influence per capita production and industrial prosperity, both in the short and long term (Mohammadi et al., 2017). According to Noori (2019), economic growth in any society directly results from productive output. Production growth, regarding quantity and quality, signifies economic progress and an enhanced economic situation. Therefore, giving special attention to production is imperative since an increase in consumption without a corresponding

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increase in production leads to a lack of economic growth within society. Studies indicate that Iran's challenges do not stem from a scarcity of natural resources or a shortage of skilled individuals but rather from unproductive behaviors that fail to generate benefits and neglect the pursuit of necessary advantages in a balanced manner (Dehghani and Naaseh, 2019). Consequently, with a comprehensive understanding of these issues in recent years, the Supreme Leader of Iran has identified the economy as a critical and sensitive subject, shedding light on its strengths and weaknesses. Through his guidance, he has consistently emphasized the crucial role of the economy and economic activities to both officials and the general population. This emphasis arises from recognizing that achieving prosperity in production requires implementing specific policies suitable for each period. Iran's economy encounters challenges during difficult times, necessitating the adoption of appropriate and sensitive policies. Therefore, it is essential to carefully examine the current conditions and identify the key variables contributing to national production's prosperity. This approach ensures the preservation of the existing state of production and employment through well-informed decision-making.

However, there is a lack of documented research in Iran regarding identifying and understanding the dynamic relationships and interactions among various factors influencing production growth and industrial value-added (Molaei and Sahraei, 2014). Shi and Gill (2005) argue that to comprehend the behavior of a system, individuals must adopt a systemic perspective and understand the different interactions within it. This understanding can be achieved by studying and recognizing all the components and their relationships within the system. The objective of modeling dynamic systems is to gain insights into system relationships and explore potential improvement policies.

Recognizing the importance of developing a specific model for production prosperity, researchers attempt to present a dynamic system model that incorporates the factors influencing production prosperity by utilizing existing theories in this field. Since one of the aims of modeling dynamic systems is to examine various policies and scenarios and their impact on system performance, it is essential to design a comprehensive model considering Iran's cultural and economic context. It will allow the model's simulation results to be broadly applicable in the long term. Given the complexities associated with national-level production, employing the system dynamics approach in designing a model for factors influencing production prosperity enables a more thorough and accurate examination of the impact of each factor on the formation of the production prosperity model. Through simulation and validation of this model, a representation that closely reflects real-world conditions can be achieved. Therefore, the present research intends to fill the gap by developing a production prosperity model applying the system dynamics approach.

## 2. Literature review

The term "production" pertains to providing goods and services, encompassing all stages involved in creating consumer, intermediate, and capital goods for use by economic agents, including producers and consumers. Alongside tangible goods and services, production entails the generation of employment opportunities for factors of production and the generation of value-added and income for their owners, such as labor and capital owners (Audretsch et al., 2016). Production is the most active element in generating income and promoting economic development, resulting from the involvement of capital and labor. Production, summarized as "creating something useful," is crucial in enhancing the economic situation, even in the face of sanctions. Iran's Supreme Leader has underscored the importance of supporting domestic production and its prosperity, recognizing it as the backbone of a resilient economy (Ghafari et al., 2019). According to Shafia and Mousavi Loghman (2015), national production significantly boosts employment and reduces imports. Moreover, it bears psychological effects such as

fostering self-confidence, nurturing national pride, and shaping individuals' identities. Furthermore, economic independence is attained through the path of production.

According to Asghari (2017), despite progress in various sectors, Iran has struggled to achieve significant success in the economic sector and stabilize the country's production and employment market. To address this, relying on domestic production and leveraging the country's internal capabilities can activate the employment market, a crucial aspect of Iran's economy and social well-being. Expanding national production has a critical impact on improving people's living standards. The unemployment rate decreases by fostering a thriving production sector, improving living conditions for individuals reliant on the production sector. Simply put, the cycle of economic activities contributes to enhancing people's lives. This improvement in living standards also fosters collective self-confidence (Carriquiry & Elobeid, 2016). Samieenasab (2018) highlights that despite repeated efforts to achieve economic progress, Iran has deviated from its goals, squandering its resources in specific years. The economic structure of Iran lacks a solid foundation based on self-sufficiency, dynamic and comprehensive economic development, and the ability to adapt to external shocks. Bakhtiari and Afghah (2017) argue that production in Iran has faced significant and persistent obstacles over the years, stemming from internal and external factors. These obstacles can be categorized as economic and non-economic barriers, consistently limiting the country's production potential. Consequently, Iran's economy relies heavily on oil exports, making it susceptible to significant fluctuations caused by oil revenues.

According to Madadi (2020), production prosperity is a crucial concept that involves identifying priorities, meeting societal needs, and focusing on production for export. By catering to national requirements and export demands, production prosperity can enhance independence and contribute to national security. Pahlavanzadeh (2019) emphasizes that production prosperity yields multiple effects and consequences, such as achieving economic independence and self-sufficiency, mitigating the impact of foreign product sanctions, preventing negative cultural effects, fostering economic growth, creating employment opportunities, reducing inflation, instilling confidence in youth and society, curbing capital flight, improving social welfare, enhancing the quantity and quality of domestic production to compete with foreign products, reducing liquidity in society, directing idle capital towards production, and decreasing the inflation rate. Jahanian and Abdolmaleki (2019) argue that recognizing the importance and necessity of production prosperity lies in understanding its effects and consequences. Establishing and organizing domestic production can bring about fundamental changes in the national economy, ultimately improving people's livelihoods, particularly in addressing economic problems and challenges. Increasing domestic production contributes to the growth of exports, leading to higher national income and production levels.

Numerous research studies have been conducted nationally and internationally to examine the factors influencing production prosperity and its specific details. However, a notable gap exists regarding a comprehensive model that identifies the influential factors and explores their relationships. For instance, Khalilian Ashkezari (2019) addresses the challenges, strategies, and requirements for production prosperity in the Islamic Republic of Iran in an article titled "Challenges, Strategies, and Requirements for Prosperity of Production in the Islamic Republic of Iran." The author highlights five significant obstacles hindering production prosperity in the country, including economic dependency, the performance of banks in providing facilities, rampant smuggling and imports, management errors in the political-economic sphere, and lack of transparency in production. Several strategies are proposed to overcome these obstacles, including aligning the educational system with production growth and requirements, promoting knowledge-based and indigenous implementation, controlling the money and capital market, cost assessment of excessive and non-useful economic activities, managing the

economy by the principles of resistance economy, and establishing a comprehensive financial information database.

Ashiri (2019), in a commentary titled "Supportive Systems for the Prosperity of Production in the Theory of Resistance Economy," introduces critical systems that contribute to national production prosperity. By critically and analytically analyzing Iran's political-economic issues, the author explains how these systems impact national production's sustainability and addresses the importance of focusing on production prosperity for officials and implementers of the system.

Ghafari et al. (2019) conducted a research study titled "An Analytical-Exploratory Analysis of the Supreme Leader of Iran's Statements in Presenting the Model of Production Prosperity." The study highlights the outcomes of achieving production prosperity based on the statements of Iran's Supreme Leader. These outcomes include increased employment, sustainable economic growth, enhanced economic resilience, national pride and enthusiasm, export development, and social justice. The research presents a conceptual model in three stages: identification of open identifiers, central concepts, and selected concepts. The model consists of 28,245 open identifiers, 199 concepts, and 32 core principles centered around the idea of the "production epic." This innovative approach aids executive policymakers in making systematic decisions regarding production prosperity.

In another research study titled "Resistance Economy and Challenges of Production in Iran" by Darijani and Fallahi (2017), the authors emphasize the Supreme Leader of Iran's focus on production and employment due to their significance in the country's current conditions. Identifying the challenges faced by the production sector in the Iranian economy is deemed crucial. The government can address poverty and unemployment by examining the strengths and weaknesses of the economy in the production sector and implementing effective economic planning for national production prosperity. The study reveals several problems in the production sector, including the neglect of small and medium-sized enterprises, production dependence on imports, high opportunity costs of investing in the productive sector, macroeconomic uncertainty, an unfavorable business environment, reliance on oil revenues, low productivity, limited position of innovative businesses, and the neglect of non-operational defense and knowledge-based economy.

Pilati (2019) suggests in their research study titled "Geographical Design of the European Union's Industrial Strategy: Policy Summaries" that the Fourth Industrial Revolution, influenced by technological changes, is transforming traditional models of production and growth. This transformation is driven by global value chains, automation, digitization, services, and innovation. However, the author highlights the risk of regional inequalities as the benefits of this transformation may be concentrated in specific areas. To mitigate this, the future industrial strategy of the European Union should actively target and involve all regions to ensure their participation in the transformation and reduce disparities.

In a research study titled "Performance Measurement for Global Production: A Model for the Italian Automotive Industry," Petrillo et al. (2018) emphasize the importance of examining production processes to minimize costs and enhance customer services for increased competitiveness. Optimization principles—including putting global production into practice worldwide—are acknowledged as valuable tools to accomplish these objectives.

Burney et al. (2018) conducted a research study titled "The Role of Long-Term Oil Revenues in Kuwait's Production and Growth Development." They find that oil revenues and technological advancements significantly impact domestic production in the long term. Furthermore, oil shocks and the stock market have a substantial long-term influence on Kuwait's actual production. The study employs a dynamic classifying model to explore these relationships.

Eshaghi (2012) identifies various barriers to achieving national production. These barriers include issues arising from existing laws and regulations, inconsistencies in financial and credit institutions, lack of confidence in investment, external conditions, smuggling and unregulated imports, and obstacles to exporting domestic products.

Overall, these research studies shed light on different aspects of production and growth. They address regional inequalities in industrial strategies, performance measurement for global production, the role of oil revenues in production and growth, and barriers to achieving national production.

## 3. Research Methods

The present research aims to have a practical and exploratory nature, focusing on identifying and extracting factors and components that influence the improvement and prosperity of national production. The research methodology involves content analysis, exploratory interviews with experts, thematic coding methods, and the system dynamics approach.

A content analysis of domestic and foreign research is conducted to identify the factors and components. Additionally, exploratory interviews are carried out with experts with sufficient research backgrounds in production. Thematic coding methods, including open, axial, and selective coding, are employed to analyze the data and extract the critical factors.

In the next stage, expert opinions are sought to determine the relationships between variables and formulate dynamic hypotheses. A production prosperity model uses the system dynamics, incorporating causal loop diagrams and flowcharts. A simulation model of the system is developed, and the designed model is validated in terms of structure and behavior.

Regarding the research population, sample, and sampling method, the study is divided into two sections: qualitative and quantitative.

1. Qualitative Section: The research population for exploratory interviews consists of academic experts with sufficient research backgrounds in the production field. Since the exact size of this population is unknown, the snowball sampling method is employed. The researcher conducts 15 interviews with the desired experts to collect qualitative data.

2. Quantitative Section: For examining the importance, prioritization, and validation of factors and components, the research population comprises senior managers, supervisors, production managers, and sales managers from selected active companies in Yazd. Convenience sampling is used to obtain quantitative data from this population.

By employing a combination of qualitative and quantitative research methods and involving experts from academia and industry, the research aims to provide practical insights and develop a comprehensive model for production prosperity.

The data collection tools used in this research include both qualitative and quantitative methods. Here is a breakdown of the tools used in each stage:

Qualitative Stage:

1. Library Studies: Extensive literature reviews use books, journals, databases, and websites relevant to the research topic. It helps in identifying influential factors and components for promoting national production.

2. Exploratory Interviews: Targeted interviews are conducted with academic experts with sufficient research backgrounds in production. These interviews are conducted after the literature review to gather expert opinions and insights. The interviews typically last

between 45 minutes and 1 hour. The researcher asks three main questions related to the factors, challenges, and suggestions for promoting national production:

1. Given the country's current situation, what factors and indicators should be considered for promoting national production, and how should they be addressed?

2. What are the problems and challenges in promoting national production in the current situation?

3. What suggestions do you propose for promoting national production?

To ensure the validity and reliability of the qualitative data, the researcher takes several steps. The derived codes from the interviews are presented to individuals who are not participants to enhance the accuracy of the data. The researcher also reviews and compares the codes repeatedly to increase accuracy and establish relationships between the codes and derived components, thus improving the validity and reliability of the components.

Quantitative Stage:

Questionnaire: A questionnaire is developed based on the identified factors and components from the qualitative stage. The questionnaire is designed to measure the importance and prioritization of these factors. Its validity and reliability are validated before use. The questionnaire is used to survey experts to identify the most influential factors and to identify the relationships between variables in the designed model using the analytical approach of system dynamics.

The validity and reliability of the tools used in both the qualitative and quantitative sections are examined in the study. These measures ensure the accuracy and consistency of the data collected and enhance the validity and reliability of the research findings.

2. In the quantitative section of the research, content validity was utilized to assess the validity of the questionnaire. Content validity involves obtaining expert judgments on the relevance and appropriateness of the test questions about the research objectives and content. This study designed the questionnaire based on the dimensions and indicators identified in the qualitative research section. University experts then reviewed it, and the questionnaire was validated with their feedback and modifications.

A 5-point Likert scale, extending from 1 (minimum score) to 5 (maximum score), was utilized to evaluate the questionnaire responses. This scale allowed participants to rate their agreement or disagreement with the questionnaire.

The Cronbach's alpha coefficient was calculated to evaluate the reliability and internal consistency of the questionnaire. The obtained value of 0.786 indicates good reliability for the entire questionnaire, suggesting that the items are internally consistent.

As the research methodology incorporates mixed methods, the data analysis is conducted at two levels:

a) Qualitative data analysis: The opinions gathered from the interviews with experts (15 experts) were analyzed using thematic coding, specifically open, axial, and selective coding. Initial codes were extracted from the interview transcripts and combined to create aggregate codes. Components and related dimensions were proposed by reviewing and integrating these aggregate codes. The software used for this qualitative data analysis was MAXQDA.

b) Quantitative data analysis: The collected data from the completed questionnaires was analyzed using Vensim software. This software was used for designing and modeling the research model based on the system dynamics approach, allowing for quantitative analysis of the data collected from the survey.

The research aims to comprehensively understand the influential factors and components related to national production and develop a dynamic model based on the system dynamics approach by employing qualitative and quantitative data analysis methods.

## 4. Research Findings

### 4.1. Qualitative Findings

During the winter of 2021, targeted interviews were conducted with 15 university experts with relevant experience to capture their opinions for the qualitative portion of the research. Based on the outputs obtained from the interviews, relevant coding was performed in the following three stages:

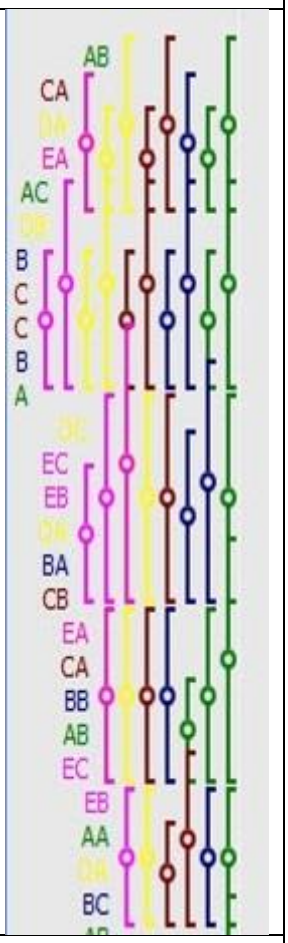
a) Open coding: Generating concepts and their characteristics (creating initial codes)

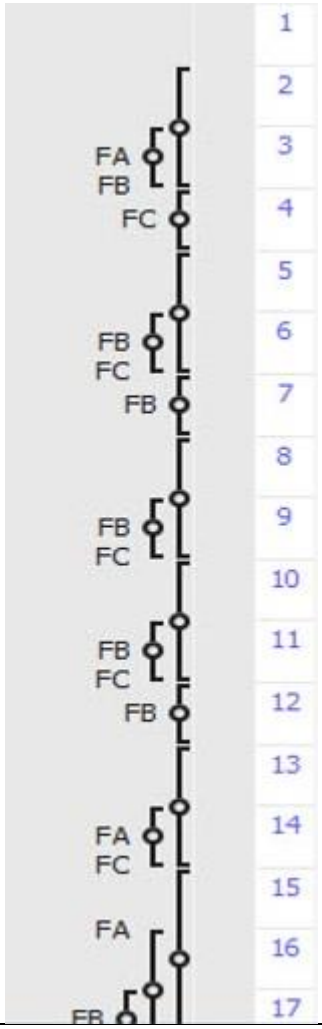
Based on the extant models in the literature and the specialists' emphasis on variables and indicators in qualitative methodology, the key concepts were extracted at this stage to select the terms for the research themes. Here, some of the outputs from the targeted expert interviews are presented.

Table 1: An example of coding by MAXQDA software

**Document Browser: Interview Analysis**

| **Main variables** / Experts | **Variable A** | **Variable B** | **Variable C** | **Variable D** | **Variable E** |
|---|---|---|---|---|---|
| Expert 1 | Index AA Index AB | Index BA | Index CA Index CB | Index DA Index DB | Index EA |
| Expert 2 | Index AB Index AC | Index BB Index BC | Index CB Index CC | Index DA Index DC | Index EB Index EC |
| Expert 3 | Index AB | Index BA Index BC | Index CA | Index DA | Index EA Index EB Index EC |
| Expert 4 | Index AA Index AB Index AC | Index BC | Index CC | Index DC | Index EA |
| Expert 5 | Index AC | Index BA | Index CB Index CC | Index DC | Index EC |
| Expert 6 | Index AA | Index BA | | Index DB | Index EB |



| Document Browser: Interview Output | |
|---|---|
| Variable F |  |
| Index FA<br>Index FB | |
| Index FC | |
| Index FB<br>Index FC | |
| Index FB | |
| Index FB<br>Index FC | |
| Index FB<br>Index FC | |
| Index FB | |
| Index FA<br>Index FC | |
| Index FA<br>Index FB<br>Index FC | |



The structure of a purposeful interview in the Document Browser section of MAXQDA software demonstrates that economic production indicators, technological production indicators, social production indicators, environmental production indicators, cultural production indicators, and political production indicators are the main concepts of the research.

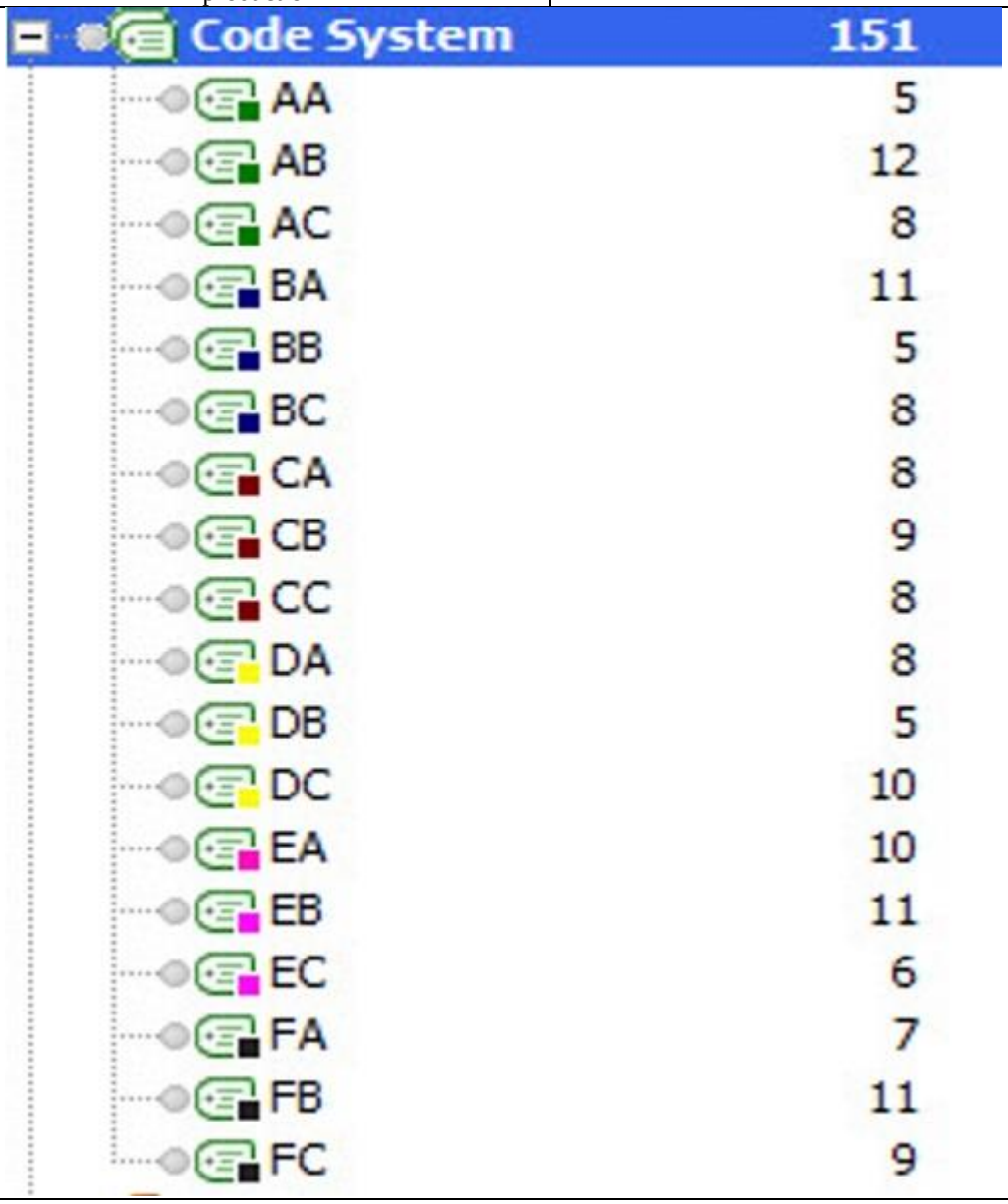
b) Central Coding: Establishing concept relationships (concept searching)

In this stage, connections are established among the main concepts to select terms for research content.

Table 2: Communication between concepts based on the coding matrix

| **Economic indicators of production** | **Social indicators of production** |
|---|---|
| The factor of reducing the real rate of inflation | Factor to improve social entrepreneurship |
| Factor to improve the employment rate | Social welfare promotion factor |
| The factor of promoting the gross domestic product | A factor in reducing crime caused by unemployment |
| Technological indicators of production | Environmental indicators of production |
| The factor of increasing the rate of production | Management of green materials |
| The factor of increasing production diversity | Green supply chain management |
| The factor of increasing production quality | Green production management |
| Cultural indicators of production | Political indicators of production |
| Promotion of the culture of supporting national production | Resistance economy policies |

| Creating an optimal consumption culture | Production jump policies |
|---|---|
| Improving the culture of knowledge-based production | Economic independence policies |




The distribution of expert responses in the content categorization of the research reveals that each of the six main research variables is associated with three identified indicators. The "Economic Production Indicators" component includes indicators related to factors that reduce the real inflation rate, improve the employment rate, and enhance gross domestic product (GDP) growth. In the "Technological Production Indicators" component, indicators focus on factors that increase production speed, enhance production diversity, and improve production quality. The "Social Production Indicators" component encompasses indicators related to factors that improve social entrepreneurship, enhance social welfare, and reduce the negative impact of unemployment. Within the "Environmental Production Indicators" component, indicators cover aspects such as green material management, supply chain management, and production management. The "Cultural Production Indicators" component includes indicators relating to promoting a culture supporting national production, establishing a culture of optimal consumption, and improving a knowledge-based production culture. Lastly, the "Political Production Indicators" component encompasses indicators related to

policies of a resilient economy, policies of production leap, and policies of economic independence.

c) Selective coding: integration and improvement of concepts (revision of concepts)

At this point, concepts have been integrated and enhanced in the software to select the keywords for the research topics.

Table 3: Integration and improvement of research concepts

| |
|---|
| Economic indicators of production (A) |
| The factor of reducing the real rate of inflation (AA) |
| Factor to improve the employment rate (AB) |
| The factor of promoting the gross domestic product (AC) |
| Technological indicators of production (B) |
| The factor of increasing the rate of production (BA) |
| The factor of increasing production diversity (BB) |
| The factor of increasing production quality (BC) |
| Cultural indicators of production (C) |
| Promotion of the culture of supporting national production (CA) |
| Creating an optimal consumption culture (CB) |
| Improving the culture of knowledge-based production (CC) |
| Social indicators of production (D) |
| Factor to improve social entrepreneurship (DA) |
| Social welfare promotion factor (DB) |
| A factor in reducing crime caused by unemployment (DC) |
| Environmental indicators of production (E) |
| Management of green materials (EA) |
| Green supply chain management (EB) |
| Green production management (EC) |
| Political indicators of production (F) |
| Resistance economy policies (FA) |
| Production jump policies (FB) |
| Economic independence policies (FC) |

The most frequent indicators for the main variables are as follows:

1. In the "Economic Production Indicators" component (Code A), the factor that improves the employment rate (Code AB) has the highest frequency. It was selected by 12 out of 15 expert respondents.

2. In the "Political Production Indicators" component (Code F), the policies of production leap (Code FB) received the highest frequency, chosen by 11 out of 15 expert respondents.

3. In the "Technological Production Indicators" component (Code B), the factor that increases the production speed (Code BA) had the highest frequency, selected by 11 out of 15 expert respondents.

4. In the "Cultural Production Indicators" component (Code E), the establishment of a culture of optimal consumption (Code EB) received the highest frequency, chosen by 11 out of 15 expert respondents.

5. In the "Environmental Production Indicators" component (Code D), the indicator of green production management (Code DC) had the highest frequency, selected by 10 out of 15 expert respondents.

6. In the "Social Production Indicators" component (Code C), the factor that enhances social welfare (Code CB) received the highest frequency, chosen by 11 out of 15 expert respondents.

4-1. Quantitative Findings

4-1-1. Model Implementation

In the quantitative section of the present study, a dynamic analysis approach was employed to design a model for national production growth using the Vensim.V9 dynamic modeling tool. The initial step involved determining the time horizon of the model. The following parameters were entered into the software to accomplish this:

- Final Time: The time the simulation ends, set to 2021 based on system dynamics.

- Initial Time: Based on system dynamics, the simulation's starting time is set to 2018.

- Saveper: The time interval between saving the simulated data, which is a multiple of the Time Step. In this study, it is set to 4 years.

- Time: The current simulation time was initially set to 2018.

- Time Step: The time increment occurs 40 times within four years.

Following the time settings, the model boundaries were established. It involved defining the main variables (endogenous) and exogenous variables as follows:

The main variables (endogenous) of the final conceptual model, derived from the qualitative section of the research, are as follows:

Table 4: Main variables (endogenous)

| **Main variables (endogenous) of the research dynamic model** | |
|---|---|
| Economic Production Indicators | Political Production Indicators |
| Technological Production Indicators | Cultural Production Indicators |
| Environmental Production Indicators | Social Production Indicators |

In addition, the exogenous variables of the research for the system dynamics method implementation are listed in the table below.

Table 5: Exogenous variables

| **Sub-variables (exogenous) of dynamic research model** | |
|---|---|
| improvement of gross domestic product (a1) | green production management (d1) |
| enhancement of the employment rate (a2) | green material management (d2) |
| reduction of the real inflation rate (a3) | green supply chain management (d3) |
| includes indicators such as an increase in production diversity (b1) | improvement of knowledge-based production culture (e1) |
| improvement of production quality (b2) | establishment of an optimal consumption culture (e2) |
| increase in production speed rate (b3) | enhancement of national production support culture (e3) |
| enhancement of social welfare (c1) | improvement of knowledge-based production culture (e1) |
| reduction of the unemployment rate (c2) | establishment of an optimal consumption culture (e2) |
| improvement of social entrepreneurship (c3) | enhancement of national production support culture (e3) |

After conducting interviews with research experts, the most crucial variables of the research were integrated into the dynamic model and system dynamics calculations, denoted as (Y). Specifically, the variable representing economic production indicators (code VA) includes indicators such as the improvement of gross domestic product (a1), enhancement of the employment rate (a2), and reduction of the real inflation rate (a3). The variable representing technological production indicators (code VB) includes indicators such as an increase in production diversity (b1), an improvement of production quality (b2), and an increase in production speed rate (b3). The variable representing social production indicators (code VC) includes indicators such as the enhancement of social welfare (c1), reduction of the unemployment rate (c2), and improvement of social

entrepreneurship (c3). The variable representing environmental production indicators (code VD) includes indicators such as green production management (d1), green material management (d2), and green supply chain management (d3). The variable representing cultural production indicators (code VE) includes indicators such as the improvement of knowledge-based production culture (e1), the establishment of an optimal consumption culture (e2), and the enhancement of national production support culture (e3). Additionally, the variable representing political production indicators (code VF) includes indicators such as production leap policies (f1), policies for economic independence (f2), and policies for resilient economies (f3).

The desired model for national production growth exhibits the following causal and dependent relationships:

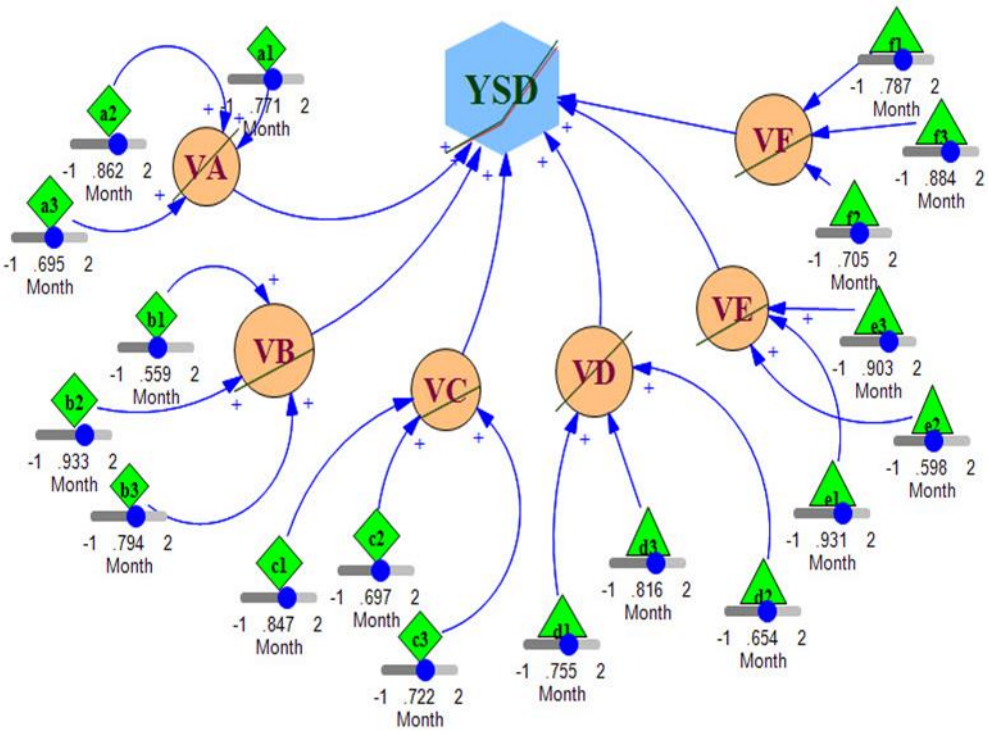



Diagram 1: Cause and effect relationships of the dynamic model

Then, the cause-and-effect relationships of the model were extracted based on the variables with an effect greater than 0.75 for the research implementation as follows:

Table 6: Causal and effect relationships of the model based on the variables with a high effect on the model

| Model indicators | Icon in Vensim | Dynamic coefficients |
|---|---|---|
| improvement of production quality (b2) | b2 | 0.933 |
| improvement of knowledge-based production culture (e1) | e1 | 0.931 |
| enhancement of national production support culture (e3) | e3 | 0.903 |
| production leap policies (f1) | f1 | 0.884 |
| enhancement of the employment rate (a2) | a2 | 0.862 |
| enhancement of social welfare (c1) | c1 | 0.847 |
| green supply chain management (d3) | d3 | 0.816 |
| increase in production speed rate (b3) | b3 | 0.794 |
| policies for resilient economies (f3) | f3 | 0.787 |
| improvement of gross domestic product (a1) | a1 | 0.771 |
| green production management (d1) | d1 | 0.755 |

The causal relationships within the dynamic research and system dynamics model reveal several influential factors in each category of production indicators. These factors and their corresponding dynamic coefficients are as follows:

1. Technological Production Indicators:

- Improvement of production quality (b2) with a dynamic coefficient of 0.933 is the most influential factor.

2. Cultural Production Indicators:

- Improvement of knowledge-based production culture (e1) with a dynamic coefficient of 0.931 is the most influential factor.

3. Political Production Indicators:

- Production leap policies (f1) with a dynamic coefficient of 0.884 are determined to be the most influential factor.

4. Economic Production Indicators:

- The most influential factor is enhancing the employment rate (a2) with a dynamic coefficient of 0.862.

5. Social Production Indicators:

- Improving social welfare (c1) with a dynamic coefficient of 0.847 is the most influential factor.

6. Environmental Production Indicators:

- Green supply chain management (d3) with a dynamic coefficient of 0.816 is the most influential factor.

After running the final model in the software, the results indicate the research model's dynamic changes. The causal loop diagram highlights that economic production indicators have the highest priority and are critical in national production growth. They exhibit a significant relationship with the dynamic changes in the research model. The accompanying graph illustrates the dynamic changes in the research model, showing an increase in "economic production indicators" and the corresponding "rate of change" from T1 to T10.

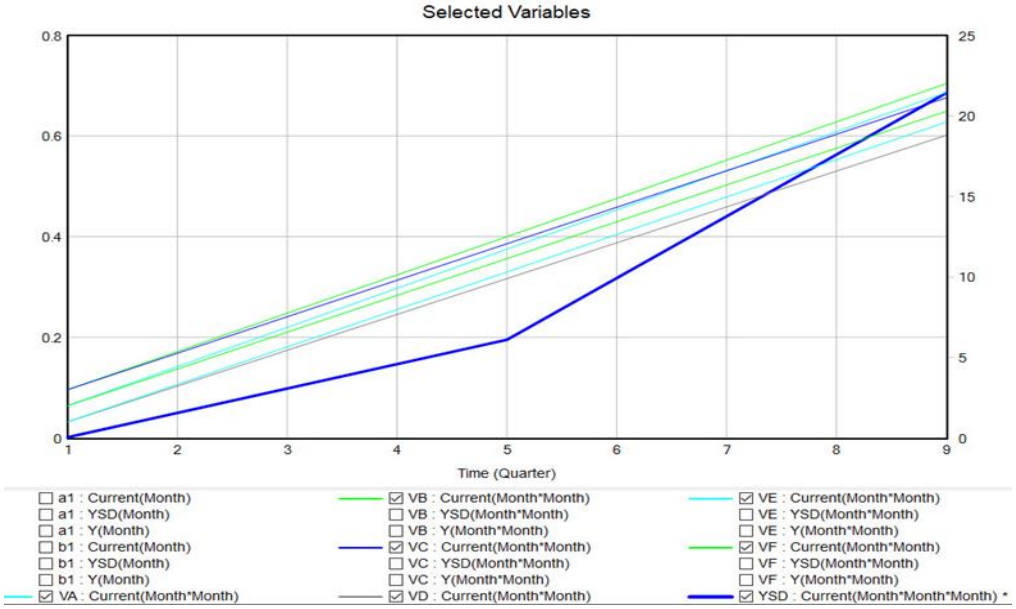



Diagram 2: Comparative chart of the growth rate of the variables of the research dynamic model

The provided graph illustrates the indicators of national production growth and their relationship with the rate of change in the dynamic research model. The dynamic variables exhibit a significant and synchronized relationship with the rate of change during the periods T1 to T10.

Based on the comparative graph of the growth rates of dynamic variables in the research model, the dynamic impact rate of "technological production indicators" (code VB) shows the highest growth value. It peaks at approximately 72% during period 9 (T9), with a dynamic coefficient of 40% during the intermediate period (T5).

In contrast, the dynamic impact rate of "environmental production indicators" (code VD) has the lowest growth value. It reaches its maximum level at around 60% during period 9 (T9), with a dynamic coefficient of 30% during the intermediate period (T5).

Among the other codes, the VE code measures the highest dynamic impact rate for "cultural production indicators," with a growth rate of 68%. The VC code measures the highest dynamic impact rate for "social production indicators," with a growth rate of 65%. The VF code measures the highest dynamic impact rate for "political production indicators," with an average growth rate of 64%. Lastly, the VA code measures the highest dynamic impact rate for "economic production indicators," with an average growth rate of 62%.

4-1-2. Model Validation

In dynamic system models, there are two types of validation: structural validity and behavioral validity. Structural validity ensures that the model accurately represents real-world relationships related to the study objective. Behavioral validity ensures that the model behaves similarly to the real-world phenomenon it represents. Structural validity is a prerequisite for behavioral validity. Common validation tests include comparing the model to reference points, assessing stability under extreme conditions, and conducting sensitivity analysis. Model validation diagrams are available to aid in the validation process.

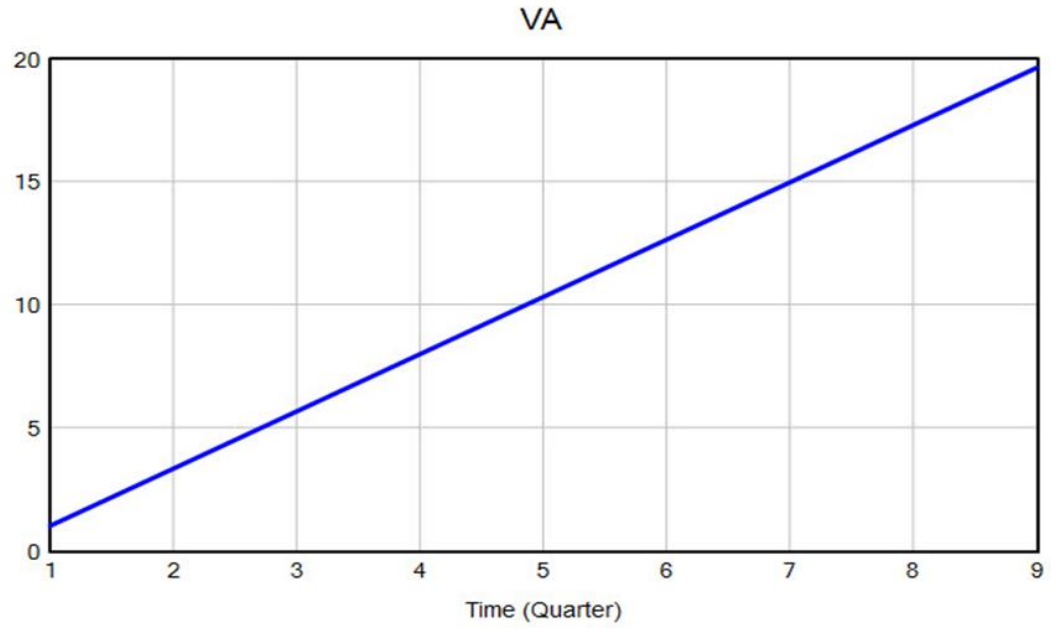



Diagram 3: Validation of the model based on the dynamic changes of "economic indicators of production" and the research target variable

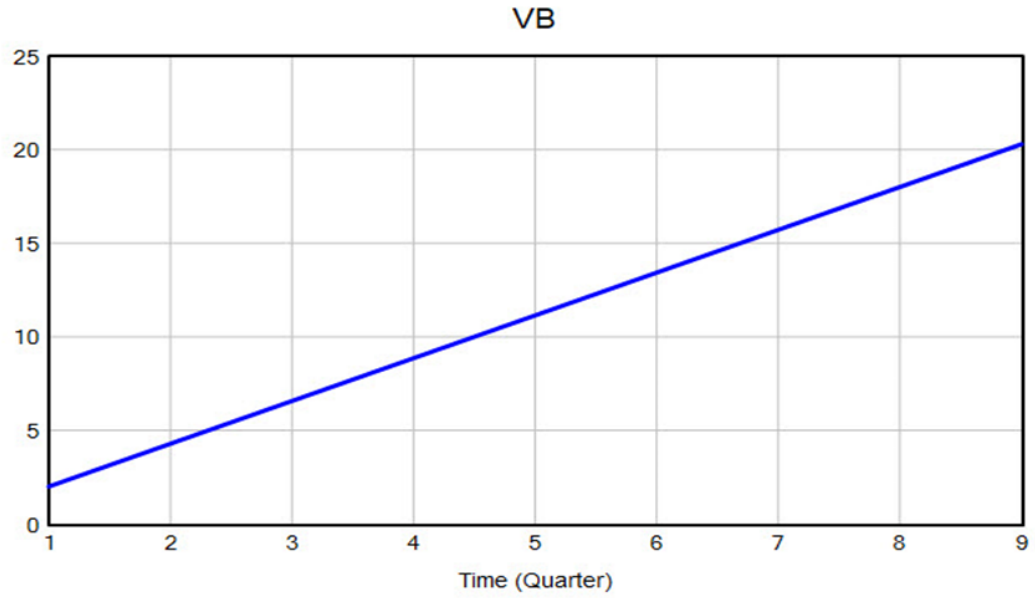



Diagram 4: Validation of the model based on the dynamic changes of "technological indicators of production" and the research target variable

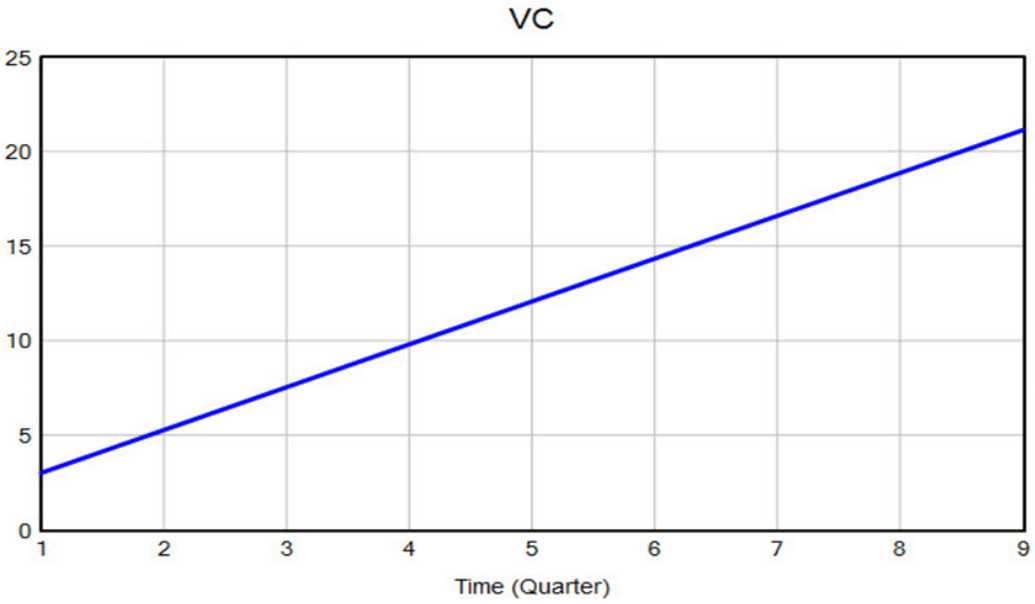



Diagram 5: Validation of the model based on the dynamic changes of "social indicators of production" and the research target variable

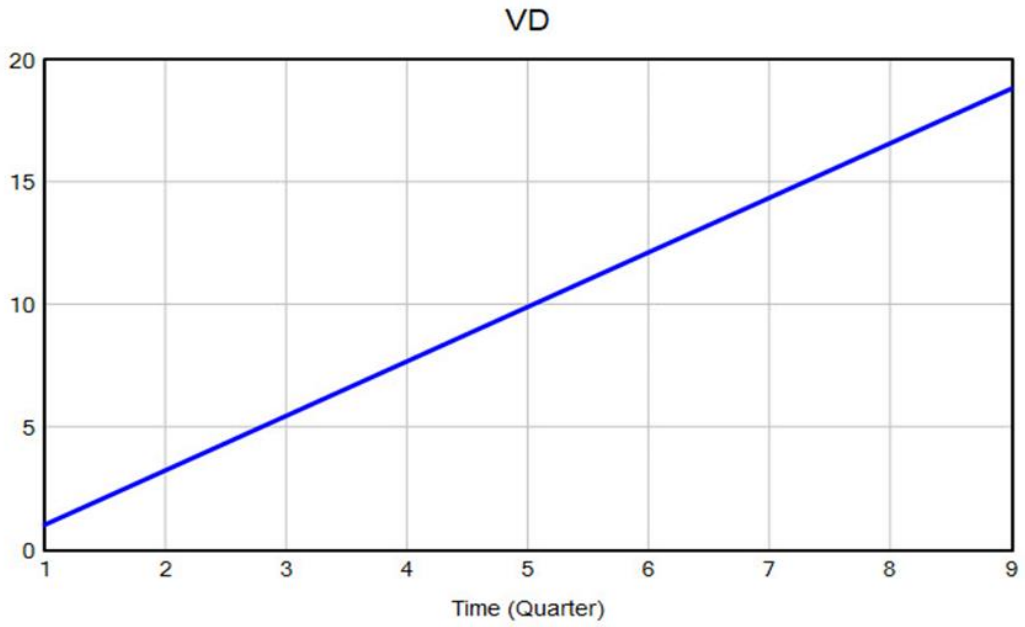



Diagram 6: Validation of the model based on the dynamic changes of "environmental indicators of production" and the target variable of the research

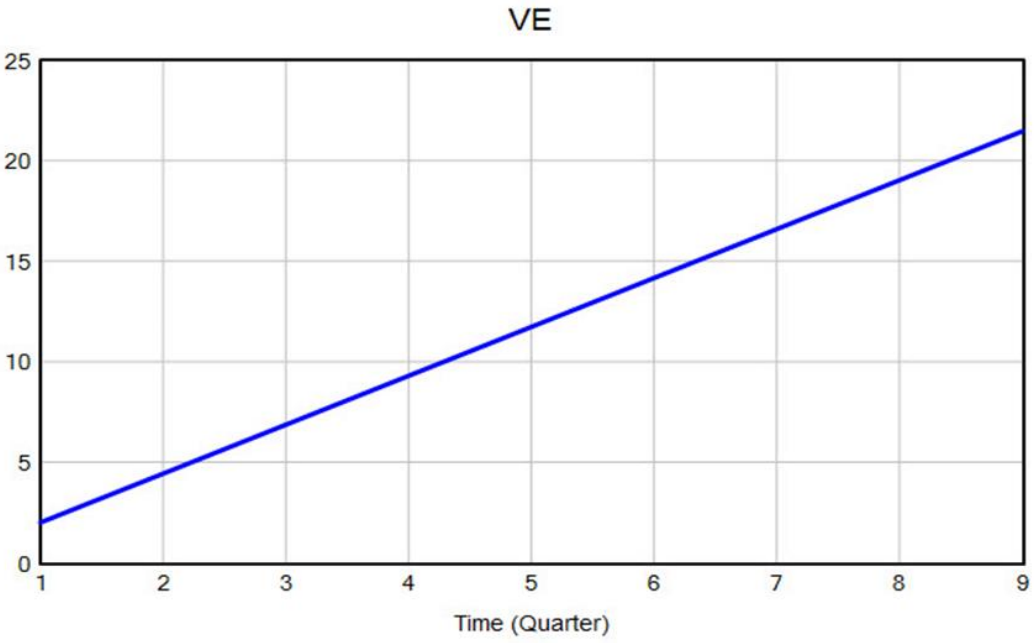



Diagram 7: Validation of the model based on the dynamic changes of "production cultural indicators" and the research target variable

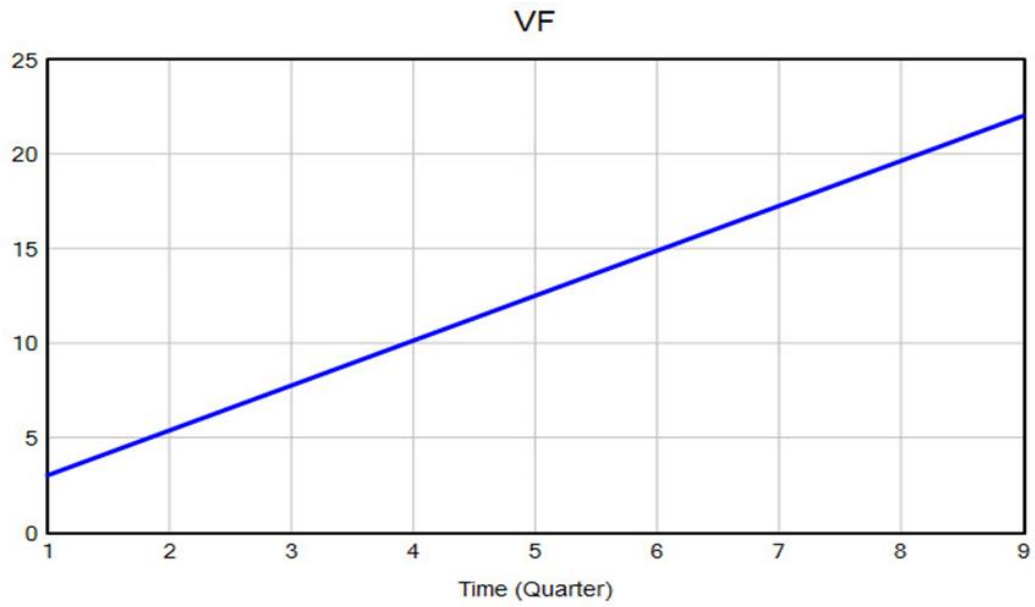



Diagram 8: Validation of the model based on the dynamic changes of "political indicators of production" and the research target variable

Based on the model validation diagram, the validation rates for the dynamic variables in the research model are as follows:

- The "economic production indicators" variable (VA code) has a validation rate of 20 out of 20, indicating it is 100% valid.

- The "environmental production indicators" variable (VD code) has a validation rate of 19 out of 20, indicating it is 95% valid.

- The "political production indicators" variable (VF code) has a validation rate of 22 out of 25, indicating it is 88% valid.

- The "cultural production indicators" variable (VE code) has a validation rate of 21 out of 25, indicating it is 84% valid.

- The "social production indicators" variable (VC code) has a validation rate of 21 out of 25, indicating it is 84% valid.

- The "technological production indicators" variable (VB code) has a validation rate of 20 out of 25, indicating it is 80% valid.

While the alignment between historical trends and simulation results cannot guarantee accurate predictions of future trends on its own, it is expected that the predictions will be consistent with future conditions if the behavior and structure of the simulation model correspond to past assumptions. The equilibrium dimensions of the variables in the model's equations were tested to guarantee dimensional stability. The units of these variables are consistent with reality, as the model does not include any non-physical variables.

Additionally, sensitivity analysis and extreme condition testing are essential in this research, which aims to model the relationships between the rate of change in the dynamic research model and the economic production indicators. The behavior of the model variables was observed under varying parameter values. Sufficiency tests were carried out to ensure the model's boundaries aligned with the model's objective. All primary and auxiliary variables are formulated as endogenous in the presented model.

Each dynamic model was analyzed to reproduce a subset of the real system's behavior to validate it in the study implementation. Critical variables underwent final tests, including

sensitivity analysis, dimensional stability testing, and comparative testing of simulation results against available documents and evidence. It was ensured that the influential variables affecting the rate of change in the dynamic research model and the economic production indicators were included as exogenous variables. Considering the minimal changes in these variables, the model can reasonably approximate their actual behavior.

This research aimed to develop and explain the pattern of national production prosperity using a system dynamics approach. One of the study's key findings is the "final research model." According to the findings, the research model is shaped by economic production indicators, technological production indicators, social production indicators, environmental production indicators, cultural production indicators, and political production indicators.

The simulation of the designed model revealed the most influential factors in each indicator category. The improvement of production quality had the highest coefficient of 0.933, signifying its significant impact on technological production indicators. Likewise, the enhancement of knowledge-based production culture, with a coefficient of 0.931, had the most substantial influence on cultural production indicators. Implementing production leap policies, with a coefficient of 0.884, was the most influential factor in political production indicators. The improvement of the employment rate, with a coefficient of 0.862, emerged as the most influential factor in economic production indicators. With a coefficient of 0.847, social welfare enhancement was identified as the most influential factor in social production indicators. Furthermore, with a coefficient of 0.816, green supply chain management significantly impacted environmental production indicators.

The validity of the model was examined and confirmed during its implementation. The "final research model" refers to a model that accurately represents the reality of national production prosperity patterns. It provides a comprehensive description and illustration of specific aspects of the real world related to the modeled issues, revealing significant relationships among different variables that affect the research. The final research model was developed using a mixed (qualitative-quantitative) method, combining qualitative and quantitative approaches.

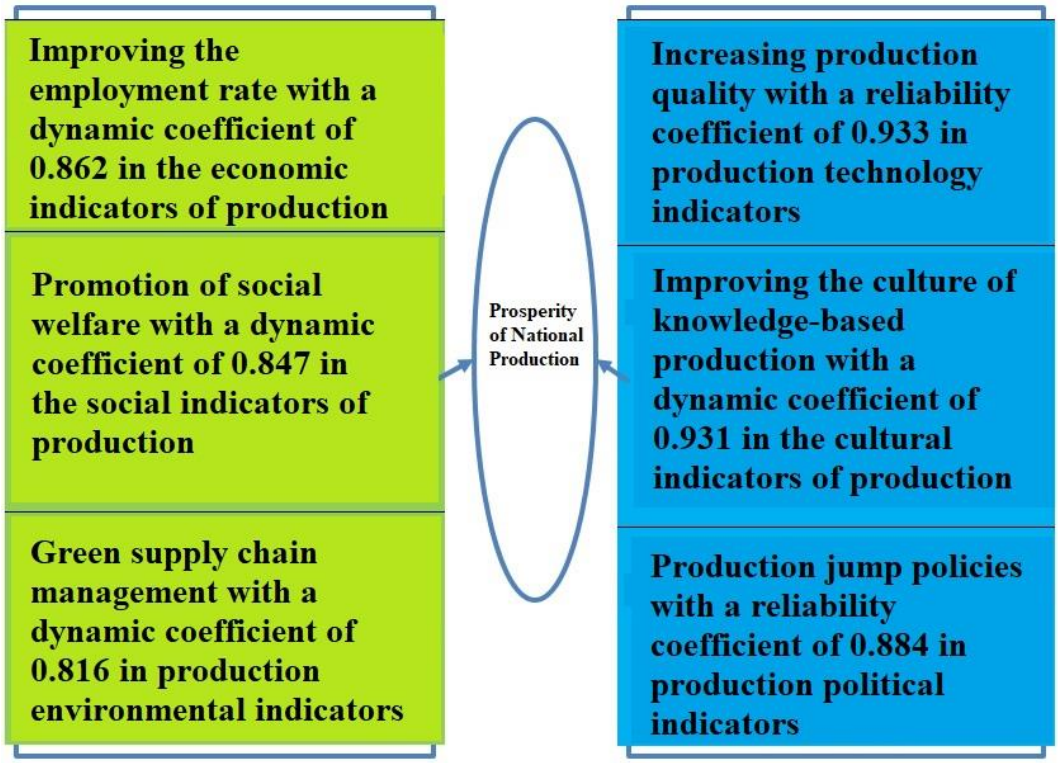



Diagram 9: The final research model

Based on a review of the theoretical foundations and background of the research, it is evident that the current study aims to address research gaps by modeling the relationships among economic production indicators, technological production indicators, social production indicators, environmental production indicators, cultural production indicators, and political production indicators. This research has the potential to contribute to innovation by filling these gaps.

The main recommendation of this research for the country's manufacturing industries is to prioritize the performance of the "economic production indicators" component. This component includes variables such as reducing the real inflation rate, improving the employment rate, and increasing gross domestic product. The "technological production indicators" component includes variables such as increasing the production rate, diversifying production, and improving production quality. The "social production indicators" component includes variables such as enhancing social entrepreneurship, improving social welfare, and reducing unemployment-related crimes. The "environmental production indicators" component includes green material management, supply chain management, and production management variables. The "cultural production indicators" component includes variables such as promoting a culture supporting domestic production, fostering a culture of optimal consumption, and improving knowledge-based production. The "political production indicators" component includes variables such as policies for a resilient economy, production leap policies, and policies for economic independence. Strategic attention should be given to these components in organizational decision-making processes.

The research identified several critical limitations in "designing the model of national production prosperity." These limitations can be categorized into two groups: researcher-controlled limitations and limitations beyond the researcher's control. Researcher-controlled limitations include limited access to a more significant number of experts in the field, constraints related to the cost and time required for a comprehensive examination of all influential indicators, and the inability to gather opinions from international experts through targeted interviews. Limitations beyond the control of the researcher include the absence of a comprehensive model examining the factors of the research model, potential biases from experts, the limited familiarity of some researchers with the techniques used in the study, and the novelty of the research topic, resulting in a lack of internal and external research in this field.

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