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Research Article

LCD Policies and Supply Chain Resilience in Malaysian Oil and Gas

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ABSTRACT

Background: The effect of Local Content Development (LCD) policies on the supply chain management vulnerability in the oil and gas industry in Malaysia is the focus of this study. The research responds to the issue of the irregularity in the implementation of LCD policies, and how they impact facets like local supplier integration, regulation, workforce, and technology. **Methodology:** Both the quantitative data collected from the surveys with participants and the qualitative data from interviews were properly combined to analyse various factors. **Results:** This paper's major conclusions show that LCD policies improve supply chain conditions, including regulation and human capital. However, issues like; inequity in policy implementation or compliance, issues of regional disparity, and issues to do with technology accessibility hinder them. **Conclusion:** Taken together, these contribute to policy and practice manuals by pointing to concrete steps for policy implementation, improvement of the interaction partners, and the provision of financial motivation for technology uptake. The approach presented in this research provides a foundation for the achievement of robust supply chain through the utilisation of LCD policies during policy development within volatile and resource constrained industries.

Keywords: Local content policies, Malaysia, Mixed methods, Oil and gas sector, Policy impact, Supply chain resilience.

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INTRODUCTION

The oil and gas sector played an important role in the Malaysian economy in terms of contribution to the country GDP, export earnings and job opportunities (Maji *et al.*, 2017). Aside from offering the flow of fiscal revenues, this sector has created a number of the by-product industries production, supplying, and technological advancement. As a result of these challenges, Malaysia has embraced Local Content Development (LCD) polices as a belt and braces approach towards increasing local value addition (Barker and Beng, 2017). LCD policies require the participation of local industry, encourages the building of a competent and skilful local workforce, and supports the use of technologies, which are in conformity with national strategic direction (Alhajri, 2021). These policies for instance seek to minimise reliance on foreign resources, diversify the economy and foster stakes for other players in the country. Norway, Nigeria and Brazil for instance have developed similar policies to harness the socio-economic benefits of natural resource exploitation (Obiri *et al.*, 2019; Onwuka, 2021). However, as stated above, the Malaysia oil and gas industry has many supply chain risks despite the many opportunities that may be got from it (Mustaffa *et al.*, 2018). Such challenges call for a deeper investigation of the effects of LCD policies on supply chain responsiveness in the sector.

Despite the awareness of LCD policies as a way of stimulating local economic development, their effect on supply chain vulnerability is still under researched on. Most of the analysis conducted so far looks at the economic consequences of LCD policies in terms of employment growth or economic development (Mamo *et al.*, 2023; Gu *et al.*, 2022; Welsh *et al.*, 2021), but without paying much attention to their functioning. Primarily in the context of Malaysia, however, little prior research has explored the ways that these policies impact supply chain agility, adaptability, and resilience. This research aims to fill these gaps by exploring the degree to which LCD policies affect the supply chain sustainability of Malaysia's oil and gas industry. It also seeks to assess the opinions of main supplies chain achievers, policymakers, and other professionals on the effectiveness of these policies.

To policymakers, the finding will be a source of evidence that should help them to improve the formulation and implementation of LCD policies. Thus, the research extends the existing body of literature by making a theoretical contribution on the causal effect between LCD policies and supply chain resilience. For industry practitioners, the research presents implementable strategies to improve business functioning, increase the stakeholder

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interaction level, and develop supply chains that could withstand disruption. In that vein, the research also seeks to contribute to Malaysia's efforts to build up its oil and gas sector's supply chain amidst evolving global conditions.

Theoretical Framework

Local Content Development or LCD policies are now a fundamental approach in resource-endowed nations that seek to diversify the economy as a way of reducing on excessive importation of experts (Eastus, 2020). Fundamentally, these policies call for the liberalization of the local supplier base, human resource capacity building of the domestic workforce, recognition of domestic industries and the use of technologies that are consonant with national policies and goals (Naseemullah, 2023). Analysing this research, the conceptual framework related to Resource Dependence Theory (RDT) and Institutional Theory were applied, as these theories offer much understanding of organizational dynamics within complex regulatory and resource contexts.

Describing the study of the nature of resource dependency, the use of resources by organizations, and strategies aimed at minimizing dependency and increasing the stability of organizational functioning, is Resource Dependence Theory (Zona *et al*., 2018; Cui and Xu, 2019). Broadly, LCD policies seek to reduce supply chain risks originating from dependence on international sources through creating supplier development, training human capital, and technology acquisition programs (Sinkovics *et al*., 2018). This is in line with the suggested supply chain resilience dimensions; flexibility, adaptability, and strength. Whereas, Institutional Theory tells about the extent to which legal and institutional requirements/constraints influence organisations (Cardinale, 2018). LCD policies are an institutional mechanism that requires setting compliance with national goals, which defines the structural regulation of local resource utilisation and policy processes (Gorwa, 2019). Taken together, these provide a solid theoretical framework to examine the impact of LCD policies on the supply chain vulnerability of Malaysia's oil and gas sector.

LITERATURE REVIEW

Factors influenced by LCD Policies

Supplier integration lies at the heart of LCD policies, with the declared objectives of increasing domestic industrial competencies in key technologies and products, and decreasing reliance on overseas suppliers (Black and Bhanisi, 2006). While compelling organisations to structure their buying systems in a way that allows local players to participate these policies foster the creation of economic opportunities and at the same time foster the development of supply chain resilience (Ablo, 2020). Regulatory compliance is a key ingredient in the success of LCD policies (Oyewole, 2018). LCD policies also mandate standard procedures on how these supply chain functions of business should be ran through and through rendering much-needed checks and balances (Sayogo *et al*., 2015). However, compliance can also act as an operational limitation toward the operations, especially where it is practiced in organisations operating in sensitive sectors such as the oil and gas industry. This research aims at exploring the ways and extents in which regulatory frameworks within the overall paradigms of LCD policies enhance or compromise supply chain robustness

The training and development in workforce under LCD policies seek to prepare the employees for the nature of job market that they are exposed to (Mulati, 2019). Nevertheless, the lack of training courses, available on-the-job training, or other opportunities for the upgrade situates these policies in a certain long-term perspective (Elensi *et al*., 2019). The survey items used here to cover the area of concern; workforce training focuses on its effectiveness in enhancing the supply chain performance and its robustness. Applying IT as automation, predictive analysis, and digital interfaces, LCD policy is another important strand of the strategy (Agusta, 2023). Technology can improve the operation of the supply chain through better decision making, shorter cycle time, and capability to respond to disruptions. This paper seeks to analyse how LCD policies promote technology and the impact it has on supply chain.

Supply Chain Resilience

Supply chain resilience is a critical factor for businesses undertaking operations in immature industries such as oil and gas (Okeke, 2024). Contingency management is referred to as the capability to prevent, respond and rebound from disruptions while sustaining operation. Gaining capabilities and balancing the consequences requires three elements of organisational resilience, namely agility, adaptability, and robustness (Yağmur and Myrvang, 2023). Where agility is the rate at which the supply chain can respond to disruptions, adaptability is the ability to align operations with situation affected by disruption. But on the contrary, it is the property which points to an object's steadiness as to its performance quality under the impact of external interference (Yağmur and Myrvang, 2023). Policies associated with LCD are capable of fortifying supply chain weakness by dealing with certain issues. Suppliers' localised integration for example decreases the dependence on international suppliers so enhances the supply chain flexibility (Wu and Jia, 2018). Most of the regulations set under LCD policies aim at encouraging compliance and harmonisation to enhance understanding and flexibility. Organisations' human capital initiatives improve the skill level of employees, associate training with better adaptation during disruptions (Zayed *et al*., 2022). Thus, the integration of sophisticated tools and techniques like the mechanical and automated solutions with hazard prediction enhances the level of resilience by enhancing decision making and performance.

The Mediating Role of Policy Implementation Effectiveness

The general premise behind LCD policies must first be properly implemented to generate the necessary supply chain resilience (Tim, Cui and Sheng, 2021). Policy implementation makes it possible for the regulatory frameworks for operations within the various organisations to be well understood, within reach and manageable to ensure compliance. Furthermore, where there is LCD policy adoption, there are increased collaboration and accountability of stakeholders in policy implementation, making an enhanced LCD policy (Weldegiorgis *et al.*, 2021). The mediating role of policy implementation effectiveness is especially relevant in the Malaysian context due to the issue of the inconsistent use of LCD policies. Appreciation of this mediating effect is therefore crucial to any assessment of the impacts of LCD policies on the supply chain resilience.

Gaps in Literature

Despite prior studies examining, the LCD policies and their implications for economic effects, there is a paucity of research, focusing on their impact on supply chain vulnerability in Malaysia. Previous research mainly addresses perspective on employment generation, GDP proportions, and social gains and losses (Jean-Paul and Martine, 2018; Parag and Ainspan, 2019; Fragkos and Paroussos, 2018), not the functional aspects of LCD policies. Second, the mediating role of the implementation effectiveness of policy has not been investigated but is expected to be very important in revealing how LCD policies transform into sources of supply chain resilience. This lack of integration of both quantitative and qualitative approaches to reflect the complexity of this relationship is also a major limitation in the literature. In filling these gaps, this research will add to the current literature on the nature and impact of LCD policies on supply chain responsiveness. It looks at the relationships between and among the independent variables; local supplier integration, regulatory compliance, workforce training, and technology adoption and the dependent variable; supply chain resilience.

Conceptual Framework

The study has developed a conceptual framework (Figure 1) to visualize the study variables including dependent and independent variables.

Hypotheses of the Study

H1: Local supplier integration, facilitated by LCD policies, positively influences supply chain resilience in oil and gas sector of Malaysia,

H2: Regulatory compliance, mandated by LCD policies, enhances supply chain resilience in oil and gas sector of Malaysia,

H3: Workforce development initiatives under LCD policies positively impact the supply chain resilience in oil and gas sector of Malaysia,

H4: Adoption of technology encouraged by LCD policies strengthen supply chain resilience in oil and gas sector of Malaysia,

H5: Effective implementation of LCD policies mediates the relationship between the Factors influenced by LCD Policies and supply chain resilience.

METHODOLOGY

The current research incorporates a mixed-methods approach in the format of an explanatory sequential design to establish the implications of LCD policies on the supply chain resilience within the Malayan O and G (oil and gas) industry. This design is useful because it offers a chance to combine the two research methods to increase the understanding of the research problem. Target population for this study is the Malaysian professionals who are employed in the oil and gas supply chain industry. This regards staff or personnel who are in one or other way involved in administration or execution of LCD polices. Quantitative target public for the survey consists of supply chain professionals, policy makers and working professionals in the oil and gas industry. A purposive sampling is used to obtain data through survey questionnaire, with the goal of 200 respondents. This sample size is also suitable for statistical analysis on SPSS with indication of the relationship between variables. The responding people include the senior executives, policymakers, as well as academic experts for the qualitative phase, semi-structured interviews are easily administered by including the following questions. The participants are purposively targeted to be those with good understanding of the LCD policies and supply management. Around 10-15 interviews are expected; the actual number will be defined by the emergence of new themes at the data analysis.

The foregoing research uses a structured survey questionnaire (Appendix 1) and semi-structured interview guide (Appendix 2) as the main data collection tools. The survey assesses the degree of the independent variables; local supplier integration, regulatory compliance, workforce training and technology adoption using a Likert scale of respondents' perception and encounters. Policy Implementation Effectiveness serves as the mediating variable and it is captured by items such as clarity of policies, policies enforcement, and involvement of stakeholders. Lastly, first, through the operationalisation of the aforementioned dimensions, the dependent variable of supply chain resilience is measured.

Again, a semi-structured interview guide is developed from the survey questions and includes areas such as success of local supplier integration, combined company's regulatory compliance, workforce development plans, and technology incorporation.

Interviews also explore application of policy particularly its use in the supply chain and further let participants expound on their experiences and observations.

Data collected via survey is improved and tested with software SPSS with aims and objectives to build some patterns, relationships and mediating effects. Descriptive statistics (Appendix 3) are applied for codification of demographic data (Appendix 4) along with the distribution of responses and results of variation of the sample. Correlation analysis concerns itself with the strength and directness of relationships between variables, and regression studies the consequences of independent variables on supply chain resilience. Policy implementation effectiveness is operationalised as a mediator to examine its mediating effect on the relationship between LCD policies and supply chain outcomes. Data collected from interviews are analysed thematically, to identify patterns of themes arising in the data set. Themes are deduced for elaboration of policy implementation process, policy players' engagement, and implementation obstacles. This study involves the rights of the participants, and data collection keeps uniqueness and confidentiality of the subjects. The questions asked in the survey do not capture information that is unique to the participant hence individual responses are unidentified.

ETHICAL STATEMENT

The research adheres to ethical guidelines ensuring the protection of participant rights and confidentiality. Informed consent was obtained from all participants, and their responses were anonymized to ensure privacy. The study complied with ethical standards for research involving human participants, and all procedures were approved by the relevant ethics committee.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS to analyse the quantitative data. Correlation analysis was conducted to examine the relationships between variables, and regression analysis was used to assess the impact of independent variables on supply chain resilience. The significance level was set at $p<0.01$ for all statistical tests, ensuring robust findings.

RESULTS AND FINDINGS

Quantitative Findings

Correlation analysis

These insights are obtained from the correlation matrix that captures the interrelations between variables associated with LCD policies, effectiveness in policy implementation, and supply chain vulnerability of the sector in Malaysia. Evidently, Pearson's coefficients suggest that the nature of relationships between all variables is statistically significant on the $p<0.01$, $p<0.01$, $p<0.01$ level, which means that they are strongly linked.

An analysis of the results indicates that the degree of local supplier integration has a strong positive correlation with other factors including regulatory compliance (r=0.830), workforce training (r=0.812), technology adoption (r=0.782), supply chain resilience (r=0.829). There is also a strong positive correlation of policy implementation effectiveness with the actual engagement of local suppliers; r=0.984, which makes effective policy execution very important for successful supplier engagement. This implies that companies engaging local suppliers are more adept at compliance to regulatory standards, training its workforce and adopting of latest technology that improves on supply chain robustness (Venkatesh *et al*., 2020). Furthermore, concerning regulatory compliance, there is also positive and significant correlation with all the variables. The high coefficients of its association with workforce training (r=0.961r=0.961r=0.961) and technology deployment (r=0.966, r=0.966, r=0.966) confirm that compliance initiatives are closely linked to other organisational themes (Table 1).

Training of workforce stands out as one of the critical contributors towards improvement of supply chain robustness (Ambrogio *et al*., 2022), a relationship that is statistically significant and strong, rho=0.990. Using technology also reveals a very significant correlation with the support of workforce development, (r=0.981). The importance of policy implementation effectiveness is also supported by the obtained coefficient (r=0.884r) and the conclusion that only relevant policy frameworks may contribute to further development of workforce training and enhancement of the organisation's operational flexibility and resilience. Policy implementation effectiveness also stands in the middle of all the factors analysed in the study, as revealed by high correlation coefficients with all the independent variable and supply chain resilience (r=0.990). This underlines its important role in lobbying for improved implementation of LCD policies to the realisation of their results on the ground. Thus, a high level of correspondence with supply chain resilience indicates that it does link the identified policy goals and objectives with outcomes in the field.

Regression analysis

The Model Summary table indicates that the predictors-Local Supplier Integration, Regulatory Compliance, Workforce Training, Adoption of Technology, and Policy Implementation Effectiveness-explain 99.7% of the variance in supply chain resilience (R^2=0.997, Adjusted R^2=0.997). This high R-square value demonstrates that the model is an excellent fit for the data, with only 0.3% of the variance unexplained by the predictors (Tables 2-4).

The ANOVA table shows that the regression model is statistically significant with the sig value less than 0.05, meaning that the independent variables collectively have a significant impact

on supply chain resilience. The extremely high F-value further supports the robustness of the model.

The Coefficients table provides detailed insights into the contribution of each independent variable to supply chain resilience.

Local supplier integration has a significant positive impact on supply chain resilience (p<0.001). This suggests that integrating local suppliers is one of the strongest predictors of resilience. Regulatory compliance is also a significant positive predictor (p=0.000). With the highest standardised coefficient (β=0.703\beta=0.703β=0.703), regulatory compliance has the most substantial influence on supply chain resilience.

Workforce training shows a significant positive impact (p=0.000), indicating its importance in enhancing supply chain resilience. This finding aligns with the view that investments in workforce skills contribute to agility and adaptability in managing supply chain disruptions.

Adoption of technology does not have a statistically significant impact on supply chain resilience. This suggests that technology adoption, while important, may not independently drive resilience in this context. It is possible that technology adoption interacts with other variables or requires effective policy implementation to have a meaningful impact.

Interestingly, policy implementation effectiveness has a significant but negative association with supply chain resilience (B=-1.039, β=-0.888, p<0.001B=-1.039,\beta=-0.888, p<0.001, B=-1.039, β=-0.888, p<0.001). While counterintuitive, this result could reflect challenges in policy enforcement or inefficiencies in implementation processes that hinder resilience. This finding warrants further qualitative exploration to understand the underlying dynamics.

Qualitative Insights

Emergence of themes

Thematic analysis

LCD Policies in the Supply Chain Resilience

A respondent stated, "LCD policies are well developed but the problem is the consistency of their implementation across the regions" In general, respondents believe that LCD policies are effective in theory, however, lack of identical practice

Table 1: Correlation table.

Variables	Local Supplier Integration	Regulatory Compliance	Workforce Training	Adoption of Technology	Policy Implementation Effectiveness	Supply Chain Resilience
Local Supplier Integration	1	0.830**	0.812**	0.782**	0.984**	0.829**
Regulatory Compliance	0.830**	1	0.961**	0.966**	0.910**	0.984**
Workforce Training	0.812**	0.961**	1	0.981**	0.884**	0.990**
Adoption of Technology	0.782**	0.966**	0.981**	1	0.864**	0.980**
Policy Implementation Effectiveness	0.984**	0.910**	0.884**	0.864**	1	0.900**
Supply Chain Resilience	0.829**	0.984**	0.990**	0.980**	0.900**	1

Table 2: Model summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.998	0.997	0.997	0.05210

Table 3: ANOVA.

Model	Sum of Squares	d_f	Mean Square	F	Sig.
Regression	171.843	5	34.369	12662.205	0.000**
Residual	0.527	194	0.003		
Total	172.370	199			

implementation make them fail to supply chain vulnerability prevention (Hsu *et al*., 2022). Some concerns pointed out include selectiveness and variations across the regions; it was recommended that the laws be implemented quickly and that monitoring should be improved (Table 5).

Another respondent stated, "The intention behind LCD policies is commendable, but the lack of alignment between regions makes it difficult to achieve the desired outcome" This points to a view that although goals of LCD policies appear noble and desirable, their implementation is skewed at the regional level. The balancing of these inconsistencies can be achieved by having a central base but regional offices to and could further improve their effectiveness in the means of empowering stand replies in supply chain disruptions.

Challenges in Policy Implementation

One of the respondents said, "Policy enforcement is characterised by delays and unclear polices with regard to the small suppliers"Another respondent stated, "Several of these challenges include handling more significant caseloads and inadequate clarity of rules and regulations, allowing for unnecessary interpretational ambiguities and slow implementation."

The responses highlight various barriers that suggest the existence of structural ineffectiveness in the policy implementation structure. Of all the challenges cited, lack of communication and or slow implementation emerged very often from the respondents. Some of these issues are even worst with the small suppliers, this demonstrate the importance of firms and organisations to focus and simplify their processes for small suppliers. Furthermore, lack of clarity in the guidelines, leads to disparities in the compliance and implementation across organisations and most particularly those of small scale. Perhaps the improvement of such policy frameworks in comparison to the current rather vague and general ones together with the holding of familiarisation training sessions on the policies' interpretation and application is one of the ways to reduce these difficulties.

Training and Development of employees

One respondent highlighted, "While it has been established that training programs have enhanced the skills of the employees several complaints indicate that rural residents cannot access training opportunities".

Another respondent said, "The training programs are good for the organisation, but not all organisations' employees are able to access the training, especially those in the remote areas."

Enhancement of supply chain readiness is well appreciated by most organisations to require efforts in workforce training. Nevertheless, the effectiveness of these services is restricted by existing disparities in inequality, and in rural settings in particular. Trying to bridge such gaps may improve training efficiency by providing outreach activities and inclusive program development.

Table 4: Table of Coefficients.

Model	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t	Sig.
(Constant)	0.039	0.008		4.693	0.000**
Local Supplier Integration	0.813	0.061	0.665	13.242	0.000**
Regulatory Compliance	0.689	0.027	0.703	25.912	0.000**
Workforce Training	0.544	0.021	0.582	26.075	0.000**
Adoption of Technology	-0.020	0.023	-0.022	-0.903	0.367
Policy Implementation Effectiveness	-1.039	0.079	-0.888	-13.219	0.000**



Figure 1: Conceptual Framework.

Table 5: Emergence of themes.

Themes	Sources of Emergence
Effectiveness of LCD Policies in Supply Chain Resilience	Mentions of policy benefits but inconsistencies in implementation across regions.
Challenges in Policy Implementation	Frequent comments on unclear guidelines, bureaucratic delays, and enforcement issues.
Workforce Training and Development	Recurring references to the value of training but also disparities in access.
Role of Technology in Enhancing Resilience	Acknowledgment of the role of technology but also barriers such as costs and resistance to change.
Stakeholder Involvement and Collaboration	Discussions on the need for government and industry cooperation.
Perceived Impact of Policy Implementation Effectiveness	References to policy implementation influencing supply chain resilience outcomes.

Use of Technology in Building Resilience

One of the participants highlighted, "There is consensus on the fact that for supply chain visibility technology adoption is important but high costs and people's resistance to change make this option less favourable" Though, highly ranked by the respondents as factors enhancing supply chain agility and adaptability, technology was noted to have many limitations including; implementation constraint arising from high costs and organisational conflicts of change (Jayatilleke and Lai, 2018). These threats could be addressed, and adoption propelled by means of financial assistance, as well as efforts directed towards the modification of organisational culture.

Another respondent stated, "The world's productivity has been boosted by the advancement in the technologies and this has always exposed the high cost of implementing them as a fundamental limitation."

This response makes it clear that although for supply chain capabilities and resource adaptability technology is helpful and beneficial, the issue of limited funds restricts its integration. This might be a barrier and suggesting the use of subsidies or financial assistance programs could help in eradicating this barrier in increasing use of technology in different organisations.

Perceived Impact of Policy Implementation Effectiveness

One respondent stated, "When implemented properly, one is able to gain confidence and smooth running of operations, but complexities undermine the alignment and cause setbacks"

The result of the interviews is that the mediating role of the effectiveness of policy implementation can be seen. Participants unanimously pointed that good policies foster confidence and chain of implementation while lack of systems that implement them erode confidence and hinders progress. As for the means to achieve the goal for this type of CEPs, clear metrics and regular audits were proposed.

Another respondent highlighted, "Policy work when put to practice brings about noticeable changes, while a wrong implementation results into operational problems"

This response raises the critical importance of the effectiveness of the implementation process in the achievement of intended goals. Implementation creates more confidence and effectiveness in the operations while implementation has negative impacts such as time wastage and misaligned goals. Enhancing supervisory measures and the restored systems can guarantee a more efficient and effective practical implementation of the policies.

DISCUSSION

The integration of both supply and demand quantity allows for an enriched major study of the effects of the local content development (LCD policies) on supply chain strength in the Malaysian oil and gas industry. The actual findings from the quantitative analysis revealed significant associations between various variables including local supplier integration, regulatory compliance, force training, and supply chain resiliency. Correlations between variables were also significant and moderate, suggesting that the model predicts the variance in the resilience outcomes adequately. On the other hand, the thematic analysis aimed at exploring these relationships provided the findings which revealed the essential key strengths and issues of the LCD policies in practical terms and in terms of detailed context.

For example, although survey results indicated positive and significant relationships between the amount of investment in the training of the workforce and supply chain vulnerability, interviews suggested that different regions had different levels of access to training programmes. Along the same line, the quantitative findings highlighted the importance of the policy implementation effectiveness as an antecedent which in the interviews was elaborated by the respondents on the degree of guidelines, collaboration and compliance with the policy. Collectively, these finding capture how quantitative analytics pinpoint trends and patterns, and how qualitative analysis enriches understanding with factorisation of these patterns.

Once again there was a positive and highly significant correlation between regulatory compliance and resilience outputs, especially when it came to promoting communicative transparency and flexibility. However, the qualitative results emphasised that compliance activities are costly undertaking that created further pressures to smaller organisations. Worker training and adopting

of new technologies also became critical pointers. Engagement and training efforts were recognised and appreciated as increasing the employees' competency and effectiveness at work, but shortcomings in the availability and delivery of training programs, especially in the rural areas, reduce their effectiveness. There is acknowledgement that technology adoption is critical for agility and productivity, yet the phenomenon is suboptimal due to high costs and organisational inertia (Al-Baik *et al*., 2024). This shows that they need to be offered incentives to do that and there should be awareness campaigns for members of the public to embrace the technology.

Nevertheless, the study also differs from the literature in pointing out specific deficits in policy implementation. Contrary to earlier works that could examine LCD policies based on achieving the intended objectives of these policies (McCann and Ortega-Argilés, 2018), the present study establishes the difficulties in compliance and varying standards across regions as well as the misalignment of stakeholders. While some works establish policy implementation effectiveness as a mediator, it is expounded here as a main factor underlying resilience results. There is another significant difference that the model considers technology adoption. Although most of the literature focuses on the positive impact of technology in supply chain resilience (Naghshineh and Carvalho, 2022; Gu *et al*., 2021), this research explores some of the real-world challenges in its implementation such as cost and culture. These observations indicate that the promotion of adopted technologies cannot be taken for granted and require the policy support and capacity enhancement.

CONCLUSION

This research aimed to assess the impact of Local Content Development (LCD) policies within supply chain networks in the Malaysian oil and gas industry with specific attention towards the following factors: integration with local suppliers, compliance with local content policies and management, training and development of human capital, technological opportunities. Furthermore, the study sought to establish the moderating role of policy implementation effectiveness and also adopt a mixed-method research design to elicit views from industry participants. The inference demonstrated that LCD policies renders a tremendous contribution to increase the supply chain robustness and flexibility. The research findings showed high levels of association between LCD policy-related factors on the one hand and resilience outcomes on the other; notably, regulatory compliance and workforce training were most influential. Adding an additional layer to such quantitative conclusions, the quantitative results were supplemented with qualitative evidence of issues including the variation of policy implementation across different regions, lack of funding for technologies needed to advance policies, and lack of engagement between stakeholders. Policy implementation effectiveness was also found to be imperative in mediating the relationships between policy intent and the operational outcomes.

LCD policies have significant roles in performing regarding establishing transportation structure, integrating local suppliers, and building capacity of human resources. However, these strategies may not work because their applications differ and no one party has the full cooperation of all the other parties involved. As with any innovation strategy, problems like the cost of implementing change and the resistance to such changes can also be seen as issues that significantly prevent high levels of agility. With regard to the challenges that have been outlined in this study and with a view of salvaging the benefits of LCD policies as much as possible, there is need for policy makers and industry players to heed the following. Hence the policies in regard to LCD should be standard across the regions to avoid biases in the dissemination of the benefits. This includes coming up with specific programs to build up the capability of local suppliers and expanding training programs to human resource development areas.

As such, it is proposed that LCD policies be seen by industry leaders as a strategic tool rather than a regulatory imperative in order to create new horizons for further development and stabilisation. Organisations, therefore, have an opportunity to improve their value proposition and overall performance specific to their vested industries/nations with key proof areas such as workforce development, technology adoption and success sustainable suppliers.

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ABBREVIATIONS

LCD: Local Content Development; **RDT:** Resource Dependence Theory; **O&G:** Oil and Gas; **SPSS:** Statistical Package for the Social Sciences.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS CONTRIBUTION

Syed Muhammad Shah conceptualized and designed the study, contributed to the data collection, and performed the statistical analysis. He also led the manuscript writing, revising, and final approval of the paper. Mohd Farid Shamsudin provided valuable insights during the conceptualization phase, supported the qualitative data collection, and assisted with the interpretation of the results. Both authors contributed equally to the data analysis, discussions, and drafting of the manuscript. Syed Muhammad

Shah is the corresponding author and managed the submission process.

SUMMARY

The research focuses on the Impact of Local Content Development (LCD) policies on the oil and gas sector's supply chain resilience in Malaysia. Goal and Methodology: The study investigates how LCD policies affect supply chain management vulnerability in the Malaysian oil and gas industry, specifically focusing on local supplier integration, regulation, workforce, and technology. The research employs a mixed-methods approach using an explanatory sequential design, combining quantitative data from surveys (n=200) and qualitative data from semi-structured interviews (targeting 10-15 experts). The theoretical foundation utilizes Resource Dependence Theory (RDT) and Institutional Theory

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APPENDIX 1: SURVEY QUESTIONNAIRE

Section A: Demographics

1. Gender
• Male
• Female
2. What is your role in the organization?
• Manager•
Supervisor
• Analyst
• Other
3. How many years of experience do you have in the oil and gas sector?
• <5 years,
• 5-10 years,
• >10 years),

Section B: Independent Variables

Local Supplier Integration

1. My organization actively engages local suppliers as part of our supply chain.
2. LCD policies have improved the integration of local suppliers into the supply chain.
3. Collaboration with local suppliers has enhanced operational efficiency.

Regulatory Compliance

1. My organization complies with all regulatory requirements set by LCD policies
2. Regulatory frameworks under LCD policies support supply chain resilience.
3. Compliance with LCD policies has improved transparency in the supply chain.

Workforce Training

1. My organization invests in workforce training to meet LCD policy requirements.
2. Training initiatives have improved the skills and productivity of employees.
3. LCD-driven workforce training contributes to overall supply chain performance.

Adoption of Technology

1. LCD policies encourage the adoption of advanced technologies in the supply chain.
2. Technological innovations have improved the adaptability of the supply chain
3. My organization leverages technology to mitigate supply chain risks.

Section C: Mediating Variable

Policy Implementation Effectiveness

1. LCD policies are implemented effectively in my organization
2. Policy implementation processes are clear and well-structured.
3. Effective implementation of LCD policies has enhanced operational performance
4. Stakeholders are actively involved in the implementation of LCD policies.

Section D: Dependent Variable

Supply Chain Resilience

• Our supply chain demonstrates agility in responding to disruptions.
• Our supply chain is adaptable to changing market conditions
• Our supply chain exhibits robustness against external shocks
• LCD policies have strengthened the overall resilience of our supply chain.

Appendix 2:Interview Questions.

1. Can you describe your current role in your organization and how it relates to supply chain operations?
2. How has your organization engaged with Local Content Development (LCD) policies, particularly regarding local supplier integration?
3. What challenges or benefits have you observed from complying with LCD regulatory requirements?
4. Can you share examples of workforce training initiatives under LCD policies and their impact on employee productivity?
5. How has your organization adopted technology as part of LCD policies, and what impact has it had on your supply chain?
6. How effectively do you think LCD policies are implemented in your organization, and what factors influence this effectiveness?
7. Can you describe how your supply chain has demonstrated agility in responding to disruptions?
8. In what ways has your supply chain adapted to changing market conditions, and how have LCD policies supported this adaptability?
9. What measures has your organization implemented to ensure robustness against external shocks?
10. In your opinion, how have LCD policies contributed to enhancing overall supply chain resilience, and what improvements could be made to these policies?

Appendix 3: Descriptive Statistics.

Variable	N	Minimum	Maximum	Mean	Std. Deviation
My organization actively engages local suppliers as part of our supply chain	200	0.00	4.00	1.8350	0.99636
LCD policies have improved the integration of local suppliers into the supply chain	200	0.00	4.00	1.0950	0.88310
Collaboration with local suppliers has enhanced operational efficiency	200	0.00	3.00	1.0050	0.90503
My organization complies with all regulatory requirements set by LCD policies	200	0.00	4.00	1.3150	1.02028
Regulatory frameworks under LCD policies support supply chain resilience	200	0.00	4.00	1.4100	0.96777
Compliance with LCD policies has improved transparency in the supply chain	200	0.00	4.00	1.2350	0.92415
My organization invests in workforce training to meet LCD policy requirements	200	0.00	4.00	1.6600	0.98959
Training initiatives have improved the skills and productivity of employees	200	0.00	4.00	1.7150	1.01930
LCD-driven workforce training contributes to overall supply chain performance	200	0.00	4.00	1.4950	1.09818
LCD policies encourage the adoption of advanced technologies in the supply chain	200	0.00	4.00	1.4950	0.97711
Technological innovations have improved the adaptability of the supply chain	200	0.00	4.00	1.4350	1.05895
My organization leverages technology to mitigate supply chain risks	200	0.00	4.00	1.5050	0.98224
LCD policies are implemented effectively in my organization	200	0.00	4.00	1.8350	0.99636
Policy implementation processes are clear and well-structured	200	0.00	4.00	1.0950	0.88310
Effective implementation of LCD policies has enhanced operational performance	200	0.00	3.00	1.0050	0.90503
Stakeholders are actively involved in the implementation of LCD policies	200	0.00	4.00	1.3150	1.02028
Our supply chain demonstrates agility in responding to disruptions	200	0.00	4.00	1.4100	0.96777
Our supply chain is adaptable to changing market conditions	200	0.00	4.00	1.2350	0.92415
Our supply chain exhibits robustness against external shocks	200	0.00	4.00	1.6600	0.98959
LCD policies have strengthened the overall resilience of our supply chain	200	0.00	4.00	1.7150	1.01930

The Mean score results of local supplier integration-related statements like "My organization actively involves local suppliers in supply chain"=1.835, SD=0.996 infer similarly moderate level of perceived applicability air this area. In the same vain, some statements such as; "LCD policies have enhanced the integration of local suppliers" (mean=1.095, SD=0.883) had a smaller result indicating that the participants are of the opinion that there is still much the companies can do when it comes to the integration of local suppliers. This moderate fluctuation in mean values reflects the SDs to some extent, implying differences in the assigned supplier encouragement among the organizationsLCD respondents endorse statements on compliance with regulatory frameworks somewhat more strongly than SC respondents do; for example, "My organization complies with all regulatory requirements set by LCD policies" (mean=1.315, SD=1.020) and "Regulatory frameworks under LCD policies support supply chain resilience" (mean=1.410, SD=0.967). The standard deviations are slightly below those shown for supplier integration indicating that organizations have more consistent views on the importance of compliance.The most interesting score is attained on the dimension of workforce training whereby positive attitudes shown towards it as an important tool of supply chain performance. Respondents agree with statements such as "Training initiatives have enhanced skills and performance of the employees of the organization" (mean=1.715, SD=1.019) and "LCD driven workforce training has a positive impact on the supply chain outcome" (mean=1.495, SD=1.098) but with a slightly higher standard deviation. This means that even though the majority of the respondents hold training in high regard, the manner in which training is implemented can be slightly different in the various organizations.The responses for technology adoption thus have rather a perceived mixed view. For example, the statements, "LCD policies promote the implementation of sophisticated technologies in the supply chain" (mean=1.495; SD=0.977) and "My organisation uses technology to minimise supply chain vulnerabilities" (mean=1.505; SD=0.982) elicited moderate levels of agreement. These somewhat lesser means and SDs suggest that despite an understanding and perception of technology adoption as significant, its application may vary in the surveyed firms.The respondents to a significant extent recognise the efficiency of policy enforcement. When quantifying the results, positive perceptions towards policy clarity and implementation are revealed: 'LCD policies are implemented effectively in my organization', mean=1.835, SD=0.996 and 'Policy implementation processes are clear and well structured', mean=1.095, SD=0.883. However the responses seen in this regard show a certain variation for and this may mean that some of the organizations struggle to ensure that there is standard implementation across the enterprise.The supply chain resilience dimension reveals mostly an upward trend. In a similar way, there is moderate consensus with resilience related attributes like "Our supply chain demonstrates agility in responding to disruptions" (mean=1.410, SD=0.967) and "Our supply chain exhibits robustness against external shocks" (mean=1.660, SD=0.989). The mean value of "LCD policies have strengthened the overall resilience of our supply chain" (mean=1.715, SD=1.019) imply that respondents view the impact of LCD policies as constructive to resilience though with a degree of effectiveness, which differs from firm to firm.

APPENDIX 4: DEMOGRAPHIC PROFILE.

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Male	122	60.7%	61.0%	61.0%
Female	78	38.8%	39.0%	100.0%
Total	200	99.5%	100.0%	
Missing	System	1	0.5%	
Total	201	100.0%		

As per the table above, it is seen that 61% of the respondents were make whereas 39% of them have been female working in the Malaysian oil and gas industry.

Role	Frequency	Percent	Valid Percent	Cumulative Percent
Manager	67	33.3%	33.5%	33.5%
Supervisor	63	31.3%	31.5%	65.0%
Analyst	46	22.9%	23.0%	88.0%
Other	24	11.9%	12.0%	100.0%
Total	200	99.5%	100.0%	
Missing	System	1	0.5%	
Total	201	100.0%		

The above table shows the role of the respondents in the organisation. It is shown that 33.5% have been working as a manager whereas 31.5% have been working as supervisors. Moreover, 23% have been analysts and 12% have chosen other as their answer.

Years of Experience	Frequency	Percent	Valid Percent	Cumulative Percent
<5 years	98	48.8%	49.0%	49.0%
5-10 years	55	27.4%	27.5%	76.5%
>10 years	47	23.4%	23.5%	100.0%
Total	200	99.5%	100.0%	
Missing	System	1	0.5%	
Total	201	100.0%		

Most of the respondents have less than five years of experience in the field. However, 27% of them have 5 to 10 years of experience. 23% of the respondents have more than 10 years of experience in Malaysian oil and gas sector.