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The Influence of the International Maritime Organization (Imo) Annex 375 Policy and Extraordinary Pioneer Services on Operational Efficiency and its Implications on the Voyage Cost of User Ships in the Strait of Malacca and Singapore

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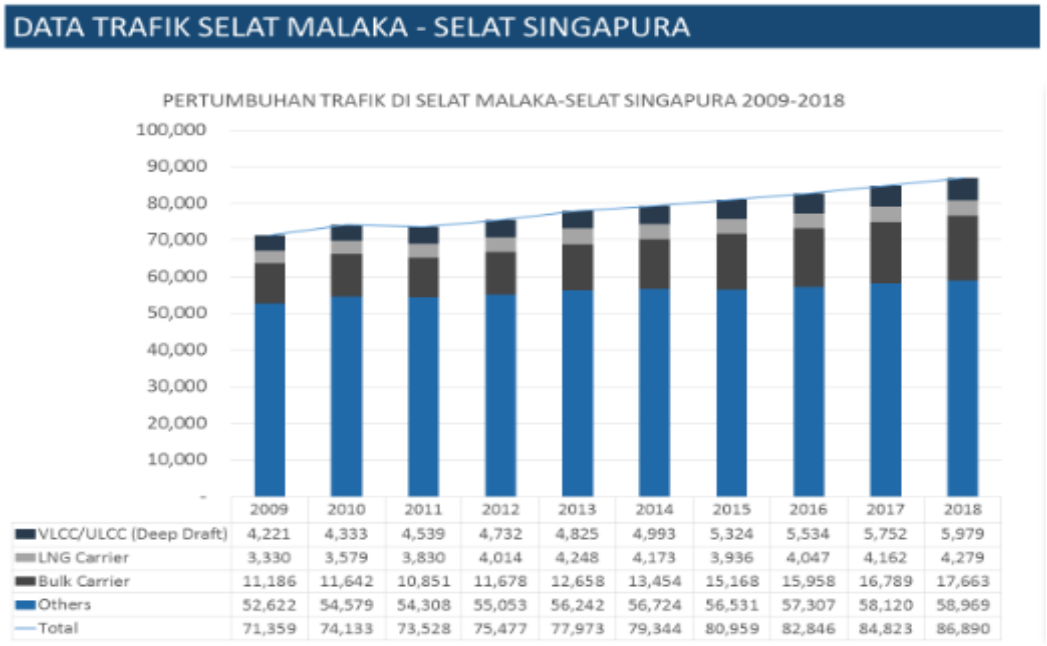
Abstract: This study addresses the urgency of improving operational efficiency and reducing voyage costs for service-user vessels operating in the strategic Malacca and Singapore Straits. It aims to examine the influence of the International Maritime Organization (IMO) Annex 375 policy and exceptional pilotage services on operational efficiency and their implications for voyage costs. Adopting a descriptive quantitative approach, data were collected through surveys using questionnaires distributed online and offline, supported by documentation. The research population comprised all vessels served in 2024, with a sample of 142 respondents—vessel officers (captains, chief mates, and chief engineers) directly involved in navigation and pilotage services—selected using Slovin's formula. Data analysis employed Structural Equation Modeling (SEM) via SmartPLS. Results reveal that both the IMO Annex 375 policy and exceptional pilotage services significantly enhance operational efficiency, which in turn positively reduces voyage costs. These findings highlight that implementing international maritime policies and optimizing pilotage services can strategically improve port competitiveness and user satisfaction. The study recommends aligning pilotage service SOPs with IMO standards and strengthening pilotage personnel capabilities to meet the challenges of increasingly complex and competitive global shipping.

Keyword: IMO Annex 375, Pilotage Services, Operational Efficiency, Voyage Costs, Maritime Policy.

INTRODUCTION

The Straits of Malacca and Singapore are highly strategic international shipping lanes with high traffic density. These lanes connect the Indian and Pacific Oceans, and serve as vital routes for global trade, connecting countries in Asia, Europe, and the Americas. More than 100,000 ships pass through them annually, making navigational safety and operational efficiency a top priority. The International Maritime Organization (IMO), as the world's maritime organization, has established various policies to maintain safety and efficiency in

these lanes, including the Voluntary Pilotage Service (VSP), which aims to help ships navigate congested and high-risk waters. This is evident in ship traffic:



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
VLCC/ULCC (Deep Draft)	4,221	4,333	4,539	4,732	4,825	4,993	5,324	5,534	5,752	5,979
LNG Carrier	3,330	3,579	3,830	4,014	4,248	4,173	3,936	4,047	4,162	4,279
Bulk Carrier	11,186	11,642	10,851	11,678	12,658	13,454	15,168	15,958	16,789	17,663
Others	52,622	54,579	54,308	55,053	56,242	56,724	56,531	57,307	58,120	58,969
Total	71,359	74,133	73,528	75,477	77,973	79,344	80,959	82,846	84,823	86,890

Figure 1. Ship traffic in the Malacca Strait and Singapore Strait areas

The high traffic density in both straits poses significant navigation challenges. Complex water conditions, narrow and shallow water points, and the potential for collisions and groundings are major risks. Furthermore, environmental threats such as oil spills from ship accidents have the potential to damage marine ecosystems. Incident data shows several major accidents, including the collision of the Kartika Segara with the JBB De Rong 19 (2017), the MT Formosa with the MV Ostende Max (2008), and the MT Bunga Kelana 3 with the MV Waily (2010). Security threats such as piracy and sea robbery are also increasing, as seen in the case of Singapore's Eastern Anchorage (2016) and a surge in incidents in 2017.

Based on a preliminary survey of 30 service users in the Straits of Malacca and Singapore regarding the implementation of IMO Annex 375, the majority of respondents did not fully understand the policy's contents. High scores of "Disagree" and "Neutral" for statements on understanding, implementation effectiveness, and training support indicate weak socialization and stakeholder engagement. This low level of understanding has the potential to reduce compliance with the policy and reduce the effectiveness of its implementation.

Another important factor is the exceptional quality of pilotage services, which are the backbone of shipping safety in the region. Preliminary survey results revealed negative perceptions from respondents regarding speed, accuracy of schedule information, personnel competence, and the appropriateness of rates to service quality. The predominance of "Disagree" and "Neutral" responses reflected user dissatisfaction. Frequent complaints included delays in pilotage schedules, lack of clear information, and doubts about personnel competence. Differences in operational standards and rates between coastal countries (Indonesia, Malaysia, and Singapore) also posed obstacles, despite coordination through the Tripartite Technical Experts Group (TTEG).

Operational efficiency is the third factor influencing ship voyage costs. Frequently encountered obstacles include long ship waiting times, suboptimal turnaround times, and unsynchronized coordination between port units. Preliminary surveys indicate high dissatisfaction with loading and unloading speeds, schedule compliance, operational

coordination, and digitalization support. The lack of integration of infrastructure, technology, and human resources results in high logistics costs and reduced port competitiveness.

Overall, the implementation of IMO Annex 375 policies and exceptional pilotage services in the Straits of Malacca and Singapore play a crucial role in supporting the safety and efficiency of international shipping. However, survey results indicate that gaps remain in policy understanding, pilotage service quality, and operational management. Therefore, strengthening policy dissemination, enhancing pilotage personnel competency, improving service information systems, and integrating technology-based port management are needed to reduce the risk of accidents, reduce ship travel costs, and ensure compliance with global maritime regulations.

Various studies have highlighted the importance of efficiency in pilotage services to reduce waiting times and shipping operational costs (Syabani, 2025; Chu & Zheng, 2024; Amir et al., 2024). Studies such as those by Lumban Batu et al. (2024) and Nalif et al. (2020) even recommend strengthening pilotage training and infrastructure to improve service performance. However, most of these studies have not explicitly examined the direct link between extraordinary pilotage services and reduced voyage costs, particularly in strategic areas such as the Straits of Malacca and Singapore. Meanwhile, the integrative aspect of pilotage services and technologies such as ASVs (Autonomous Surface Vehicles) is still focused on increasing time efficiency, rather than overall economic efficiency (Chu & Zheng, 2024; Weintrit, 2020). Therefore, there is still a gap in measuring the direct contribution of extraordinary pilotage services to shipping cost efficiency in specific commercial and geographic areas, such as those handled by PT Pelindo.

Although several studies have addressed IMO policies in relation to energy efficiency and ship decarbonization (Tadros et al., 2023; Cullinane & Yang, 2022; Schinas & Bergmann, 2021), their primary focus has been on the technical and cost aspects of adopting alternative fuels. Few studies have thoroughly evaluated the direct implications of IMO Annex 375 on the operational costs of vessels using port services in busy and strategically sensitive waterways such as the Straits of Malacca and Singapore (Ho, 2009; Pangestu, 2019). Meanwhile, IMO policies often create a dilemma between compliance with environmental regulations and commercial efficiency pressures (Apostolou et al., 2024). Furthermore, no study has combined evaluations of IMO policies and extraordinary pilotage services to measure their impact on the efficiency and cost savings of vessels served by national port authorities such as PT Pelindo. This creates a research opportunity to align international regulations with local operational practices in high-risk international waterways.

METHOD

The research method used in this thesis is a survey with a quantitative approach. According to Arikunto (2018:12), quantitative methods are objective research approaches, encompassing the collection and analysis of quantitative data and the use of statistical testing methods. This research is based on the characteristics of rational, empirical, and systematic science.

The study population included all service-using vessels in the Malacca and Singapore Straits for the 2019–2024 period, specifically vessels receiving exceptional pilotage services, totaling 55 vessels. The unit of analysis was the ship's officers (master and engineer), assuming each vessel was operated by four principal officers, resulting in a total population of 220 ship's officers. Based on Slovin's calculations, the sample size was set at 142 respondents. Data processing was performed using SmartPLS 3 software to facilitate rapid and accurate analysis. The processing stages included editing (checking for possible errors or uncertainties in respondents' answers), coding (assigning marks/codes to similar answers to facilitate tabulation), and tabulation (arranging data into tables according to categories for easy reading). The processed data were then analyzed using path analysis techniques and hypothesis testing

with the SEM-PLS method, in accordance with the research objective of comprehensively examining the relationships between variables.

RESULTS AND DISCUSSION

Based on the results of a survey involving 142 respondents, all of whom were male (100%), it is clear that the profession of ship officers—both captains and engineers—is still entirely dominated by men, in line with the structurally and culturally masculine characteristics of the global maritime industry. The majority of respondents were in the 31–40 years age range (73.2%), followed by those aged >41 years (17.6%), and only 9.2% were aged 20–30 years, indicating that ship officer positions are generally achieved after a long career path and sailing experience. In terms of education, the majority of respondents were Diploma 3 graduates (57.7%), followed by Bachelor's degree graduates (24.6%), Vocational High School (16.2%), and Master's degree (1.4%), reflecting the dominance of maritime vocational education in producing technical shipping human resources, although some officers pursue higher education to improve their competencies and career development.

Measurement Model Testing (Outer Model)

Convergent Validity Test Results

The results of the convergent validity test show that all indicators in the IMO Annex 375 Policy (X1), Exceptional Pilotage Services (X2), Operational Efficiency (Y), and Cost Voyage of Service User Vessels (Z) variables have loading factor values above 0.7, thus declared valid. The dimensions with the highest contributions are Supervision and Enforcement (0.949) in X1, Responsiveness (0.948) in X2, Ship Navigation Technology (0.921) in Y, and Bunker Cost (0.936) in Z, which emphasizes the importance of maritime law enforcement, pilotage service responsiveness, utilization of navigation technology, and fuel cost control. Meanwhile, the lowest contributions are found in Safety Standards (0.933) in X1, Empathy (0.878) in X2, Ship Service Speed (0.888) in Y, and Port Charges (0.912) in Z, which indicate areas that still have room for improvement. All indicators have met the criteria for factor loading values >0.6 according to convergent validity standards (Hair et al., 2015).

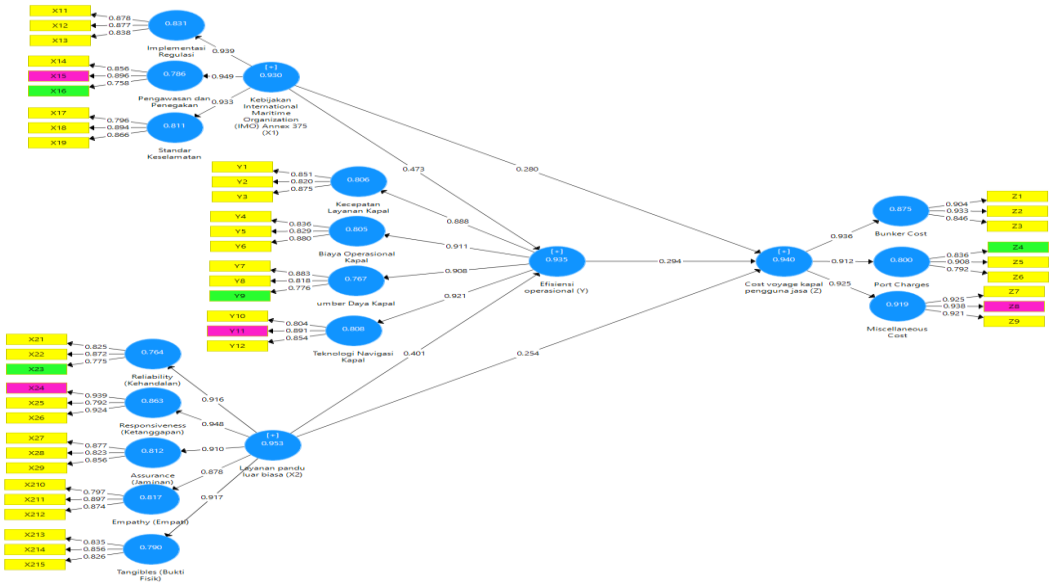


Figure 1 Full Structural Model (PLS Algorithm)

This explanation shows that the yellow boxes represent each indicator, while the blue circles represent the latent variables. Each arrow also has a number indicating the validity value

of each indicator and testing the reliability of the construct of the studied variable. An indicator is considered valid if its factor weighting value is greater than 0.60.

Discriminant Validity Test Results

Discriminant validity testing through the Average Variance Extracted (AVE) value shows that all variables have an AVE value above 0.5 (X1 = 0.640; X2 = 0.607; Y = 0.585; Z = 0.677) so that they are declared valid. The Heterotrait-Monotrait Ratio (HTMT) test also shows that all relationships between variables are below the threshold of 0.9, indicating that the construct differentiation is well maintained. The Fornell-Larcker Criterion results confirm that the square root of the AVE for each variable is higher than the correlation with other variables, which means that each construct has good discriminant validity. Thus, this research instrument is able to clearly differentiate between variables and there is no multicollinearity between constructs.

Reliability Test Results

Reliability testing shows that all research variables have Cronbach's Alpha and Composite Reliability values above 0.7, thus meeting the recommended reliability criteria. Variable X1 has a Cronbach's Alpha value of 0.930 and CR of 0.941, X2 of 0.953 and 0.958, Y of 0.935 and 0.944, and Z of 0.940 and 0.949. These values indicate that all measurement instruments are able to produce consistent and stable data when reused in similar measurements. This high reliability value strengthens the reliability of the measurement model used in the study.

Structural Model (Inner Model)

R-Square (Coefficient of Determination)

The R-Square test results show that the Operational Efficiency (Y) variable has a value of 0.587, which means that 58.7% of the variation in operational efficiency can be explained by the International Maritime Organization (IMO) Annex 375 Policy (X1) and Exceptional Pilotage Services (X2). The remaining 41.3% is influenced by other factors outside the model. This value is in the moderate to strong category, indicating that the model is quite substantial in explaining ship operational performance.

Meanwhile, the Cost Voyage variable of Service User Ships (Z) has an R-Square value of 0.517, which means that 51.7% of the variation in shipping costs can be explained by X1, X2, and Y, while the remaining 48.3% is influenced by external factors such as fluctuations in fuel prices, port rates, and internal policies of shipping companies.

Effect Size (f^2)

Based on the results of the effect size analysis, the largest influence was shown by the relationship between X1 and Y with a value of 0.388 (strong category). This indicates that the implementation of the IMO Annex 375 policy significantly increased ship operational efficiency.

The influence of X2 on Y has a value of 0.278 (medium category), which indicates that the existence of extraordinary pilotage services also makes a significant contribution to the smooth navigation of ships.

Meanwhile, the influence of X1 on Z (0.084), X2 on Z (0.075), and Y on Z (0.074) is in the weak category. This finding indicates that increasing operational efficiency has not had a significant impact on reducing shipping costs, because other major cost factors outside the model are still dominant, such as fuel prices and port fees.

Predictive Relevance (Q^2)

The results of the predictive relevance test show that variable Y has a Q^2 value of 0.327 and variable Z has a Q^2 value of 0.331. Both are in the range of 0.25–0.50, indicating that the model has moderate predictive relevance. This means that this research model is quite reliable in predicting endogenous variables, but there is still an opportunity to improve its predictive ability by adding relevant external variables, such as weather conditions, company operational policies, and global shipping market factors.

Hypothesis Testing Results (Bootsrapping)

The significance of the estimated parameters provides valuable information regarding the relationships between the research variables. The output path coefficient values are used as the basis for hypothesis testing. Model evaluation is performed by examining the significance values to confirm the influence of the variables through a bootstrapping procedure (Ghozali, 2016).Hypothesis testing in this study was carried out by considering T-statistics and p-values. The hypothesis is considered accepted if the T-statistics > 1.64 (ttable value) and P-values < 0.05. The following are the results.Path Coefficientsdirect influence:

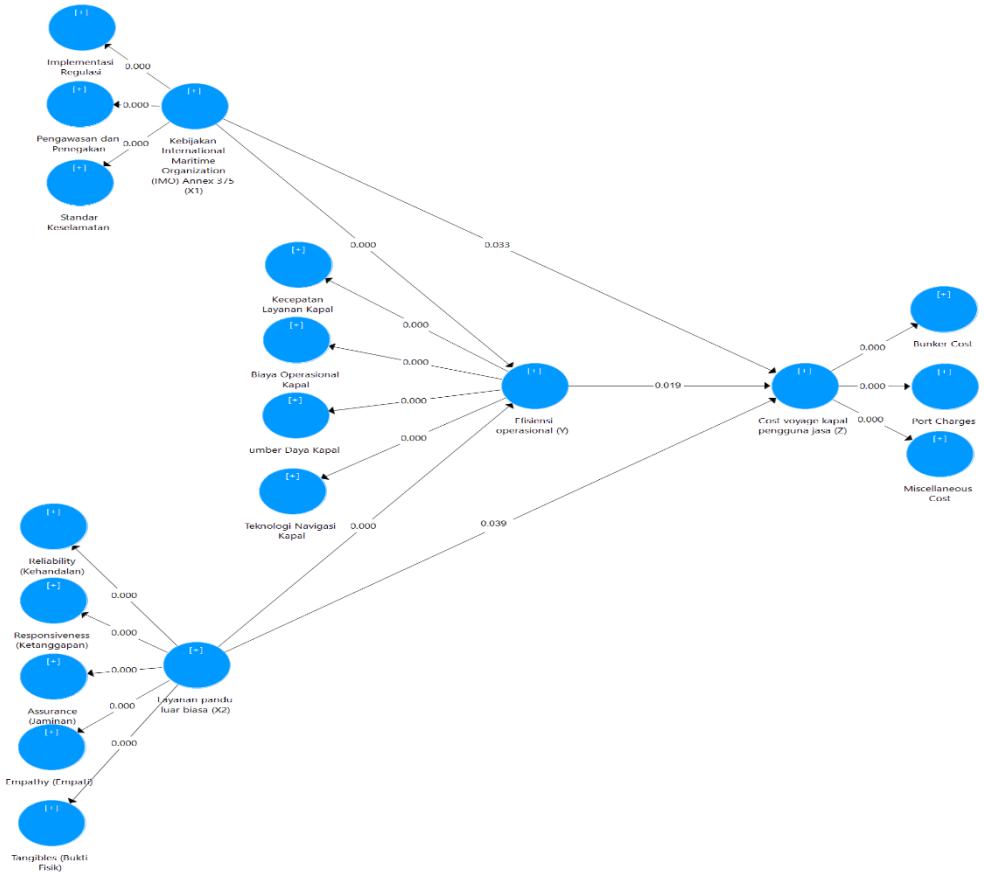


Figure 2 Bootstrapping

Table 1 Direct and Indirect Influences

Hypothesis	Influence	Original Sample (O)	T Statistics (|O/STDEV|)	P Values	Information
H1	International Maritime Organization (IMO) Annex 375 Policy (X1) -> Operational efficiency (Y)	0.473	4,307	0,000	Significant
H2	Excellent guide service (X2) -> Operational efficiency (Y)	0.401	4,013	0,000	Significant

Hypothesis	Influence	Original Sample (O)	T Statistics (|O/STDEV|)	P Values	Information
H3	International Maritime Organization (IMO) Annex 375 Policy (X1) -> Cost voyage of service user ship (Z)	0.280	2,142	0.033	Significant
H4	Excellent guide service (X2) -> Cost of voyage of the service user's ship (Z)	0.254	2,011	0.039	Significant
H5	Operational efficiency (Y) -> Cost of voyage of service user vessel (Z)	0.294	2,348	0.019	Significant
H6	International Maritime Organization (IMO) Annex 375 Policy (X1) -> Operational efficiency (Y) -> Cost of voyage of service user vessel (Z)	0.139	2,857	0,000	Significant
H7	Excellent pilot service (X2) -> Operational efficiency (Y) -> Cost of voyage of service user vessel (Z)	0.118	2,179	0.030	Significant

Hypothesis 1: Direct Effect of IMO Annex 375 Policy on Operational Efficiency

The results of the study indicate that the International Maritime Organization (IMO) Annex 375 policy has a direct, positive and significant impact on the operational efficiency of vessels using its services. The path coefficient value of 0.473, the T-statistic of 4.307, and the p-value of 0.000 demonstrate that this regulation encourages increased efficiency. This indicates that the implementation of this policy is not merely a formality of compliance but also contributes to improving vessel operational performance.

These findings demonstrate that IMO Annex 375 not only creates global standards but also drives real changes in shipping operational governance. Increased efficiency can include reduced port waiting times, more efficient fuel use, and more timely scheduling. These effects are crucial, especially in busy shipping lanes like the Strait of Malacca.

Theoretically, the relationship between IMO policies and operational efficiency can be explained through a compliance-based management system approach that emphasizes the integration of regulations into daily operational activities. This way, policies are no longer considered a burden, but rather a strategic tool for improving performance.

This research is supported by studies by Liu & Zheng (2023), Tan et al. (2020), Ardiansyah & Yusuf (2021), Bergstrom (2022), Garcia & Chen (2020), and Ong et al. (2019), which show that IMO regulations significantly boost operational efficiency in the long term despite initially increasing costs.

Hypothesis 2: Direct Effect of Outstanding Guide Service on Operational Efficiency

The results of the study indicate that the Extraordinary Pilotage Service has a significant direct influence on the operational efficiency of ships, with a coefficient of 0.401, a T-statistic of 4.013, and a p-value of 0.000. This means that a more structured and responsive pilotage service contributes directly to the smooth operation of ships.

These findings indicate that improving the quality of pilotage services, including response speed, navigation accuracy, and preparedness for adverse weather conditions, is a catalyst for accelerating vessel turnaround times. This is particularly important for high-traffic ports where time is a crucial commodity.

In terms of inter-variable relationships, operational efficiency increases when external factors, such as navigation services, synergize with the ship's internal systems. Outstanding pilotage services act as a link between port infrastructure and the ship, creating overall efficiency.

This research is in line with the findings of Supriyadi (2022), Kim & Lee (2020), Wahyono (2021), Ramadhan & Nurhayati (2021), Nakamura (2021), and Wirawan (2022) which emphasize that high-quality pilotage services directly increase ship efficiency in the navigation and berthing process.

Hypothesis 3: Direct Influence of IMO Annex 375 Policy on Voyage Costs of Service User Vessels

Based on the statistical test results, the IMO Annex 375 policy has a direct, positive and significant effect on voyage costs, with a coefficient of 0.280, a t-statistic of 2.142, and a p-value of 0.033. This indicates that this international regulation does increase shipping costs, especially in the early stages of implementation.

These findings reinforce the view that IMO policies are often accompanied by mandatory new technologies or procedures that require initial investment, such as emissions monitoring systems or the use of low-sulfur fuels. The consequence is a direct increase in operational costs.

The relationship between IMO policy and cost voyage reflects the principle of cost compliance, where implementing regulations requires adjustments in operational costs, particularly for fuel, crew training, and additional certification. However, in the long term, these regulations remain geared towards achieving overall efficiency.

This research is supported by studies by Zhang & Liu (2022), Johansen (2021), Andersson (2023), Tan et al. (2020), Chen & Fang (2023), and Omer et al. (2022), which confirm that IMO policies do impact costs directly, although they result in higher efficiency in the long run.

Hypothesis 4: The Direct Effect of Extraordinary Pilot Services on the Cost of Voyage of Service User Vessels

Testing the direct influence of extraordinary pilot services on the cost of voyage of service user vessels showed significant results, with a coefficient value of 0.254, a T-statistic of 2.011, and a p-value of 0.039. Since the T-statistics > 1.64 and the p-value < 0.05, Hypothesis 4 is declared accepted.

These findings indicate that improving the quality of pilotage services—such as speed of response, navigation accuracy, and efficient coordination between pilots and tugboats—significantly contributes to shipping cost efficiency. This means that the better the pilotage services provided, the more measurable and controllable the voyage costs borne by shipping service users.

The relationship between these variables reinforces the understanding that support services such as pilotage are not merely technical components but also part of an operational cost-efficiency strategy that directly impacts a shipping company's bottom line. Thus, exceptional pilotage services act as a catalyst for efficiency in the overall maritime logistics chain.

This assertion is further reinforced by studies by Suyono et al. (2021), Hwang & Hsiao (2020), Tijan et al. (2019), Aritonang (2022), and Chakraborty & Lalwani (2023), which concluded that reliable and standardized pilotage services can shorten waiting times, reduce risks, and directly lower voyage costs for vessels using the services.

Hypothesis 5: Direct Effect of Operational Efficiency on Voyage Costs of Service User Vessels

The test results show that operational efficiency has a direct effect on reducing voyage costs, with a coefficient of 0.294, a t-statistic of 2.348, and a p-value of 0.019. The higher the ship's operational efficiency, the lower the voyage costs borne by service users.

These findings reinforce the view that efficiency is not just a technical concept but also has a direct financial impact. Ships that are efficient in terms of time, fuel, and other resources will be able to reduce total shipping costs.

The relationship between these variables illustrates the principles of lean maritime operations, where optimizing operational processes leads to direct cost savings. High efficiency reduces vessel idle time, lowers fuel consumption, and results in more frequent scheduled maintenance.

This research is in line with the findings of Hamzah (2023), Kim & Lee (2020), Sitorus (2020), Taufiq (2021), Wibowo (2021), and Zhang & Liu (2022) which state that ship operational efficiency has a major contribution in reducing voyage costs directly.

Hypothesis 6: Indirect Effect of IMO Annex 375 Policy on Voyage Costs through Operational Efficiency

The test results show a significant indirect effect between IMO Annex 375 policy on voyage costs through operational efficiency, with a coefficient of 0.139, a T-statistic of 2.857, and a p-value of 0.000. This means that operational efficiency acts as a mediator in the relationship between regulations and voyage costs.

These findings suggest that the regulatory effect on shipping costs stems not solely from the initial implementation burden, but also from the resulting efficiency changes. Therefore, this policy represents a long-term investment in building structural efficiency.

Relationally, the efficiency variable acts as a bridge that channels policy impact into cost savings. This creates an understanding that efficiency is a strategic path to more effective cost management.

This research is supported by the results of Andersson (2023), Tan et al. (2020), Bergstrom (2022), Garcia & Chen (2020), Liu & Zheng (2023), and Zhang & Liu (2022) which confirm that IMO regulations have an efficiency impact which then contributes to cost reduction.

Hypothesis 7: Indirect Effect of Outstanding Pilot Service on Voyage Cost through Operational Efficiency

The test shows that the Outstanding Pilot Service has an indirect effect on voyage cost through operational efficiency, with a coefficient of 0.118, a T-statistic of 2.179, and a p-value of 0.030. This proves that the outstanding pilot service makes a significant contribution to efficiency which ultimately reduces voyage costs.

These findings reinforce the urgency of improving the quality of pilotage services as a cost-effective strategy. Reliable pilotage services not only protect vessels from navigational risks but also expedite the sailing and berthing process.

The relationship between these variables illustrates an operational linkage model, where external factors (guide services) indirectly influence costs through efficiency. Therefore, a guide service improvement strategy is a critical component of cost control.

This research is in line with the results of studies by Supriyadi (2022), Kim & Lee (2020), Wahyono (2021), Nakamura (2021), Wirawan (2022), and Wibowo (2021) which found that the quality of guide services increases efficiency and has a positive impact on voyage costs indirectly.

CONCLUSION

The analysis results show that the International Maritime Organization (IMO) Annex 375 Policy (H1) and the Extraordinary Pilotage Service (H2) have a positive and significant effect

on Operational Efficiency. The IMO Policy has a coefficient of 0.473 (T=4.307; p=0.000) with the dominant indicator being law enforcement against regulatory violations (X1.12; loading 0.854). The Extraordinary Pilotage Service recorded a coefficient of 0.401 (T=4.013; p=0.000) with the main indicator being a quick response to pilotage requests (X2.24; loading 0.897). These findings confirm that strict international regulations and responsive pilotage services directly improve the smooth operation of ships.

Furthermore, both the IMO Policy (H3) and the Extraordinary Pilotage Service (H4) were also proven to have a positive and significant effect on the Cost Voyage of service user vessels. The IMO Policy recorded a coefficient of 0.280 (T=2.142; p=0.033) and the Extraordinary Pilotage Service had a coefficient of 0.254 (T=2.011; p=0.039). This cost efficiency was mainly influenced by indicators X1.12 and X2.24 which focused on law enforcement and pilotage speed. These results confirm that regulatory factors and the quality of port services play an important role in reducing shipping costs.

Testing of Hypothesis 5 (H5) shows that Operational Efficiency has a significant positive effect on Cost Voyage, with a coefficient of 0.294 (T=2.348; p=0.019). The highest indicator is the integration of the latest technology in the ship's navigation system (Y11; loading 0.817), which proves that the adoption of digital innovation is key to cost savings. In other words, the more optimal the operational process, the greater the potential for reducing the cost burden borne by service users.

Mediation analysis revealed that Operational Efficiency mediates the relationship between IMO Policy (H6) and Exceptional Pilotage Services (H7) on Cost Voyage. IMO Policy has an indirect effect of 0.139 (T=2.857; p=0.000), while Exceptional Pilotage Services has an indirect effect of 0.118 (T=2.179; p=0.030). The dominant indicators in this mediation path are X1.12, X2.24, and Y11, which synergistically accelerate the navigation process, reduce risks, and reduce shipping costs. This finding confirms that efficiency improvement strategies are an important link between policies and services to cost savings.

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