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Sensitivity Analysis In Operations Research Decisions: A Case Study On A Mathematical Model

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Abstract
This study explores sensitivity analysis within the realm of decision-making in Operations Research, focusing on integrated mathematical models. The investigation centers on a critical variable—supplier lead time—using a case study to comprehend its impact on both operational efficiency and the overall costs of a manufacturing company. To optimize inventory levels, production costs, and total operational costs, an integrated mathematical model is devised, taking into account variations in supplier lead times. Sensitivity experiments are performed by manipulating supplier lead times, and the ensuing outcomes are scrutinized to offer comprehensive insights. The findings reveal that substantial alterations in supplier lead time can significantly affect operational performance and strategic decision-making. In response to lead time changes, adaptive strategies, such as implementing tighter contracts and exploring alternative suppliers, are suggested. This research enhances our understanding of how sensitivity analysis serves as a valuable tool for enhancing operational resilience and making informed decisions amidst uncertainties in supply chains.

Keywords: Sensitivity Analysis, Operations Research, Integrated Mathematical Model, Supplier Lead Time, Operational Resilience, Strategic Decision-making, Supply Chain.

Introduction

Operations Research (OR) represents a scientific field that integrates mathematical concepts, statistical analysis, and modeling to tackle intricate decision-making challenges (Soedarso, 2018). Employed as a primary tool in OR, integrated mathematical models play a crucial role in translating real-world complexities into mathematical formulations, facilitating the design and comprehension of optimal solutions (Arulan, 2013). Sensitivity analysis, recognized as an indispensable method in this context, assesses the impact of uncertainty in model parameters on resulting decisions (Suharyo et al, 2017). The utilization of case studies on integrated mathematical models provides profound insights into the practical application of sensitivity analysis within Operations Research. These models often encompass numerous variables and constraints, forming intricate systems demanding a deep understanding to reach optimal solutions. Consequently, sensitivity analysis becomes pivotal in gauging how changes in parameters can affect final decisions.

Systematic and fundamental to OR, sensitivity analysis is a process allowing exploration and measurement of the influence of key parameter changes on model solutions (Muhajirin & Panorama, 2017). This awareness empowers decision-makers to make more informed and responsive decisions in the face of an ever-evolving environment. This paper delves into the application of sensitivity analysis through a case study on an integrated mathematical model, emphasizing the identification of critical parameters, determination of acceptable parameter value ranges, and interpretation of results to enhance decision reliability and relevance. By applying sensitivity analysis, this research aims to delve deeper into the

uncertainty of model parameters, offering a more nuanced understanding of the trustworthiness of decisions across various scenarios. Decision-makers can then formulate adaptive strategies responsive to fluctuations in environmental or business conditions. Ultimately, this study underscores the pivotal role of sensitivity analysis in fortifying the foundation for decision-making grounded in mathematical models across diverse application contexts.

LITERATURE REVIEW

Sensitivity Analysis

A pivotal element in Operations Research, sensitivity analysis goes beyond identifying critical parameters, providing an in-depth comprehension of system dynamics in response to change (Sulartopo et al., 2023). In the realm of integrated mathematical models, where complexity and uncertainty pose significant challenges, sensitivity analysis offers invaluable insights. It not only reveals parameters with a substantial impact on decision outcomes but also establishes acceptable ranges of parameter values critical for decision consistency (Tanjung et al., 2005). Case studies in supply chain optimization exemplify how sensitivity analysis can be applied practically. For instance, if sensitivity analysis identifies production costs as a significant factor, a company may respond by exploring cost reduction strategies, negotiating with suppliers, or altering raw material sources. Beyond risk management, sensitivity analysis contributes to optimizing business policies, enabling organizations to develop adaptive strategies responsive to dynamic business or environmental conditions.

In essence, sensitivity analysis is not merely an analytical tool but a strategic approach fostering an understanding, management, and optimization of decision systems. In complex decision-making scenarios, a profound grasp of how parameter changes influence decisions is crucial for achieving resilience, effective risk management, and the formulation of adaptive business policies.

Operations Research

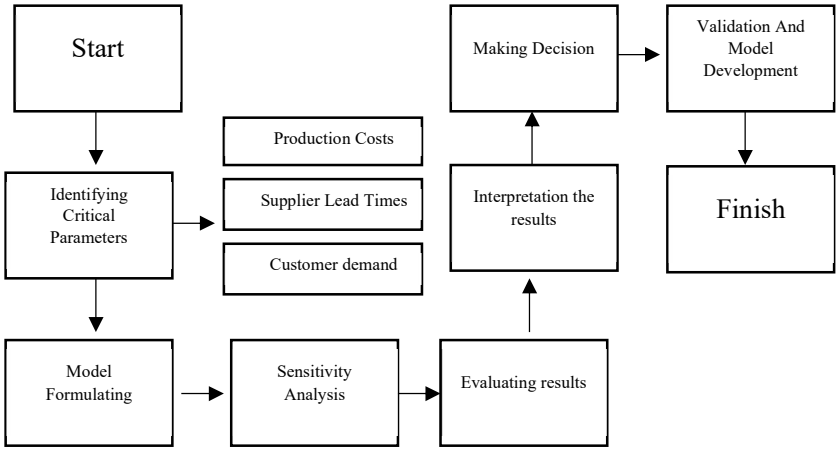
Operations Research (OR) is a scientific discipline dedicated to simplifying and optimizing decision-making through analytical and mathematical approaches (Ramdhani, 2001). Providing a framework for designing optimal solutions across various fields, including manufacturing, logistics, finance, and services, OR encompasses mathematical techniques like linear programming, dynamic programming, and queuing theory (Sari et al., 2023). At its core, OR aims to optimize goals such as minimizing production costs, maximizing profits, or allocating resources efficiently (Okviana, 2011). Integrated mathematical models play a crucial role in OR, representing problems through mathematical equations and inequalities. Sensitivity analysis, integral to OR, evaluates how variations in model parameters influence the resulting solution, offering insights into solution robustness and reliability in the face of changing conditions or model assumptions. Case studies in OR often involve complex problems like supply chain optimization, resource allocation, or production planning. Sensitivity analysis identifies critical parameters, manages risks, and supports the development of adaptive policies, ensuring that decisions are grounded in a deep understanding of dynamic and uncertain environments.

RESEARCH METHODS

The sensitivity analysis research method in OR decisions is a systematic approach comprising several steps to comprehend the impact of parameter changes on integrated mathematical model solutions (Syaifuddin, 2011). The process begins with identifying critical parameters exerting a significant influence on optimal decisions. In case studies, parameters like production costs, supplier lead times, and customer demand are commonly identified as critical. After pinpointing critical parameters, the subsequent steps involve formulating an integrated mathematical model that includes relevant variables and constraints. The model is implemented using appropriate software or analysis tools. A sensitivity experiment is then designed, setting variations in parameter values based on relevant scenarios or value ranges. Subsequently, sensitivity analysis is executed for each scenario, and the results are evaluated.

Interpreting the results and deducing implications are crucial steps in this research method. Decision-makers grasp the impact of parameter changes on model solutions, understanding how optimal decisions can fluctuate in the face of variations in critical parameters. The outcomes guide the selection of adaptive strategies, enabling organizations to respond effectively to risks. The final step involves validation and model development, wherein sensitivity analysis results enhance the reliability of integrated mathematical models. Model development may include adding parameters, altering the model structure, or adjusting assumptions. In conclusion, the sensitivity analysis research method contributes not only

to understanding uncertainty in OR decisions but also serves as a foundation for making smarter and more responsive decisions in dynamic business and industrial environments.



Flowchart Figure 1 Research procedure

RESULTS AND DISCUSSION

In the domain of Operations Research decisions, particularly within integrated mathematical models, sensitivity analysis assumes a crucial role in guiding decision-making amidst the uncertainties and dynamic nature of the business environment. This research aims to delve into and comprehend how alterations in critical parameters, with a specific emphasis on supplier lead time, can impact optimal solutions and strategic decisions within the supply chains of manufacturing companies. The integrated mathematical model formulated for this study encompasses various pertinent variables and constraints associated with supply chain operations, including inventory levels, production costs, and overall operational costs. A pivotal focal point is the supplier lead time, recognized as a critical parameter exerting a substantial influence on operational efficiency and costs. The model's implementation through optimization software facilitates the simulation of diverse sensitivity scenarios by manipulating supplier lead times. Sensitivity experiments were conducted, introducing variations in supplier lead times at 20%, 40%, and 60%, with the subsequent results meticulously recorded for comprehensive analysis.

Sensitivity Analysis Results

The outcomes of the sensitivity analysis reveal noteworthy alterations in key variables, as succinctly presented in the ensuing table:

Table 1 Analysis Of Operations Research Decisions

Supplier Lead Time	Inventory Levels	Production cost	Total Operational Costs
Normal	1000 units	$50,000	$150,000
+20%	800 units	$55,000	$180,000
+40%	700 units	$60,000	$200,000
+60%	600 units	$65,000	$220,000

The sensitivity analysis conducted in the realm of Operations Research decisions, particularly within integrated mathematical models, assumes a pivotal role in guiding decision-making amid the uncertainties and dynamic nature of the business environment. This study aimed to explore how changes in critical parameters, specifically focusing on supplier lead time, can influence optimal solutions and strategic decisions in the supply chain of manufacturing companies. The integrated mathematical model developed for this investigation incorporates various variables and constraints relevant

to supply chain operations, including inventory levels, production costs, and overall operational costs. Supplier lead time, identified as a critical parameter with a significant impact on operational efficiency and costs, took center stage. The model's implementation, facilitated by optimization software, allowed the simulation of diverse sensitivity scenarios by manipulating supplier lead times. Sensitivity experiments were conducted, introducing variations of 20%, 40%, and 60% in supplier lead times, and the subsequent results were meticulously recorded for in-depth analysis.

The outcomes of the sensitivity analysis unveil that a 40% increase in supplier lead time correlates with a substantial upswing in total operational costs. This introduces new challenges such as delayed product delivery and escalated storage costs. The implications underscore the critical importance of managing supplier lead time to uphold efficiency and timeliness within the supply chain. Faced with these findings, decision-makers opted for an adaptive strategy. Measures included fortifying collaboration with suppliers through tighter contracts, enhancing supply chain visibility, and exploring alternative, more reliable supplier options. This strategic approach aims to mitigate risks and enhance supply chain reliability in the face of lead time uncertainty. The results of sensitivity analysis not only offer insights into how supplier lead times impact operational decisions but are also instrumental in validating integrated mathematical models. Model refinement involves considering additional factors, such as fluctuations in customer demand or potential variations in lead time, ensuring model relevance in the dynamic business landscape.

This research makes a substantial contribution to understanding the role of sensitivity analysis in Operations Research decisions, especially within integrated mathematical models. The findings underscore that critical parameters, like supplier lead time, wield a significant influence on operational efficiency and overall costs. Sensitivity analysis emerges as an effective tool for decision-makers to comprehend and navigate uncertainty. The adaptive strategies implemented following sensitivity analysis exemplify the company's ability to adapt to evolving dynamics in its business environment. Organizations, through the application of this method, can enhance their preparedness to confront challenges and changes within their supply chains. Sensitivity analysis transcends mere risk identification; it provides a foundation for developing proactive and effective adaptive strategies. This research affirms that, alongside the development of integrated mathematical models, sensitivity analysis stands as an integral element supporting more informed decisions in Operations Research.

DISCUSSION

The discussion of the results from sensitivity analysis research on supplier lead time in Operations Research decisions, particularly within integrated mathematical models, brings forth several crucial considerations within the context of supply chain management. This analysis provides profound insights into how changes in critical parameters, such as supplier lead times, can impact a company's optimal solutions and operational strategies. The significance of sensitivity analysis in Operations Research decisions lies in its capacity to assess the influence of changes in critical parameters on solutions derived from integrated mathematical models. In this research, supplier lead time emerges as a critical parameter due to its pivotal role in determining the efficiency and availability of raw materials within the supply chain. The research findings confirm that substantial alterations in supplier lead times can yield noteworthy changes in total operational costs.

In the dynamic landscape of business, effective supply chain management stands as a linchpin for company success. The sensitivity analysis, as conducted in this research, becomes a strategic tool for companies to identify and manage potential risks in their supply chains (Meflinda, 2011). By comprehending how changes in specific parameters impact operational decisions, decision-makers can formulate adaptive strategies to enhance the resilience and agility of their businesses. It is imperative to emphasize the tangible impact of changes in supplier lead time on company operations. In this study, a 40% increase in supplier lead time resulted in a substantial reduction in inventory levels, an upswing in production costs, and ultimately, an increase in total operational costs. This impact extends beyond financial considerations, potentially influencing the quality of customer service and customer satisfaction.

One of the primary contributions of this research is the identification of adaptive strategies that companies can adopt in response to changes in supplier lead times. Initiatives such as tighter contracts with suppliers, heightened supply chain visibility, and exploration of alternative supplier options are proactive measures taken to mitigate risks and counteract negative impacts. This showcases a company's ability to learn from sensitivity analysis and implement necessary changes to fortify the reliability of its operations.

The outcomes of this research carry significant implications for business management. Company leaders can leverage the results of sensitivity analysis as a guide for making more informed decisions regarding their supply chains. They can identify potential risks, develop mitigation strategies, and enhance the sustainability of their supply chains. The validity of the integrated mathematical model employed in this research holds critical importance. The results of sensitivity analysis serve as a foundation for ensuring the model's reliability in simulating parameter variations. Model development encompasses additional considerations, such as accounting for fluctuations in customer demand or variations in lead time, to ensure ongoing relevance in the face of changing business environments. Despite the valuable insights provided by this research, it is essential to acknowledge certain limitations. Sensitivity analysis relies on specific assumptions that may not fully capture the complexity of the entire supply chain. Therefore, the results of this study should be interpreted with these limitations in mind.

This research paves the way for future exploration in several areas. Firstly, conducting exploratory sensitivity analysis on other parameters within the supply chain can offer a more comprehensive understanding of uncertainty and its impact. Additionally, future research could focus on integrating new technologies, such as artificial intelligence or blockchain technology, into integrated mathematical models to anticipate more intricate changes in the business environment.

Thus, the results of this study underscore the significance of sensitivity analysis in Operations Research decisions, particularly in the realm of supply chain management. Supplier lead time is identified as a critical parameter that significantly influences operational performance and total operational costs. The proposed adaptive strategy can serve as a guide for companies in managing risks and improving the resilience of their supply chains. Consequently, this research contributes substantially to understanding and managing uncertainty within the dynamic landscape of corporate operations.

CONCLUSION

The overarching conclusion drawn from the sensitivity analysis research on supplier lead times in Operations Research decisions, with a specific focus on integrated mathematical models, is that a profound understanding of the impact of changes in critical parameters can offer valuable guidance for decision-makers. Through sensitivity analysis, companies can pinpoint potential risks, assess their impact, and devise adaptive strategies to bolster the resilience of their operations. The significance of supplier lead time in supply chain management and company operations has been unequivocally validated. This research affirms that significantly increasing supplier lead time can lead to heightened total operational costs, diminished production efficiency, and potential delays in meeting customer demand. Adaptive strategies, such as tighter contracts, increased supply chain visibility, and exploration of alternative supplier options, emerge as effective measures to manage risk and respond to changes in lead time.

Sensitivity analysis transcends being a mere analytical tool; it serves as the basis for intelligent and proactive decision-making. By gaining a better understanding of how uncertainty can impact optimal solutions, companies can navigate change more effectively and take appropriate steps to ensure smooth operations. These conclusions also underscore the pivotal role of integrated mathematical models in supporting sensitivity analysis. The model must evolve and be refined over time, considering new dynamics in the business environment. The model's validity is paramount, and the results of sensitivity analysis provide a basis for ensuring ongoing relevance.

REFERENCES

Apriliyana, D. A., Masfu'ah, S., & Riswari, L. A. (2023). Analisis Pemahaman Konsep Matematika Siswa Kelas V pada Materi Bangun Ruang. *JIIP-Jurnal Ilmiah Ilmu Pendidikan*, *6*(6), 4166-4173.

Arulan, B. D. (2013). *Media komik matematika dalam meningkatkan pemahaman materi perkalian pada siswa kelas 3 MI Nurul Huda Malang* (Doctoral dissertation, Universitas Islam Negeri Maulana Malik Ibrahim).

Budhayanti, C. I. S., Wijayanti, S. H., & Dirgantara, V. E. (2022). Analisis Instruksional Pembelajaran Terpadu Berbasis Literasi Budaya Pada Pelajaran Matematika Dan Bahasa Indonesia. *Jurnal Cakrawala Pendas*, *8*(1), 70-81.

Hanif Fakhrurroja, M. T. (2013). Model-Model Riset Operasional.

Hozairi, H., Krisnafi, Y., Buhari, B., & Alim, S. (2022). RISET OPERASI PENERAPAN SOLVER EXCEL UNTUK MENYELESAIKAN MASALAH LINIER, TRANSPORTASI, TRANSSHIPMENT, PENUGASAN, DAN JARINGAN.

Juliawan, K. G. S., Darmawiguna, I. G. M., & Kesiman, M. W. A. (2015). Simulasi Metode Penugasan dan Transportasi untuk Pembelajaran Riset Operasional Berbasis Web. *Jurnal Nasional Pendidikan Teknik Informatika: JANAPATI*, *4*(3), 96-103.

Meflinda, A. (2011). Operations Research (Riset Operasi).

Muhajirin, M., & Panorama, M. (2017). PENDEKATAN PRAKTIS; Metode Penelitian Kualitatif dan Kuantitatif.

Oka, J., & Kartikasari, D. (2017). Evaluasi Manajemen Waktu Proyek Menggunakan Metode Pert Dan Cpm Pada Pengerjaan "Proyek Reparasi Crane Lampson" Di Pt Mcdermott Indonesia. *Journal of Applied Business Administration*, *1*(1), 28-36.

Okviana, E. (2011). *Penerapan Target Costing dalam Mencapai Eflsiensi Biaya Produksi pada PT Liebra Permana*(Doctoral dissertation, Fakultas Ekonomi Dan Bisnis Universitas Pakuan).

Ramdhani, M. A. (2001). *Perancangan sistem pendukung keputusan kriteria majemuk pada pengambilan keputusan kelompok* (Doctoral dissertation, Institut Teknologi Bandung).

Rony, Z. T., Wijaya, I. M. S., Nababan, D., Julyanthry, J., Silalahi, M., Ganiem, L. M., Judijanto, L., Herman, H., and Saputra, N. (2024). Analyzing the Impact of Human Resources Competence and Work Motivation on Employee Performance: A Statistical Perspective. *Journal of Statistics Applications & Probability, 13(2), 787-793*. DOI: 10.18576/jsap/130216

Sari, M., Purwoto, A., Achmad, V. S., Arkwright, D., Tanjung, R., Hasyim, M., ... & Siswati, T. (2023). *Penelitian Operasional*. Global Eksekutif Teknologi.

Shofia, N. (2019). Analisis Representasi Matematis Mahasiswa Teknik Informatika Dalam Menyelesaikan Soal Riset Operasi. *Efektor*, *6*(2), 136-141.

Shofia, N. (2019, October). Representasi Matematis Mahasiswa Berkemampuan Matematika Tinggi Dalam Menyelesaikan masalah Transportasi. In *Prosiding Seminar Nasional Pendidikan dan Pengajaran UNP Kediri* (pp. 508-514). UNIVERSITAS NUSANTARA PGRI KEDIRI.

Soedarso, S. W. (2018). Riset Operasi: Analisis Perhitungan Matematik Dan Aplikasinya.

Suharyo, O. S., Rosyid, I. R., Daniel, M., Promotor, C. O., Armono, D. R., & Haryo, D. (2017). Model Penentuan Lokasi Pangkalan Angkatan Laut Berbasis Sustainabilitas. *Surabaya: Institut Teknologi Sepuluh Nopember*.

Sulartopo, S., Kholifah, S., Danang, D., & Santoso, J. T. (2023). Transformasi Proyek Melalui Keajaiban Kecerdasan Buatan: Mengeksplorasi Potensi AI Dalam Project Management. *Jurnal Publikasi Ilmu Manajemen*, *2*(2), 363-392.

Syaifuddin, D. T., SE, M., Syaifuddin, D. T., & SE, M. (2011). Riset operasi.

Tanjung, T. L., Soegiharto, S., & Prayogo, D. N. (2005). Perancangan Model Optimasi Pemotongan Material Satu Dimensi.