Volume: 22, Issue: 1
Page: 53-70
2023

International Journal of Science and Business

Journal homepage: ijsab.com/ijsb

A study of Lean Production and Quality Management on Production Performance: The Evidence in High-tech Manufacturing Companies in China

HUANG XUELIANG

Abstract

Based on the relevant studies of lean production, production technology improvement, quality management and production performance, the relationship model of lean production, production technology improvement, quality management and production performance of high-tech manufacturing companies is constructed, and the influence mechanism of lean production and production technology improvement on production performance of high-tech manufacturing companies is revealed. Specifically, by systematically reviewing relevant theories and existing research results, this paper proposes a logical idea of "lean production, production technology improvement -- quality management -- production performance", discusses and proposes relevant research hypotheses according to the relationship between variables in the theoretical model, and sends out questionnaires to Chinese high-tech manufacturing companies on a large scale, and recovers 425 questionnaires. The incomplete or invalid questionnaires with obvious errors were eliminated, and 411 valid questionnaires were finally obtained. The statistical analysis software SPSS 24.0 and AMOS 24.0 were used for reliability analysis, validity analysis, exploratory factor analysis, typical correlation analysis of the collected data, multiple linear regression analysis model and mediation effect model was established. Test the theoretical paper. In this paper, a total of 7 research hypotheses are proposed, among which 7 hypotheses are supported by the survey data. Combining qualitative analysis and quantitative analysis, this paper draws the following conclusions: (1) Lean production has a significant positive impact on the production performance of high-tech manufacturing companies; (2) The improvement of production technology has a significant positive effect on the production performance of high-tech manufacturing companies; (3) Quality management has a significant positive effect on the production performance of high-tech manufacturing companies; (4) Quality management has a partial mediating effect between lean production and production performance of high-tech manufacturing companies; (5) Quality management plays a partial mediating role between production technology improvement and production performance of high-tech manufacturing companies.

IJSB
Accepted 07 April 2023
Published 09 April 2023
DOI: 10.58970/IJSB.2095

ISSN: 2520-4750 (Online) 2521-3040 (Print)

Papers published by IJSAB International are licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

Keywords: *High-tech Manufacturing Company, Lean Production, Production Technology Improvement, Quality Management, Production Performance.*

About Author (s)

HUANG XUELIANG, Asia Metropolitan University, Malaysia.

Introduction

The development of high-tech manufacturing companies has had an important impact on China's economy, military, and people's livelihoods, and has become a key driving force for driving China's economic growth. Chinese high-tech manufacturing companies have experienced a rapid growth stage after the reform and opening up, gradually narrowing the gap with the high-tech manufacturing companies of developed countries such as Europe, America, and Japan. Low labor cost has always been a big advantage for Chinese high-tech manufacturing companies to participate in international competition. In recent years, the demographic dividend is gradually disappearing, so China's high-tech manufacturing companies need to optimize and perfect the production mode, production technology, management mode, and production performance. By changing production modes, improving production technology, reducing production costs, and enhancing corporate management level, the competitiveness and production performance of the company can be improved. At the same time, high-tech manufacturing companies have high intelligence, high earnings, high risk, high integration, and other characteristics, so they face high research and development risks and fierce market competition, resulting in high operation risk. How to enhance the overall strength of high-tech manufacturing companies and improve their production performance is of great significance for promoting China's economic growth. (Xiao et al., 2022; Wang, 2020). This study takes Chinese high-tech manufacturing companies as the research object and investigates the mechanism of the role of lean production and production technology improvement on the production performance of high-tech manufacturing companies through an empirical analysis method. Firstly, the independent variable (lean production, production technology improvement), the mediator (quality management) and the dependent variable (production performance) are identified by the method of literature research, which lays a foundation for the establishment of the theoretical model and framework of this study, then the theoretical hypotheses are put forward for the relationship between the variables. Secondly, using the 411 valid sample data obtained from the questionnaire survey, the statistical analysis methods of reliability analysis, validity analysis, canonical correlation analysis, exploratory factor analysis, and multiple regression are used to empirically test the theoretical hypotheses. The research results show that lean production has a significant positive impact on the production performance of high-tech manufacturing companies, therefore, high-tech manufacturing companies should adopt a lean production model to improve the company's production performance. Production technology improvements also have a significant positive effect on the production performance of high-tech manufacturing companies, so high-tech manufacturing companies should improve production technology to improve their production performance. Quality management plays a partial mediating role in the relationship between lean production, production technology improvement, and company production performance. Therefore, in practice, high-tech manufacturing companies should employ lean production models, pay attention to cultivating and improving the enterprise's production technology improvement ability, provide funds support for production technology improvement by increasing R&D input intensity, provide talent reserve for production technology improvement by introducing high-quality innovative talents, and make use of synergy effect through cooperation with other high-tech manufacturing companies, universities and scientific research institutes. Next, high-tech manufacturing companies should pay attention to the cooperation of quality management. The key to quality management lies in the senior management of high-tech manufacturing companies, and the innovation and experience of the management personnel are the guarantees for the company to carry out quality management. Therefore, it is necessary to strengthen the training of senior managers in high-tech manufacturing companies, analyze and learn the experience of other enterprises in management innovation through the exchange and cooperation between enterprises,

selectively absorb and apply it in combination with the enterprise's own situation, and pay attention to the construction of a good enterprise culture and atmosphere. Furthermore, high-tech manufacturing companies should also pay attention to the coordinated development of lean production and production technology improvement, improve quality management, thus promoting the improvement of the performance of the company's production. (Xiao et al., 2022)

Problem Statement

If high-tech manufacturing companies want to gain competitive advantages, they should first truly evaluate the production performance of the company, find out the path to improve the production performance, and formulate the correct development strategy for the company. So, it is particularly important to discuss how to improve the production performance of high-tech manufacturing companies. Based on this, this paper respectively discusses the influence mechanism and promotion paths of lean production and production technology improvement on production performance; secondly, it studies the mediating role of quality management in the relationship between lean production, production technology improvement, and production performance; on the basis of the research conclusions, the paper builds the lean production, production technology improvement and quality management mechanism of high-tech manufacturing companies, and puts forward corresponding countermeasures for the government and decision-makers and managers of high-tech manufacturing companies respectively. The research results of this paper can provide some theoretical and practical references for relevant parties (Al-Ettayyem et al., 2015; Xiao et al., 2022).

Research Questions

Based on the above research background analysis, it is known that China's manufacturing industry occupies a very important position in the world, but in stark contrast, there is relatively little research on the relationship between lean production, production technology improvement, and production performance of Chinese high-tech manufacturing companies, and the relevant research is still in the primary stage. It is known from the problem statement of this paper that lean production and production technology improvement are one of the competitive advantages relied upon by high-tech manufacturing companies and are important factors affecting the production performance of high-tech manufacturing companies. Quality management is the use of new management ideas and management models to achieve more effective resource allocation, and effectively utilize the achievements of lean production and production technology improvement in the production process. Under the guidance of lean production thinking and innovation-driven strategies, more and more high-tech manufacturing companies have become aware of the importance of lean production and production technology improvements. Research indicates that lean production and production technology improvements have a significant positive effect on a company's production performance, but there are a few studies that claim lean production and production technology improvements have no direct effect on production performance. Through the above questions' exposition and analysis, as well as the sorting out and evaluation of relevant theories, this research, based on the research results of theories such as lean production, production technology improvement, quality management, and production performance, takes Chinese high-tech manufacturing companies as its research object and explores the improvement of the company's production performance from the perspective of background variables- production model (lean production), production technology (production technology improvement), and management model (quality management). This paper focuses on the basic question of how lean production and production technology improvement affect the production performance of a company directly or indirectly through quality management, and analyzes the inner mechanism of the

four elements along the logical line of "lean production- production technology improvement - quality management - production performance", and conducts a series of theoretical and empirical studies to address the following three questions:

1. What is the relationship between lean production and production performance of high-tech manufacturing companies? At present, many scholars at home and abroad have conducted academic studies on lean production, but most of them focus on the development status and specific implementation and application of lean production, or macro-analysis at the strategic level. Very few people pay attention to and verify the correlation and causal relationship between lean production and corporate production performance. So, establishing a causal relationship between lean production and company production performance, using multiple regression analysis to evaluate the impact of lean production on company production performance to help the company improve production performance is necessary. Analyzing whether the implementation of lean production can improve a company's production performance and what kind of lean production method is the best strategy when the company faces a dynamic market environment will help company managers to be aware of lean production issues and keep abreast of manufacturing industry dynamics, thus further improving the company's production performance. This paper divides lean production into three dimensions: company culture, employee participation, and production environment. The relationship between lean production and production performance is quantified using a multiple linear regression model to verify the relationship and mechanism between lean production and production performance, and to explore what is the best strategy for high-tech manufacturing companies to adopt lean production, thus proposing corresponding countermeasures to the idea and promotion of lean production. It is hoped that this will be useful for the in-depth discussion of lean production theory in high-tech manufacturing companies and production practice in the practical world.

2. What is the relationship between production technology improvement and production performance of high-tech manufacturing companies? Taking new energy vehicles as an example, in addition to implementing lean production and controlling costs, production technology should be actively improved to enhance the production performance of the company. In 2013, the official launch of Tesla electric cars has made people generally optimistic about the leading position of electric energy in the future clean energy market. There is a clear distinction between electric cars and traditional cars, for example, traditional cars use fuel tanks as a component for storing fuel, whereas electric cars rely on electricity as their energy source and use battery packs for storage. Due to the long driving range requirement for electric vehicles, high-energy battery packs must be used. The battery packs consist of hundreds to thousands of high-energy lithium-powered cells. For a long time, high-capacity lithium batteries have been widely used in digital product fields. However, in the field of power batteries, lithium batteries have unavoidable shortcomings, such as the capacity has approached its theoretical limit, and its high temperature resistance and collision resistance performance are limited, making it difficult to meet the requirements of volume and safety performance of vehicles. The lithium battery industry has developed several new types of cathode materials in order to solve many of the problems that lithium batteries face in the field of power. However, new materials have put forward extremely high requirements for production technology level. Since the production technology level of Chinese high-tech manufacturing companies is generally lagging behind that of developed countries such as the US, Japan and South Korea in battery manufacturing, when facing the emerging markets that will be opened soon, the products provided by China's high-tech manufacturing companies can only concentrate on the middle and low end, and they have never been able to open the international market in the field of advanced cathode materials. At present, China's domestic high-tech manufacturing companies are investing large amounts of research and development

funds, transforming and upgrading production equipment, drawing closer to developed countries such as Europe and America in terms of hardware, and actively improving production technology. In this paper, production technology improvement is divided into four dimensions: production design technology improvement, production site technology improvement, production line technology improvement, and production waste identification technology improvement; production performance is divided into three dimensions: financial performance, competitive performance and customer satisfaction, and the relationship between production technology improvement and company production performance is verified by using multiple linear regression model to test the impact relationship and mechanism between production technology improvement and company production performance.

Significance of Research

In the context of globalization, competition in the international manufacturing market is becoming increasingly fierce. The sudden outbreak of the Covid 19 epidemic in 2020 has brought huge challenges to Chinese high-tech manufacturing companies. In order to enhance the core competitiveness and production performance of Chinese high-tech manufacturing companies, the Chinese government has repeatedly emphasized the importance of high-quality development for high-tech manufacturing companies. For a long time, the research on the production performance of a company through lean production and production technology improvement has been a hot topic, receiving attention from both academic circles and the industry. However, the production models, production technology levels, and management capabilities of Chinese high-tech manufacturing companies vary, and there are no clear definitions of the impact of using lean manufacturing, production technology improvement, and quality management on the production performance of high-tech manufacturing companies in particular, and no more complete theoretical explanations and implementation recommendations have been developed. Therefore, it is particularly necessary to understand the functioning mechanism. This study takes the relationship between lean production, production technology improvement and the performance of high-tech manufacturing companies in a high-tech background as an entry point, by combing classic theories and relevant literature to explore the basic ideas to solve the problem, constructing a theoretical model to identify the relationship between lean production, production technology improvement, quality management and high-tech manufacturing performance, and proposing research hypotheses. It is of great theoretical and practical significance to test the paper by means of questionnaire survey and empirical analysis, and to explore the influence mechanism of lean production and production technology improvement on the production performance of high-tech manufacturing companies under the background of high technology. Below are explanations of the research significance of this paper from both theoretical and practical perspectives.

Literature Review

First of all, the theory of lean production theory, quality management theory, innovation theory, and management by objectives are systematically expounded; second, the key concepts involved in the research, such as lean production, production technology improvement, quality management, and production performance, are systematically sorted out; finally, based on the above theoretical foundation, the theoretical paper of this study is proposed, and the theoretical model and research framework of this study are constructed to provide the theoretical basis for the later empirical analysis.

Dependent Variables: Production Performance

How to improve the production performance of high-tech manufacturing companies has been a hot issue of concern by academia and industry. In today's dynamic, complex, and unpredictable global economy, achieving good production performance has gradually become the key to improving the competitiveness and production performance of high-tech manufacturing companies. Therefore, the performance of high-tech manufacturing companies in production has become a forefront issue in current research. Among them, the path to achieve production performance, i.e., how to improve the firm's production performance, and other related topics are the focus of existing research (Huang & Chen, 2010; Xiao et al., 2022). Ruekert, Walker, and Roering (1985) argued that company production performance consists of three components such as effectiveness, efficiency, and adaptability of the firm. Foreign scholars' views on the definition of company production performance can be divided into three categories:(1) performance is not a result, but a behavior;(2) performance is a result;(3) performance is a combination of behavior and result. Some domestic scholars have discussed the concept of company production performance, as shown in Table 2-1.

Table 2-1 The Concept of Company Production Performance

Years	Scholars	Related Discussions
2010	Yuan	It is believed that the company's performance in terms of production mainly includes both financial performance and growth performance. The company's effectiveness or performance is the company's production performance, which can be used as an indicator to measure the degree to which the company's strategic objectives have been achieved, reflecting the company's efficiency and operational efficiency in a certain period of time.
2017	Liu	The effects of the company in terms of financial value, operational efficiency, strategic implementation and customer value during its operations are the company's production performance.
2019	Chen	The economic result of the sales profits obtained during the business activities is the company's production performance.
2020	Wang	Using AHP method, construct unicorn company's production performance evaluation index: profit ability, risk management ability and financial ability, etc.

Independent Variable: Lean Production

The lean production philosophy originated from Toyota Motor Corporation in Japan. Lean production is recognized by high-tech manufacturing companies from developed countries such as the USA, Europe, and Japan as the best production model, which focuses on eliminating all the non-valuable wastes during product production, reducing the associated cost and expenses during the product production and operational process, and pursues the highest quality products and a production of "zero waste", thus meeting customer demand and achieving customer satisfaction. The essence of lean production is to promote continuous optimization of quality management, improve the company's quality management level, achieve zero waste and flexibility in the company's production, and reduce unnecessary waste in the production-related links, to achieve pull on-time production and maximize the company's production performance. Liu (2020) took X hi-tech manufacturing company as the research object, and compared and analyzed the situation before and after the implementation of lean production of X company, and found that after the implementation of lean production, X company optimized the production process, reduced waste, reduced production costs, and improved production efficiency and employee work enthusiasm. Scholars from both domestic and abroad have researched the connotation of lean production from different perspectives, such as Ocak and Zeynep (2011) who studied it from the perspective of value waste and pointed out that lean production can prevent companies from having irrelevant operational behaviors, and perfect their production and management; Creese. Robert C (2000), Wang (2003), Ning (2013), Monroy C R and Nasiri A (2014), Mantas Vilkas (2015), and Wu (2016) studied the

connotation of lean production based on the perspective of cost control and found that by applying lean production methods, companies can reduce their operating costs and production costs and improve the company's production performance; Daryl Powell (2013), Anonymous (2015) and Wang (2021) studied the connotation of lean production based on the perspective of production efficiency and found that lean production can improve the company's production efficiency; Tobias Wagner and Christoph Herrmann (2017) argued that with the advent of the Industry 4.0 era, the model, connotation and concept of lean production are increasingly aligned with the development philosophy of high-tech manufacturing companies, and provided a new elaboration and interpretation of lean production systems and lean production concepts. Womack and Jones (2011) have summarized the lean production thought into five aspects based on existing scholars' research as well as their own practice and research: (1) accurately defining the value of products; (2) distinguishing the value stream of various products; (3) making the value stream flow; (4) creating value by pulling; (5) striving for perfection. This study believes that these five criteria reflect the essence and nature of lean production.

Independent Variable: Production Technology Improvement

In the face of increasingly fierce market competition, production technology improvement has become an important factor for high-tech manufacturing enterprises to improve production performance, and is the basis of the core competitiveness of companies, moreover, it is the biggest capital to participate in international competition, and is also the key to improve the quality management capability of high-tech manufacturing companies. Production technology is the foundation for the survival and development of high-tech manufacturing companies, and it is critical to the company's operation. Currently, production technology has developed into a very modern technology due to the influence of computer and information technology, far different from the early manual production methods. Since the idea of production technology improvement was first proposed by the United States in the late 1980s, production technology improvement has always been an important goal for high-tech manufacturing companies. Through the analysis of the existing domestic and foreign literature, it is found that the definition of production technology improvement by foreign scholars is based on the perspective of process, that is, production technology improvement starts from the formation of new thinking and new ideas, and through repeatedly solving various problems in the transformation of ideas to practice, finally, the valuable new technologies and ideas can be successfully promoted and implemented. And domestic scholars mainly based on the specific path of production technology improvement. For example, Feng and Liu (1995) argued that the main reason for high-tech manufacturing firms to improve their production technologies is to enhance their competitiveness, and continuous optimization and innovation of production technology is the improvement of production technology. He believed that production technology improvement is not a static and absolute concept, but rather a dynamic and relative concept. It is a general term for the production technology that high-tech manufacturing companies absorb the achievements of machinery, electronics, information, materials, energy and modern management, and apply them comprehensively to the whole process of manufacturing to achieve high-quality, high-efficiency, low-consumption, clean and flexible production and improve the company's production performance. Zhang (1995), based on the findings of the existing research, studied the connotation of production technology improvement based on an overall perspective, and believed that production technology improvement should include different production methods and take into account the development requirements of different periods, and the combination of management technology, production technology, automation technology and information technology is production technology improvement. Wan et al. (2020) categorized production technology improvement into the tendencies in technological improvement, input of resources capability,

research and development capability, and manufacturing capability. On the basis of reference to the existing literature, this paper argues that the improvement of production technology is not an automation or informatization of single manufacturing technology or process, but an advanced technology of constantly integrating emerging production technologies such as information technology and new materials organically into the product life cycle based on the continuous development of traditional production technology. It involves comprehensive factors such as people, technology, and organization. From a macro perspective, production technology improvement is a production system formed under the premise of rapid development of economy and science and technology, which will be continuously improved with its development (Wang, 2021).

Methodology

Research Design

This study adopts literature research method, questionnaire survey method, and empirical analysis method to explore the impact mechanism of lean production and production technology improvement under the background of high-tech technology on the production performance of high-tech manufacturing enterprises. First, this study provides theoretical guidelines for the construction of the research framework by systematically reviewing existing theories and related literature; second, the four main variables involved in this study - lean production, production technology improvement, quality management, and production performance - are "unobservable" variables that are not supported by data in the operations of high-tech manufacturing firms. Therefore, this study uses a questionnaire to collect data of high-tech manufacturing companies; Third, this paper collects the corresponding theoretical evidence on the problems of lean production, production technology improvement, quality management, and company production performance. The main research contents and possible future research directions of relevant theories are clarified, the collected data are sorted, and the different views put forward by various scholars are analyzed and studied, to further discuss the current research directions, research contents and research progress in the impact mechanism of lean production, production technology improvement, quality management on the production performance of high-tech manufacturing enterprises in China. Focus of Study: What is the effect mechanism of lean production, production technology improvement and quality management? Does quality management play a mediating role between lean production, production technology improvement, and the company's production performance? What is the effect mechanism of lean production and production technology improvement on company production performance? To construct the overall research framework of this paper: the theoretical model of the impact of lean production and production technology improvement of high-tech manufacturing enterprises in China on corporate production performance, which lays a solid theoretical foundation for this research. In terms of access to information, it mainly includes networks and libraries, in which network information mainly comes from CNKI (China National Knowledge Infrastructure), Baidu Academic, Google Academic, and other network databases.

Questionnaire survey

Based on the relevant channels, materials and information available to this paper, the survey subjects of this study are high-tech manufacturing companies in the more technologically advanced regions of China to understand the basic situation of these high-tech manufacturing companies in the process of globalization opportunities and anti-globalization challenges. Due to the epidemic situation, the distribution and collection of questionnaires were mainly completed online. The URL of the online questionnaire was

directly sent to the relevant High-tech manufacturing enterprises, the respondents could directly fill in the online questionnaire, and the results are directly saved on the server.

Empirical research method

The empirical analysis method is based on the data obtained from the questionnaire survey. First, the reliability analysis of the data is used to confirm the stability and consistency of the survey data, and then the validity analysis of the data is used to confirm that the survey data can get the desired conclusion. Then, the correlation between variables is studied by using the canonical correlation analysis. Multiple linear regression analysis is used to verify the validity of the previous conceptual model and theoretical paper. This paper constructs a theoretical research framework by sorting out the relevant literature and collects data through a large-scale questionnaire distribution to high-tech manufacturing enterprises in the more technologically developed regions of China. According to the results of the survey, the internal relationship and the mechanism of lean production and production technology improvement affecting production performance in high-tech manufacturing enterprises are analyzed. Statistical analysis software such as SPSS 24.0 and Amos24.0 is used to test the reliability and validity of the sample data. Through the descriptive statistical analysis, correlation analysis of variables, and multiple linear regression analysis, corresponding analysis and paper verification are carried out to test whether each paper is supported, explain the research results, and finally draw corresponding conclusions. The quantitative research method of empirical test further deepens the theoretical model by testing the research hypotheses and helps to improve the accuracy and reliability of the research conclusions.

Population/Sampling/Unit of Analysis

This study obtained the required sample data through questionnaire survey, mainly selecting high-tech manufacturing enterprises in Fujian, Jiangsu, Guangdong, Zhejiang and Shanghai as the research objects. These regions belong to the provinces and cities with relatively advanced science and technology in China, which can better reflect the relationship between lean production, production technology improvement, quality management and production performance under the background of high technology. For this survey, 425 original data samples were obtained by online distribution, excluding invalid questionnaires with incomplete or obvious errors, 411 questionnaires were valid, with a completion rate of 96.71%. The survey involved high-tech manufacturing enterprises in 12 provinces and municipalities directly under the central government of China, including state-owned high-tech manufacturing enterprises, private high-tech manufacturing enterprises and foreign-funded high-tech manufacturing enterprises, and the years of establishment of the companies ranged from half a year to more than 5 years.

Instrumentation

This study mainly investigates the relationship between lean production, production technology improvement, quality management and production performance in high-tech manufacturing enterprises, as well as the mediating role of quality management in a high-tech context. Among which, the independent variable is lean production and production technology improvement, the dependent variable is the production performance of a high-tech manufacturing enterprise, and the mediator is quality management. First, scale development is carried out for variables (production technology improvement) that lack mature scales. Based on existing theories and related research, this research provides operational definitions of variables, combines case materials to further explore the dimensions of production technology improvement, and compiles an item pool. After consulting the opinions of experts and scholars

in the manufacturing field, business managers, and members of the research team, the scale was improved many times, and the measurement items were modified and perfected through the questionnaire pre-test, and finally, a scale that meets the requirements of reliability and validity was obtained. Second, on the basis of the maturity scale with high academic citation rate and recognition, according to the research object, research content and research situation, the scale of lean production and quality management was modified to form a variable measurement scale. Finally, the production performance measurement scale of high-tech manufacturing enterprises originates from mature measurement items adopted by a number of research institutes. Based on previous measurement items of company production performance, this paper selects items consistent with the content of this study to measure the production performance of high-tech manufacturing enterprises. All the scales used in this study were 5-point Likert scale, which was divided into five levels:" Strongly disagree"," Disagree"," Neither agree nor disagree", "Agree" and " Strongly agree". According to the design of the scale, this paper uniformly uses LP, PT, QM, and PP to represent lean production, production technology improvement, quality management, and production performance, respectively. Among them, LP1, LP2, and LP3 respectively represent company culture, employee participation, and production environment; PT1, PT2, PT3, and PT4 respectively represent production design technology improvement, production site technology improvement, production line technology improvement, and production waste identification technology improvement; QM1 and QM2 respectively represent quality management basic dimension and quality management core dimension; PP1, PP2, and PP3 respectively represent financial performance, competitive performance, and customer satisfaction.

Table 3-2 Lean Production (LP) Measurement Items Table

Dimensions	Item number	Items	Basis or source
Company Culture (LP1)	A1	The top management of the company firmly implements lean production methods.	Hall and Mark (1992), Faisal Badi Al-khateeb (1999), Zimmer (2000), Simchi-Levi et al. (2000), Gary Andrew O'Dell (2003), M.Barad and D.Even Spair (2003), Jeffrey L.Kelley (2004), Susan E. Koole (2005), Conti et al. (2006), Shah (2007), Zhang (2010), Liang (2010), Zhou (2011), Hou (2022).
	A2	A full trust between the company and employees.	
	A3	The company actively adopts reasonable suggestions put forth by employees.	
	A4	The company actively improves traditional production techniques.	
	A5	The company views lean production as strategic engineering.	
Employee Participation (LP2)	A6	The company views its employees as the most valuable resource within the company.	
	A7	There are different types of collaborative teams in the company.	
	A8	The company encourages employees to make reasonable suggestions.	
	A9	The company develops career plans for key personnel.	
	A10	The company provides a healthy and safe working environment for its employees.	
	A11	The company provides corresponding training to employees in different positions.	
Production Environment (LP3)	A12	The company has the ability to meet market demands.	
	A13	The company has an effective communication channel between the company and its customers.	
	A14	The company has established a strategic partnership with the supplier.	
	A15	The company produces without damaging the environment.	
	A16	The company shares its values with the community.	

Table 3-3 Production Technology Improvement (TP) Measurement Item Table

Dimensions	Item number	Items	Basis or source
Production Design Technology Improvement (TP1)	B1	The selection of the new factory should consider the logistics costs and the delivery of raw materials.	Kincaid (1986), Burgess and Gules (1998), Swamidass and Kotha (1998), Tracey et al. (1999), Boyer and Pagell (2000), Zimmer (2000), Pavnaskar (2003), Li et al. (2004), Isao Endo (2007), Lander (2007), James P.Womack et al. (2015), and Chen and Ruan (2020)
	B2	The device layout should use group technique.	
	B3	Product design using concurrent engineering.	
	B4	During the process design phase, consideration should be given to one-piece flow and U-shaped production lines.	
Production Site Technology Improvement (TP2)	B5	Complete and strict implementation of standard operating practices.	
	B6	5S is strictly implemented.	
	B7	Color management applications should be encouraged.	
	B8	Fully utilize visual technology applications such as andon and bulletin boards.	
	B9	Proactively apply the error-proofing technique.	
	B10	All personnel participate in equipment maintenance.	
	B11	Materials are distributed timely and in good quality.	
	B12	The goods are delivered in a mixed parcel.	
	B13	The workshop is equipped with high-level working position apparatus to increase materials activity.	
Production Line Technical Improvement (TP3)	B14	Production pulled by orders.	
	B15	The products are produced in a balanced manner.	
	B16	Use SMED technology to enable production to have strong flexibility.	
	B17	Using computer technology to increase the flexibility of manufacturing.	
	B18	The company has a high degree of automation in production.	
	B19	Try to minimize the batch size of the product.	
	B20	A real-time process control system has been applied in the production system.	
	B21	Information processing capabilities in the manufacturing system are at the leading level in the industry.	
Production Waste Identification Technology Improvement (TP4)	B22	The company is making full use of value stream analysis technology.	
	B23	The company appropriately employs human-machine operation analysis.	
	B24	The company reasonably utilizes task analysis.	
	B25	The company uses computer simulation technology to analyze waste in the process.	

Reliability Test

In the process of using questionnaire survey data, reliability is one of the most frequently used indexes. The main use of reliability is to check whether the survey data is stable and consistent, and to measure the authenticity and reliability of the test results. Generally the larger the reliability value, the more reliable the questionnaire and survey data. Cronbach's alpha coefficient method is commonly used in questionnaire survey reliability analysis, where Cronbach's alpha coefficient = $\frac{k}{k-1}\left(1-\sum_{i=1}^{k} SS_i \Big/ SS_p\right)$, k is the number of questions in the questionnaire, SS_i is the variance of the i question, SS_p is the total variance, when the variance between individuals is relatively small, it means that the survey data have consistency and stability, that is the survey data are more credible. According to the formula of Cronbach's alpha coefficient, it is known that Cronbach's alpha coefficient is larger at this time. The reliability of the data is reflected by measuring Cronbach's alpha coefficient, and the relationship between Cronbach's alpha coefficient and the reliability of the survey data is shown in Table 3-5.

Table 3-4 Table of Reliability Test

Serial number	Range of Cronbach's Alpha values	Credibility
1	0.60-0.65	Survey data are not used
2	0.65-0.70	Survey data is acceptable
3	0.70-0.80	Good quality of survey data
4	Above 0.80	Excellent quality of survey data

1. Reliability analysis of lean production

As shown in Table 3-6, the Corrected Item-Total Correlation (CITC) of the 16 questions measuring lean production is greater than 0.7, indicating that the 16 questions on the lean production scale are highly related to the survey objectives; Cronbach's alpha coefficient for lean production is 0.965, indicating high internal consistency and stability of the 16 questions on lean production, that is, the data quality of the lean production survey questionnaire is very good; after the items removed, the Cronbach's alpha is greater than 0.9 and less than 0.965, indicating good discrimination of the 16 questions measuring lean production, and any of the 16 question items removed will lead to a decrease in the data survey reliability coefficient. The test results indicate that the reliability test results of this survey questionnaire about lean production are very good. The empirical analysis using the data from this survey on lean production shows that the empirical results are highly reliable in terms of statistical significance.

Table 3-5 Lean Production Reliability Test

Items	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's alpha coefficient
A1	0.718	0.964	0.965
A2	0.767	0.963	
A3	0.815	0.963	
A4	0.799	0.963	
A5	0.816	0.962	
A6	0.830	0.962	
A7	0.632	0.964	
A8	0.808	0.963	
A9	0.821	0.962	
A10	0.822	0.963	
A11	0.800	0.963	
A12	0.823	0.963	
A13	0.804	0.963	
A14	0.813	0.963	
A15	0.714	0.964	
A16	0.780	0.963	

2. Reliability analysis of production technology improvement

As shown in Table 3-7, the Corrected Item-Total Correlation(CITC) of 25 questions on measuring production technology improvement is almost all greater than 0.7, and only the 19th question with a CITC of 0.696, indicating that the 25 questions of production technology improvement are highly related to the survey objectives; the Cronbach's alpha coefficient for production technology improvement is 0.979, indicating that the internal consistency and stability of the 25 questions for production technology improvement are high, and the quality of data for the survey questionnaire is very good; after the items removed, the Cronbach's alpha coefficient is all greater than 0.9 and less than 0.979, which indicates that the 25 questions on measuring lean production have good discriminability, and any one of the 25 question items removed will lead to a decrease in the quality of survey data. The test results show that the reliability test results of the production technology improvement questionnaire are very good. The empirical analysis using the data from this survey on production technology improvement shows that the empirical results are highly reliable in terms of statistical significance.

Findings

Profile of Respondents

The respondents of this questionnaire survey are mainly production technicians and management personnel of high-tech manufacturing enterprises, and the sample companies mainly focus on high-tech manufacturing companies in Fujian, Beijing, Guangdong, Jiangsu, Zhejiang and Shanghai with relatively developed science and technology. Additionally, the backgrounds of the surveyed respondents such as the years of work experience, educational background, position and department at the surveyed high-tech manufacturing enterprises, as well as the backgrounds of the high-tech manufacturing enterprises such as the size of the company, nature of the company and operating years of the company, are used as control variables in the empirical model, respectively, which can improve the overall goodness-of-fit of the model in the following multiple linear regression analysis.

Description of the Basic Situation of the Sample

1. From the sample survey data, it can be seen that this questionnaire survey received a total of 425 questionnaires from 13 provinces (municipalities) in China. In this paper, questionnaires that were incompletely filled out or had outliers were eliminated as invalid questionnaires, and finally, 411 valid questionnaires were obtained, among which Zhejiang, Jiangsu, Shanghai, Beijing and Fujian ranked in the top five, accounting for a total of 96.71%, and these regions are all Chinese more developed regions in science and technology (as shown in Table 4-1).

Table 4-6 Source of Respondents

Source	Number of samples	Proportion
Zhejiang	193	46.96%
Jiangsu	86	20.92%
Shanghai	46	11.19%
Beijing	34	8.27%
Fujian	27	6.57%
Other	25	6.08%
Total	411	100.00%

2. This survey covers senior managers, middle-level managers, grassroots managers, and frontline staff of high-tech manufacturing enterprises. Among the surveyed, 33.6% were senior managers, who represented the highest proportion of all respondents; 19.5% were middle-level managers, 29.7% were grassroots managers and 17.3% were frontline staff, who had the lowest proportion in all the respondents. As shown in Table 4-2, the proportions of senior managers, middle-level managers, grassroots managers, and front-line staff are similar, covering people from all levels and departments of high-tech manufacturing companies.

Descriptive Statistical Analysis of Variables

Before making hypotheses test on the survey data, it is necessary to carry out descriptive statistical analysis on each variable and its dimension data. The following is a descriptive statistical analysis of sample data from 411 valid questionnaires for four variables: lean production, production technology improvement, quality management, and production performance. It should be noted that the dimensions of lean production, production technology improvement, quality management, and production performance and their sub-dimensions are obtained by the exploratory factor model, and the exploratory factor analysis model normalizes the obtained factors, so that the means of these dimensions and their sub-dimensions are 0 and the standard deviations are 1, as shown in Table 4-7.

Table 4-7 Descriptive Statistical Analysis of Sample Data for Each Variable

Variables	Dimension	Number of samples	Minimal value	Maximum value	Mean	Standard deviation
Lean Production	Company Culture	411	-4.40406	1.18227	0.000	1.000
	Employee Participation	411	-4.23546	3.64097	0.000	1.000
	Production environment	411	-3.81785	3.19844	0.000	1.000
Production technology improvement	Production design technology improvement	411	-4.18143	1.27094	0.000	1.000
	Production site technology improvement	411	-3.69976	3.83139	0.000	1.000
	Production line technology improvement	411	-4.48871	3.66761	0.000	1.000
	Production waste identification technology improvement	411	-5.01602	6.36199	0.000	1.000
Quality Management	Top-level design	411	-4.37238	1.15078	0.000	1.000
	Customer Orientation	411	-7.32150	3.56562	0.000	1.000
	Employee Management	411	-4.73910	3.40157	0.000	1.000
	Supplier Management	411	-5.31291	5.29876	0.000	1.000
	Process Management	411	-4.18660	5.37227	0.000	1.000
	Information Analysis	411	-6.44801	3.12251	0.000	1.000
	Product Design	411	-5.51186	3.44952	0.000	1.000
Production Performance	Financial Performance	411	-4.16550	1.30952	0.000	1.000
	Competitive Performance	411	-6.35482	3.75803	0.000	1.000
	Customer Satisfaction	411	-3.14055	5.75573	0.000	1.000

Research Objective 1 (R.O.1): Impact of Lean Production on the Production Performance of High-tech Manufacturing Enterprises

This section discusses the empirical relationship model between lean production and the production performance of high-tech manufacturing enterprises based on empirical analysis, existing literature, and related lean production and production performance theories. This section analyzes the correlation between lean production, its sub-dimensions and production performance of high-tech manufacturing firms and its sub-dimensions using data from a valid sample of 411 questionnaires; the role of lean production in influencing production performance of high-tech manufacturing firms; and the causal relationship between lean production and production performance of high-tech manufacturing firms based on the results of the empirical analysis.

Analysis

In the third chapter of this study, exploratory factor analysis model is used to subdivide independent variables of lean production into three dimensions: company culture, employee orientation, and production environment. With 411 valid sample data from questionnaires, this paper uses a canonical correlation analysis model to empirically study the correlation between lean production and its sub-dimensions and production performance and its sub-dimensions of high-tech manufacturing enterprises. As shown in Table 4-8. The correlation coefficient between lean production and production performance of high-tech manufacturing companies reaches 0.843 and is significantly positive at the 1% significance level, i.e., they move in the same direction, either increasing together or decreasing together; The correlation coefficients between lean production and the three dimensions of financial performance, competitive performance and customer satisfaction are 0.735, 0.823 and 0.824, respectively, and are significantly and positively correlated at the 1% significance level, i.e., all the sub-dimensions of lean production and production performance show significant positive correlations with each other; The correlation coefficients between company culture and production performance, financial performance, competitive performance and customer satisfaction are 0.782, 0.636, 0.766 and 0.753, respectively, and all of them are significantly positive at 1%

significance level, i.e., there is a significant positive correlation between company culture and production performance and its sub-dimensions; The correlation coefficients between employee participation and production performance, financial performance, competitive performance and customer satisfaction are 0.800, 0.679, 0.770 and 0.778, respectively, and all of them are significantly positive at 1% significance level, i.e., there is a significant positive correlation between employee participation and production performance and its sub-dimensions; The correlation coefficients between production environment and production performance, financial performance, competitive performance and customer satisfaction are 0.812, 0.700, 0.791 and 0.792, respectively, and all of them are significantly and positively correlated at 1% significance level, i.e., there is a significant positive correlation between production environment and production performance and its sub-dimensions. The study of correlation analysis is mainly to portray the closeness of linear correlation between two types of variables. From the results of the above analysis, it is clear that the linear relationship between lean production as well as its sub-dimensions and production performance as well as its sub-dimensions are both very close, but canonical correlation analysis can only study the correlation between variables but not the causality between variables, while multiple linear regression analysis can reveal the magnitude of the effect of lean production as well as its sub-dimensions on production performance as well as its sub-dimensions. Therefore, in order to examine the causal relationship between lean production as well as its sub-dimensions and production performance as well as its sub-dimensions, further multiple linear regression analysis needs to be done.

Table 4-8 Correlation Analysis Results between Lean Production and High-Tech Manufacturing Enterprise's Production Performance

	LP	LP1	LP2	LP3	PP	PP1	PP2	PP3
LP	1							
LP1	-	1						
LP2	-	-	1					
LP3	-	-	-	1				
PP	0.843***	0.782***	0.800***	0.812***	1			
PP1	0.735***	0.636***	0.679***	0.700***	-	1		
PP2	0.823***	0.766***	0.770***	0.791***	-	-	1	
PP3	0.824***	0.753***	0.778***	0.792***	-	-	-	1

Note: *** means p<0.01; ** means p<0.05; * means p<0.1.

Research Objective 2 (R.O.2): Impact of Production Technology Improvements on Production Performance of High-Tech Manufacturing Enterprises

This section discusses the empirical relationship between production technology improvement and the production performance of high-tech manufacturing enterprises based on previous research conclusions, existing research literature, and related production technology improvement and production performance theories. This section analyzes the correlation between production technology improvement, its sub-dimensions and production performance of high-tech manufacturing firms and its sub-dimensions using data from a valid sample of 411 questionnaires; the role of production technology improvement in influencing production performance of high-tech manufacturing firms; and the causal relationship between production technology improvement and production performance of high-tech manufacturing firms based on the results of the empirical analysis.

Analysis

This study subdivides production technology improvement (TP) into four dimensions: production design technology improvement (TP1), production site technology improvement (TP2), production line technology improvement (TP3), and production waste identification

technology improvement (TP4), and subdivides company production performance (PP) into three dimensions: financial performance (PP1), competitive performance (PP2), and customer satisfaction (PP3), and empirically investigates the relationship between production technology improvement and production performance of high-tech manufacturing companies using valid sample data from 411 survey questionnaires. According to the results of the correlation analysis shown in Table 4-10, the canonical correlation coefficient between production technology improvement and production performance reaches 0.891, and the significance level is less than 0.01, that is, there is a significant positive correlation between production technology improvement and the production performance of high-tech manufacturing enterprises at the 1% significance level; the canonical correlation coefficients between production technology improvement and the three sub-dimensions of production performance: financial performance, competitive performance and customer satisfaction are 0.781, 0.882 and 0.858, respectively, and the significance level is all less than 0.01, that is, there is a significant positive correlation between production technology improvement and the three sub-dimensions of production performance: financial performance, competitive performance and customer satisfaction at the 1% significance level; the canonical correlation coefficients between production design technology improvement and production performance, financial performance, competitive performance and customer satisfaction are 0.783, 0.665, 0.772, 0.754, respectively, and the significance level is all less than 0.01, that is, there is a significant positive correlation between production design technology improvement and production performance, financial performance, competitive performance and customer satisfaction at the 1% significance level; the canonical correlation coefficients between production site technology improvement and production performance, financial performance, competitive performance and customer satisfaction are 0.855, 0.734, 0.845, 0.811, respectively, and the significance level is all less than 0.01, that is, there is a significant positive correlation between production site technology improvement and production performance, financial performance, competitive performance and customer satisfaction at the 1% significance level; the correlation coefficients between production line technology improvement and production performance, financial performance, competitive performance and customer satisfaction are 0.855, 0.746, 0.841, 0.822, respectively, and the significance level is all less than 0.01, that is, there is a significant positive correlation between production line technology improvement and production performance, financial performance, competitive performance and customer satisfaction at the 1% significance level; the correlation coefficients between production waste identification technology improvement and production performance, financial performance, competitive performance and customer satisfaction are 0.856, 0.703, 0.831, 0.828, respectively, and the significance level is all less than 0.01, that is, there is a significant positive correlation between production waste identification technology improvement and production performance, financial performance, competitive performance and customer satisfaction at the 1% significance level.

Table 4-9 Correlation Analysis Results between Production Technology Improvement and Production Performance of High-Tech Enterprises

	TP	TP1	TP2	TP3	TP4	PP	PP1	PP2	PP3
TP	1								
TP1	-	1							
TP2	-	-	1						
TP3	-	-	-	1					
TP4	-	-	-	-	1				
PP	0.891***	0.783***	0.855***	0.855***	0.856***	1			
PP1	0.781***	0.665***	0.734***	0.746***	0.703***	-	1		
PP2	0.882***	0.772***	0.845***	0.841***	0.831***	-	-	1	
PP3	0.858***	0.754***	0.811***	0.822***	0.828***	-	-	-	1

Note: *** means p<0.01; ** means p<0.05; * means p<0.1.

The research of canonical correlation analysis mainly aims to depict the closeness of linear correlation between two variables, while regression analysis can reveal the magnitude of the effect of the independent variable on the dependent variable. Therefore, in order to examine the magnitude and causality of the relationship between production technology improvement and production performance, further multivariate regression analysis is needed.

Conclusion

This study takes Chinese high-tech manufacturing companies in a high-tech context as the research object (Xiao et al. 2021; Yang et al. 2022; Wang 2021; Huang, 2013; Kanagi et al., 2017; Mo, 2015;)ivided into three dimensions: company culture, employee participation and production environment; production technology improvement is divided into four dimensions: production design technology improvement, production site technology improvement, production line technology improvement and production waste identification technology improvement; quality management is divided into basic and core dimensions, with basic dimensions including top-level design, customer orientation, employee management and supplier management; core dimensions include process management, information technology and product design; and production performance is divided into financial performance, competitive performance and customer satisfaction (Yang & Yuan, 2022; Wang 2020; Talib et al., 2013; Wu, 2014). This paper takes quality management as a mediator variable and constructs a theoretical model of "lean production-production technology improvement-quality management-production performance". Using the data obtained from 411 valid questionnaires as a research sample, exploratory factor analysis, canonical correlation analysis and multiple regression analysis are used to empirically analyze the influence between lean production, production technology improvement, quality management and enterprise production performance, as well as the mediating role of quality management between lean production, production technology improvement and enterprise production performance. It provides a theoretical and practical basis for the path design of implementing lean production and production technology improvement in high-tech manufacturing enterprises. (Xiao et al. 2021; Al-Ettayyem et al. 2015; Bums & Stalker, 1961; Cai et al., 2018; Cao 2020; Edwards et al., 2007; Garcia et al., 2019; Ning 2013; Qi & Chen 2016; Qian 2017).

References

Al-Ettayyem, Rawan, & M. F. Zu'bi. (2015). Investigating the effect of total quality management practices on organizational performance in the Jordanian banking sector. *International Business Research,* 8(3), 79.

Bums, T & GM. Stalker. (1961). *The management of innovation*. Tavistock.

Burgess, Thomas F., & Hasan Kursat Gules.(1998). Buyer–supplier relationships in firms adopting advanced manufacturing technology: an empirical analysis of the implementation of hard and soft technologies. *Journal of Engineering and Technology Management,* 15 (2-3),127-152.

Cai, L.Y., Hao, Y.Q., An, R.Y., Zhao, W., Liu, Z.X., Liu, Y.X., Zheng, J., Zhao, Z.J., & Xu, J.P. (2018). Application of lean six sigma in semiconductor material production line. *Value engineering*, 37(31),271-274.

Cao, W. (2020). Study on production management improvement of MD company based on lean production. *Anhui University*.

Edwards, Jeffrey R., & Lisa Schurer Lambert. (2007). Methods for integrating moderation and mediation: a general analytical framework using moderated path analysis. *Psychological Methods,* 12(1), 1.

Fullerton, Rosemary R., & Cheryl S. McWatters. (2001). The production performance benefits from JIT implementation. *Journal of Operations Management,* 19(1), 81-96.

Garcia-Macia, Daniel, Chang-Tai Hsieh, & Peter J.Klenow. (2019). How destructive is innovation? *Econometrica,* (5), 1507-1541.

Huang, C. (2013). Can political affiliation improve the productive performance of private firms? —A re-examination based on data from a national sample of private enterprises. *Research on Finance and Economics*, (12),102-109.

Kanagi Kanapathy, Chiok Sook Bin, Suhaiza Zailani, & Ali Haj Aghapour. (2017). The impact of soft TQM and hard TQM on innovation performance: the moderating effect of organisational culture. *International Journal of Productivity and Quality Management,* 20(4), 429-461.

Mo, W. (2015). Exploration of cost management with lean accounting as a starting point. *Modern Business*, 3,220-221.

Ning, Y.M. (2013). A practical study of lean production management system in Chinese enterprises. *Mall Modernization*, 26, 53-54.

Qi, E.S., & Chen, G. (2016). A review of the classification and evolution of business model innovation theory. *Science and Technology Progress and Response*, 6,155-160.

Qian, B. (2017). A study on the moderating role of environmental dynamics on lean production and firm performance. *Nanjing University*.

Talib F, Rahman Z, & Qureshi M N. (2013). An empirical investigation of relationship between total quality management practices and quality performance in Indian service companies. *International Journal of Quality & Reliability Management*.

Wu, J.X. (2014). The connotation and characteristics of innovation ecosystem and its policy implications. *Scientific Research*, 1, 44-51.

Xiao, R.Q., Shen, J.J., & Qian, L. (2021). The impact of digitization level on firms' new product development performance—the mediating role of dual innovation capability. *Science and Technology Progress and Countermeasures,* 38(24), 106-115.

Yang, X.J., & Yuan, K. (2022). The sub-dimensional impact of quality management practices on innovation performance in strategic emerging industries—from a sample survey of Guangdong enterprises from 2014-2018. *International Business (Journal of the University of International Business and Economics),* (04), 139-156.

Cite this article:

HUANG XUELIANG (2023). A study of Lean Production and Quality Management on Production Performance: The Evidence in High-tech Manufacturing Companies in China. *International Journal of Science and Business, 22*(1), 53-70. doi: https://doi.org/10.58970/IJSB.2095

Retrieved from http://ijsab.com/wp-content/uploads/2095.pdf

Published by