Fayoum University
Faculty of Agriculture
Department of Agricultural Economics

The Impact of Dimensions of Manufacturing Flexibility on The Performance of Food Processing Projects in Fayoum Governorate

By

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(B.Sc. In Agribusiness Management)
Faculty of Agriculture, Fayoum University, 2013
Master of Agricultural Sciences (Agricultural Economics)
Faculty of Agriculture, Fayoum University, 2021

A Dissertation Submitted in Partial Fulfilment
Of requirements for the
Doctor of Philosophy degree
In Agricultural Sciences
(Agricultural Economics)

Department of Agricultural Economics
Faculty of Agriculture
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2025

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2024

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Defense Date: 11/05/2025.

Abstract

This study aimed to measure the impact of various dimensions of manufacturing flexibility on the performance of food manufacturing projects in Fayoum Governorate. To achieve the study's objective, Structural Equation Modeling (SEM) was used to analyze a set of regression equations in an integrated and simultaneous manner. Several statistical methods and tests were also employed to ensure that assumptions of SEM were met.

The study model showed the positive impact of manufacturing flexibility, represented by seven dimensions, on the operational and financial performance of the sample projects. It was found that the most influential dimension on operational performance was production process flexibility, followed by flexibility in handling production materials, flexibility in the production mix, and flexibility in production routes. Statistical significance was confirmed for the regression coefficients of these dimensions, while the regression coefficients for the dimensions of machine flexibility, volume flexibility, and labor flexibility were not statistically significant. On the other hand, the most influential dimensions on financial performance were flexibility in production routes, production volume flexibility, production mix flexibility, labor flexibility, production process flexibility, flexibility in handling production materials, and finally, machine flexibility.

Based on the findings, the study reached several recommendations, the most important of which are: launching financial and technical support programs for small projects to adopt flexible manufacturing, redesigning production processes to make them more flexible in the face of demand fluctuations, developing integrated strategies to reduce the impact of energy source shortages and high prices, enhancing innovation in the design of production lines to increase the ability to switch between different products, developing a composite index for manufacturing flexibility that reflects the industrial sector's ability to adapt to economic and external changes, providing continuous training for workers in multiple skills and adopting flexible work policies such as changing work schedules, Enhancing project transparency and increasing the accuracy and availability of data from the government, and reconsidering tax exemptions and supporting policies granted to the public sector over the private sector.

Keywords: Manufacturing flexibility, Operational flexibility, Tactical flexibility, Operational performance, Financial performance, Structural equation modeling, SEM, Food manufacturing.

Summary

Agricultural manufacturing increases the added value of agricultural crops and reduces waste. It helps achieve a balance between the supply of agricultural products and the demand, leading to price stability throughout the year and preventing fluctuations. This is because manufacturing absorbs the surplus beyond fresh consumption needs and provides products for export. Moreover, manufacturing facilitates the handling and storage of agricultural products, subjecting them to quality standards, enabling penetration into foreign markets, increasing competitiveness, and contributing to economic development by creating job opportunities and utilizing available resources in the community.

Organizations strive to ensure flexibility in their manufacturing systems to enhance their ability to cope with unexpected changes in their production processes, such as machine breakdowns, varying times for task completion, delays in order execution, and rework. This is to address the rapidly changing business environment, characterized by speed, intensity, diversity, and suddenness, often resulting from accelerated technological advancement and shifts in customer preferences.

Despite the economic importance of food manufacturing, there is noticeable idle capacity in various food manufacturing sectors in Egypt. In 2021, idle capacities amounted to approximately 13.04% and 13.3% of available capacities in the public and private sectors, respectively. Additionally, production technology in food industries has not developed sufficiently, while a surplus in production is often exported as raw material or suffers significant losses. This has resulted in a decline in annual exports and limited competitiveness in global markets. Consequently, this negatively affects the performance of the food industry sector, leading to higher unit production costs, waste of limited societal resources, reduced productivity, and lower returns on investment.

The success of enterprises lies in their ability to respond quickly to customer needs. Enterprises must balance meeting these needs with minimizing the costs of manufacturing the products or services required by customers,

considering the time needed to deliver products to the market and achieving better performance than competitors.

This study primarily aimed to measure the impact of the dimensions of manufacturing flexibility on the performance of food manufacturing projects in Fayoum Governorate. To achieve its objectives, the study relied on descriptive and quantitative statistical and economic analysis methods to measure the extent to which manufacturing flexibility dimensions affect the performance of food manufacturing projects in Fayoum. Simple statistical methods were utilized to calculate arithmetic, geometric, and harmonic means, frequencies, percentages, standard deviations, coefficients of variation, geometric standard deviations, standard errors, and rankings.

The study also employed covariance-based structural equation modeling (CB-SEM) using the Maximum Likelihood (ML) method to analyze a set of regression equations in an integrated and simultaneous manner. Assumptions were verified using the Variance Inflation Factor (VIF), Power Analysis, and Mardia's Coefficient. Additionally, a meta-analysis was conducted on studies examining the relationship between manufacturing flexibility and enterprise performance to construct and test a theoretical model of this relationship. The study utilized Cronbach's Alpha, Composite Reliability, and Convergent and Discriminant Validity to test the reliability and validity of the data collection tool used to measure the study variables. Moreover, general time trend equations were applied using simple linear regression.

To achieve its objectives, the study relied on secondary data, including published and unpublished sources, books, studies, research papers, theses, references, reports, and relevant websites. It also relied on primary data collected through a field sample of those managing food manufacturing projects in Fayoum Governorate by designing a questionnaire containing questions that align with the study's objectives.

The study comprises five chapters in addition to the introduction, which includes the research problem, objectives, data sources, and methodology, alongside the abstract in Arabic and English, the summary, recommendations, and appendices.

The first chapter includes two sections. **The first section** addresses the theoretical framework of the study, exploring the basic concepts, such as manufacturing flexibility, its dimensions, financial and operational performance, their importance, and measurement indicators. It also reviews the statistical methods and models were used in the study. **The second section** reviews key studies related to the research topic, divided into four categories, along with a meta-analysis of previous studies' findings. The meta-analysis results demonstrated the consistency of the study model, indicating its alignment with one of the conditions for using structural equation modeling methodology.

The second chapter analyzes the production performance of the food industry sector in Egypt and Fayoum Governorate. It consists of two sections, with **the first** focusing on the development of production performance in Egyptian food industries. Results showed that the real value of food industry products reached approximately 114.5 billion EGP in 2023 (2008 prices), representing about 7.5% of the real GDP for the same year. The findings indicated that the contribution of the food industry sector to public sector manufacturing is significantly lower than its contribution to the private sector, which has grown considerably, particularly between 2006 and 2023, accounting for a significant portion of manufacturing output.

The total number of food industry companies in the public and private sectors reached approximately 128 and 63,500 companies, respectively, in 2023, with an average of 171.8 and 22,400 companies during the study period. The real value of available capacity in food product manufacturing for the public and private sectors amounted to approximately 4.2 billion EGP and 127.4 billion EGP, respectively, in 2023 (2008 prices), with utilization rates of about 89.1% and 86.9%, respectively.

It was found that the average real value of idle capacity relative to the average available capacity in the public sector was higher than that in the private sector during the study period, with idle capacity accounting for approximately 16.2% of the available capacity in the public sector, compared to only 11.2% in the private sector. This reflects the private sector's efficiency in

resource management.

A lack of raw materials ranked as the primary cause of idle capacity in the public sector's food product manufacturing, followed by technical issues and marketing difficulties, which collectively accounted for about 70.4% of idle capacity during the 2008–2023 period. Conversely, in the private sector, marketing difficulties were the leading cause, followed by technical issues and raw material shortages, accounting for approximately 82.3% of idle capacity.

Manufacturing flexibility plays a role in reducing idle capacity. Flexible production processes can address machine breakdowns by altering scheduling or production sequences. Labor flexibility mitigates issues arising from workforce shortages and absences. Machine flexibility helps manage spare part shortages, reduces maintenance and replacement times, and minimizes downtime.

The sugar refining industry ranked first in the public sector, followed by the grain milling, starch, and vegetable oil and fat industries, collectively accounting for 89.6% of the total real operational capacity in the public sector food industries. In contrast, in the private sector, grain milling and starch industries ranked first, followed by fruit and vegetable processing, uncategorized food industries, dairy products, vegetable oils and fats, and bakery products.

The second section examines the production performance of food manufacturing projects in Fayoum and the current state of food industry products in the governorate. Fayoum contributes to food manufacturing through various industries classified under three international economic activity categories. Key industries include dairy products, pickles, and pasta. Dairy production ranked first in the number of food manufacturing projects in Fayoum, with an average of 107.8 factories, accounting for 77.9% of the governorate's total food manufacturing projects and about 9.7% of all dairy factories in Egypt. Their average total production capacity was 5.4 thousand tons, of which 3.2 thousand tons were utilized, achieving an operational efficiency of 59.9% during the 2008–2023 period.

The third chapter is divided into two sections. **The first section**

addresses the financial performance of the Egyptian food industry sector. Results indicated that the average real value of assets and liabilities in the public sector's food industries was 6.7 billion EGP and 6.8 billion EGP, respectively, during 2008–2023. Meanwhile, the average real value of assets and liabilities in the private sector's food manufacturing was 12.1 billion EGP and 12.7 billion EGP, respectively (2008 prices), during the same period.

The average real value of current assets and current liabilities in the food industry within the public sector amounted to approximately 3.7 and 2.7 billion EGP, respectively, during the period (2008–2023). Meanwhile, the average real value of current assets and current liabilities in private-sector food manufacturing companies was about 5.8 and 5.2 billion EGP, respectively, during the study period. Additionally, the average total and net real invested capital in the public business sector reached around 4.6 and 4.5 billion EGP, respectively, while for private-sector companies, these values amounted to 8.6 and 8.1 billion EGP, respectively, at 2008 prices over the period (2008–2023).

On another front, the average real value of net working capital for the public business sector was about 961.6 million EGP, compared to 600.5 million EGP for the private sector during the period (2008–2023). The average real value of equity in the public business sector amounted to 1.6 billion EGP, while it reached 3.9 billion EGP in the private sector during the same period. The average real production costs in the public business sector were approximately 4.8 billion EGP, compared to 10.4 billion EGP for the private sector, based on 2008 prices over the period (2008–2023).

Similarly, the average real wage costs in the public business sector were about 731 million EGP during the study period, compared to approximately 903.2 million EGP in the private sector over the period (2008–2023). The average real value of administrative and financial service costs in public business companies was about 401.9 million EGP, compared to 1.4 billion EGP in the private sector over the same period. The average real cost of marketing services in public business companies was approximately 123.2 million EGP, while it reached 804 million EGP in the private sector at 2008 prices over the period (2008–2023).

Additionally, the average real value of cash balances in the public business sector amounted to about 358.8 million EGP, compared to 797.8

million EGP in the private sector over the period (2008–2023). The average real sales value in the public business sector was estimated at approximately 5.4 billion EGP, while in the private sector, it reached around 12.3 billion EGP over the same period. The average real net profit or loss in the public business sector was around 196 million EGP, compared to about 540.6 million EGP in the private sector over the period (2008–2023), based on 2008 prices. The average number of workers in the public and private sectors was approximately 43.8 and 162.8 thousand workers, respectively, during the study period.

The second section discusses the development of financial indicators for evaluating the performance of Egypt's food industry sector. Results indicated a higher turnover rate of invested capital in the private sector compared to the public business sector, reflecting the private sector's superior efficiency in utilizing invested capital and managing its projects productively. Marketing efficiency ratios, represented by the turnover rate of net working capital, highlighted greater marketing challenges in the private sector compared to the public business sector during the study period.

Calculating the net return on assets for both the public business and private sectors revealed the private sector’s lower capacity to generate profits from its operational activities. However, the increased capacity of the public business sector was largely due to a significant rise in the net return on assets in 2023, which resulted from a substantial increase in net profits for public business companies that year. The net profit to equity ratio for both sectors indicated greater investor confidence in directing investments toward the private sector due to its higher return rates compared to the public business sector.

The total asset turnover rate for both sectors demonstrated the private sector's superior efficiency in managing its fixed assets and leveraging them to generate sales. Similarly, the current asset turnover rate showed the private sector's better management of its current assets in generating sales compared to the public business sector.

The current ratio values during the study period indicated the private sector's inability to meet its obligations during that period. The quick liquidity ratio for both sectors fell below 1, indicating that, despite the public business sector's higher ability to meet its obligations compared to the private sector, neither sector could address urgent or critical commitments.

Calculating the average total liabilities to total assets revealed a decline in both sectors' ability to pay off their current obligations and loans during the study period. The total liabilities-to-equity ratio results indicated that the public business sector's food product manufacturing segment faced more challenges in repaying debts and loan interests from total equity compared to its private-sector counterpart.

Chapter four comprises two sections, with **the first** focusing on describing the study population and sample. It consists of six main sections. The first section describes the study population, noting that a geographical distribution study of food manufacturing projects in Fayoum Governorate during 2023 revealed 139 food manufacturing projects. These were distributed across Fayoum city and the districts of Tamya, Senoures, Etsa, Ibshway, and Youssef El Seddik, with 71, 25, 22, 9, 9, and 3 projects, respectively.

In the second section, the study did not conduct a comprehensive survey due to a lack of response from some population elements and inaccuracies in secondary data concerning the number and geographical distribution of food manufacturing projects. Consequently, 123 questionnaires were distributed, of which 113 were retrieved. After excluding 17 questionnaires for being unfit for statistical analysis, the final sample comprised 96 questionnaires, representing approximately 78% of the distributed forms.

Further, the study’s tool exhibited high reliability and validity, as measured by Cronbach’s Alpha coefficient and composite reliability. Convergent and discriminant validity measures were also applied to evaluate the data.

The fifth section analyzed the socio-economic characteristics of survey respondents and study sample projects. Results highlighted the respondents' high educational levels, enhancing their comprehension of the questionnaire, which in turn increased its reliability and validity. The standard deviation of workers per project (91.2 workers) indicated a wide variation due to differing labor requirements and project sizes. Moreover, the high space utilization rates in sample projects suggest limitations in their future expansion potential, especially for dairy-related projects located near residential areas.

Chapter five comprises two sections, **the first** focuses on validating assumptions for structural equation modeling (SEM) and confirms the data's

suitability for this methodology. Multicollinearity tests (VIF and tolerance) and skewness values were within acceptable ranges, confirming data validity. Financial performance variables deviated most from a normal distribution and were transformed to ordinal levels for analysis.

Regarding the most influential dimensions of manufacturing flexibility in the studied projects, it is clear that labor flexibility is the most influential dimension of manufacturing flexibility, with a standardized regression coefficient of 0.711. Following it are production route flexibility, flexibility in handling production inputs, production process flexibility, product mix flexibility, production volume flexibility, and machine flexibility, with standardized regression coefficients of 0.692, 0.651, 0.643, 0.626, 0.576, and 0.509, respectively.

Regarding the most influential dimensions contributing to the operational performance of the studied projects, on-time delivery is the most influential factor, with a standardized regression coefficient of 0.84. This is followed by product quality and production cost, with standardized regression coefficients of 0.753 and 0.574, respectively.

section two discusses the structural model analysis of the impact of manufacturing flexibility on the performance of the studied projects, as well as the analysis of the most influential dimensions of manufacturing flexibility on financial and operational performance.

Variance analysis indicates that the differences observed in manufacturing flexibility, operational performance, and financial performance in the studied projects result from factors other than paid-up capital, labor size, and project activity categories.

The study model highlights the impact of manufacturing flexibility, represented by seven dimensions, on the financial performance of the studied projects, expressed through six indicators representing measures of productivity efficiency, marketing efficiency, activity efficiency, liquidity, and financial solvency. The standardized regression coefficient for the effect of manufacturing flexibility on financial performance was estimated at 1.086, indicating that for each increase of a standard unit in manufacturing flexibility, the financial performance of the studied projects improves by 1.086 standard units.

Additionally, the study model reveals that the most influential dimension on operational performance is production process flexibility, with a standardized regression coefficient of 0.494. This is followed by flexibility in handling production inputs (0.456), product mix flexibility (0.252), and production route flexibility (0.241). Statistical significance was confirmed for all these regression coefficients, while the regression coefficients for machine flexibility, production volume flexibility, and labor flexibility were not statistically significant.

On the other hand, the model shows that the most influential dimension on financial performance is production route flexibility, with a standardized regression coefficient of 0.527. This is followed by production volume flexibility (0.481), product mix flexibility (0.405), labor flexibility (0.383), production process flexibility (0.372), handling production inputs flexibility (0.304), and machine flexibility (0.207).

The study of the problems affecting the performance of the studied projects reveals that high transportation costs rank first as the most influential problem, with a standardized value of 77.6. It is followed by high interest rates on bank loans, weak demand for products in markets, power outages, difficulties in obtaining permits, unavailability of spare parts, fluctuating raw material prices, high fuel prices and their unavailability, and rising labor wages, in that order. These problems represent approximately 81.1% of the most significant issues affecting the performance of food manufacturing projects, as perceived by the respondents in the Fayoum Governorate. Therefore, the study suggests focusing on these problems due to their significant impact on the performance of the studied projects.

Moreover, it was found that the rising prices and unavailability of energy sources—such as high transportation costs, frequent power outages, and the unavailability and high prices of fuel—constitute approximately 29.4% of the impact on the performance of the studied projects.

Recommendations:

Based on the results and findings obtained, the study recommends:

Recommendation	Responsible Party	Implementation Mechanism	Success Indicator

Recommendation	Responsible Party	Implementation Mechanism	Success Indicator
1. Launch financial and technical support programs for small enterprises to adopt flexible manufacturing.	· Ministry of Finance · Banks · Small Enterprise Support Agencies	· Provide easy loans and guidance programs to implement flexible manufacturing technologies.	· Increase the percentage of projects adopting flexible manufacturing.
2. Redesign production processes in projects to be more flexible in response to demand fluctuations.	· Production Departments in Projects	· Implement integrated production systems based on actual demand (JIT).	· Reduce response time to demand. · Minimize waste in operations.
3. Work on increasing labor flexibility in the food manufacturing sector.	· Ministry of Manpower · Human Resources Department in Projects	· Develop comprehensive training programs to enhance employees' skills. · Increase coordination between labor offices and industrial projects. · Adopt flexible work policies, including variable work schedules and part-time programs.	· Percentage of trained workforce. · Degree of benefit from training programs. · Level of project satisfaction with market adaptation.
4. Develop and strengthen integration between suppliers and customers to ensure the flow of raw materials and spare parts.	· Ministry of Industry · Chambers of Commerce	· Formulate strategies focusing on improving supply chains and diversifying sources of production materials. · Strengthen cooperation between local and international suppliers. · Grant customs exemptions on raw material imports for manufacturing purposes and tax exemptions for spare parts manufacturing projects.	· Increase exports of processed food products. · Strengthen the stability of supply chains. · Reduce idle energy percentage in projects.
5. Develop comprehensive strategies to mitigate the impact of unavailability and rising prices of energy sources.	· Ministry of Transport · Ministry of Electricity and Energy · Ministry of Petroleum and Mineral Resources · Industrial Projects	· Improve transportation networks and activate the use of public transport for raw materials and products. · Support projects in transitioning to alternative and renewable energy sources. · Adopt policies to provide subsidized energy sources for projects and ensure stable supply.	· Lower transportation and energy costs in projects.
6. Promote innovation in production line design to increase the ability to switch between different products.	· Industrial Engineering Department in Projects · Universities and Research Centers	· Apply Modular Manufacturing techniques that enable rapid setup of production lines.	· Reduce time required to switch between products. · Increase flexibility of production lines.

Recommendation	Responsible Party	Implementation Mechanism	Success Indicator
7. Develop a composite index reflecting the manufacturing flexibility of the Egyptian industrial sector and publish its results regularly.	· Central Agency for Public Mobilization and Statistics · Universities and Research Centers	· Design a comprehensive index based on manufacturing flexibility dimensions and publish its results regularly to support decision-making.	· Publish the index regularly. · Adopt the index as a reference for policy formulation. · Achieve tangible improvements in industrial sector performance.
8. Analyze the regulatory policies impacting the financial performance structure of the Egyptian food manufacturing sector, focusing on tax exemptions and their impact on project performance.	· Ministry of Finance · Ministry of Industry · Universities and Research Centers	· Conduct analytical studies comparing tax and regulatory policies between the private and public sectors.	· Reduce the performance gap between the private and public sectors. · Increase investor satisfaction with supporting policies.
9. Conduct further studies on the impact of strategic manufacturing flexibility on organizational performance in its various dimensions.	· Universities and Research Centers	· Design field studies to explore other dimensions of manufacturing flexibility, such as design flexibility, supply chains, innovation, decision-making, and their impact on competitive performance.	· Increase the number of studies published in this field. · Have study results adopted by industrial projects.
10. Enhance transparency for projects and provide updated and accurate secondary data.	· Ministry of Finance · Central Agency for Public Mobilization and Statistics	· Develop mandatory policies for projects to publish periodic financial and operational data. · Update national databases and make them available to investors and researchers.	· Increase the number of projects committed to publishing data. · Improve the use of national databases in economic studies.