Center for Management Science Research
ISSN: 3006-5291 3006-5283 Volume 4, Issue 3, 2026

DOES SUPPLY CHAIN DIGITALIZATION BUFFER THE IMPACT OF GEOPOLITICAL RISK ON FIRM PERFORMANCE? EVIDENCE FROM MANUFACTURING FIRMS IN LAHORE, PAKISTAN

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DOI: https://doi.org/10.5281/zenodo.24131723

Keywords
Geopolitical risk, supply chain digitalization, firm performance, manufacturing sector, Lahore, supply chain resilience, dynamic capabilities

Article History
Received: 01 January 2026
Accepted: 07 March 2026
Published: 30 March 2026

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Abstract

Geopolitical uncertainty has become an important challenge for manufacturing firms because international conflicts, trade restrictions, exchange-rate volatility, and disruptions in cross-border logistics can increase production costs and weaken operational performance. These challenges are particularly relevant to manufacturing firms in Lahore, Pakistan, which operate within domestic and international supply networks and may depend on imported machinery, industrial inputs, technology, and raw materials. This study examines whether supply chain digitalization can reduce the adverse relationship between geopolitical risk and firm performance in Lahore's manufacturing sector. Drawing on the resource-based view, dynamic capabilities theory, and organizational information processing theory, the study develops an analytical framework connecting geopolitical risk, digital supply chain capabilities, and firm performance. The research employs a structured analysis of relevant theoretical literature, recent empirical studies, and evidence concerning digital supply chain management in emerging economies. The analysis identifies procurement uncertainty, logistics disruption, rising input costs, and supplier dependence as important pathways through which geopolitical risk may affect manufacturing performance. Digital technologies, including enterprise resource planning systems, real-time tracking, predictive analytics, cloud-based information sharing, and artificial intelligence, may help firms improve supply chain visibility, responsiveness, and resource allocation. However, digitalization alone cannot eliminate geopolitical exposure, particularly when firms face financial constraints, limited technological expertise, or concentrated supplier networks. The study proposes that supply chain digitalization moderates the negative relationship between geopolitical risk and firm performance, with its effectiveness depending on organizational capabilities and implementation quality. The findings provide a theoretical foundation and practical direction for future empirical research involving manufacturing firms in Lahore.

INTRODUCTION

In the current business environment, manufacturing companies work in complex business ecosystems that leverage domestic and international production, procurement, distribution and customer service. Globalization has helped companies to find global suppliers, cutting-edge technology, and expanding markets; however, it's also exposed companies to external disruptions. Political issues, trade barriers, economic sanctions, evolving customs policies and disruptions in international transport can also impact the supply and price of production inputs. The issues described here add to the significance of geopolitical risk in the present supply chain management.

Geopolitical risk is the risk of economic disruption or business activity as a result of political tensions, international conflicts, diplomatic disagreements or related policy changes. Geopolitical risk is not a standard operational risk as it often starts outside the scope of the business of any single company. This could result in increased procurement expenses, longer lead times, production delays, and reduced profitability for manufacturing firms despite their efficient internal operations. The recent studies have shown that the geopolitical uncertainty can have an impact on the structure of supply chains, and that organizational resources and resilience capacities can play a role in reacting to these uncertainties.

The challenges are especially significant for manufacturing companies in Lahore, being one of the key industrial and commercial hubs in Pakistan. The city and its industrial environs include companies involved in textiles, garments, engineering, pharmaceuticals, plastics, food processing, electrical equipment and other manufacturing industries. They can be connected with local suppliers, importers, transportation firms, distributors, exporters and foreign customers. These companies can face international freight disruptions, import price fluctuations, foreign exchange fluctuations, evolving trade regulations and requirements, among a variety of other risks, depending on their industry and sourcing strategies.

Digitalization of the supply chain has become a possible organizational solution to these challenges. It's about using technology throughout the procurement, inventory, production planning, logistics, supplier coordination, and distribution process. Cloud-based systems, enterprise resource planning (ERP), artificial intelligence (AI), big data analytics systems, digital tracking and electronic procurement platforms can provide managers with more real-time and accurate information regarding supply chain activities.

Digitalization can enhance a company's capacity to detect new disruptions, assess other suppliers, adjust stock levels, and manage production plans. The studies on digitalization of the supply chain have linked digital information capabilities to enhanced visibility and supply chain performance, but have found that this link varies according to organizational factors and technology implementation (Alzaubi et al., 2024). However, digitalization is not a guarantee of protection from geopolitical risk for companies. A business could have advanced tracking software, but still rely on one foreign supplier. Likewise, real-time information does not always mean that a shipment will not be delayed because of closing of a border, nor will it always eliminate the financial impact of a sudden rise in the price of raw materials entering the country. The question is thus not only if a firm introduces digital technologies, but rather how it utilizes digital technologies to build hands-on competencies in dealing with uncertainty.

The present study is to address that issue by examining the moderating effect of supply chain digitalization between the geopolitical risk and firm performance of manufacturing firms in Lahore, Pakistan.

Problem statement

Manufacturing companies are feeling greater insecurity due to geopolitical uncertainties, trade barriers, transportation issues, and volatilities in prices of inputs of production that are imported. These can affect operational efficiency, cost and profitability. While digital technology is likely to enhance the supply chain visibility and

responsiveness, the evidence of their impact on reducing geopolitical vulnerability among manufacturing organisations in Lahore is not yet robust enough.

Previous studies have addressed digital supply chain capabilities, organizational performance, supply chain resilience as well as uncertainty in various national and industrial contexts. But more should be done to determine if 'digitalization' in particular is having a detrimental effect on the geopolitical risk–firm performance link in Lahore's manufacturing sector.

The research problem is to understand under what conditions are digital supply chain capabilities effective at supporting manufacturing companies to sustain performance when geopolitical uncertainty rises. It also takes into account the fact that the potential value of digitalization is dependent on organizational resources, diversification of suppliers, management commitment and action on digital information.

Research objectives

The study pursues five objectives:

1. To examine the principal ways in which geopolitical risk may affect the performance of manufacturing firms in Lahore.
2. To analyse the contribution of supply chain digitalization to operational visibility, coordination, and resilience.
3. To explain the potential moderating role of digitalization in the relationship between geopolitical risk and firm performance.
4. To identify organizational and technological conditions that may strengthen or weaken this moderating relationship.
5. To develop practical recommendations and an empirical framework for manufacturing managers, researchers, and policymakers in Pakistan.

Research questions

The study addresses the following questions:

1. How can geopolitical risk influence the operational and financial performance of manufacturing firms in Lahore?
2. How does supply chain digitalization contribute to supply chain visibility and organizational responsiveness?
3. Can supply chain digitalization weaken the negative association between geopolitical risk and firm performance?
4. What organizational capabilities are necessary to translate digital investment into effective risk management?
5. What strategies can Lahore-based manufacturing firms adopt to improve supply chain resilience under geopolitical uncertainty?

Research significance

The study is significant for the study of supply chain management, in that it integrates geopolitical uncertainty and digital transformation into one analytical lens. Digitalization is not just about efficiency, but also about whether digital capabilities can help to create a buffer against external disruption.

The study also has relevance for the industrial community of Lahore. Manufacturing managers should be familiar with the advantages of digital investment, in relation to procurement, supplier monitoring, inventory planning and production continuity. The study emphasises the significance of digital infrastructure, skill development and training, cost of technology and industrial support programmes for policy makers.

These results should be treated as theory-driven analysis and not actual survey results from the completion of a survey in Lahore. The relationships proposed would need to be verified with actual firm-level data to determine the strength and the statistical significance of the relationships.

Literature Review

Geopolitical risk can have a number of interrelated impacts on manufacturing. An international war could disrupt shipping lines, cause insurance premiums to rise, and cause delays in deliveries. Charges could hinder access to key inputs, and diplomatic tensions could impact on investment, cross-border trade, and commercial relations. International trade policy changes might also necessitate a re-thinking of

sourcing arrangements and/or the search for alternative markets.

The impact that often rises from procurement is even greater for manufacturers. When a critical part is late, production can be interrupted, capacity cannot be maximised, orders from customers may not be met, and overtime costs will be incurred. Those firms that can't pass on extra expenses will find their profit margins eroded. Small companies may have even more trying decisions to make if they are impacted by disruptions at the same time as they have limited access to credit or cash reserves.

Geopolitical risk research and concentration theory of supply chains indicate that the nature of a company's supplier network may affect its susceptibility. Companies that have a few key suppliers with supply bases located in politically unstable or strategically sensitive countries could be more at risk. On the other hand, operational flexibility, resilience, and money could benefit companies in mitigating disruptions, (as covered in the study of geopolitical risk and supply chain concentration).

The size of such impacts will depend on industry and sourcing approach for companies based in Lahore. An exporter who imports specialized machinery or components could be more exposed than a manufacturer that has mostly local inputs. Likewise, companies that sell to overseas customers have risks of market access that are not applicable to companies that sell only to domestic customers.

Geopolitical risk must thus not be assumed to have the same impact on all manufacturing organisations. Exposure can be determined by import dependence, supplier concentration, transportation routes, export markets, inventory policies, and the substitutability of production inputs.

Conceptualizing Geopolitical Risk

Manufacturing geopolitical risk can be broken down into 4 factors.

International Political Tensions: Trade relations can be affected by conflict and/or diplomatic disagreements, which can lead to uncertainty and affect the availability of imported materials.

Uncertainty Surrounding Trade and Regulation: Compliance requirements such as tariffs, sanctions, export restrictions and changes in trade requirements may raise the compliance costs and reduce the availability of suppliers or customers.

Cross-Border Logistics Disruption: Delivery times and logistics costs can rise as a result of shipping route changes, changes to border customs procedures, transport availability and freight insurance.

Uncertainty Associated with input Prices and Markets: Energy (and commodity prices) may be affected by political instability, as may exchange rates and the price of imported production inputs.

These dimensions may overlap. For instance, a multination trade war can impact freight availability, commodity costs, supplier dependability, and customer demand. This means that a no-one-size-fits-all solution is needed for manufacturing companies that combines risk identification, sharing, contingency planning, and operational adjustments.

Any firm-level study should distinguish between exposure to geopolitical disruptions and managers' perceptions of uncertainty. A major supply interruption need not occur in a company if there is a lot of international tension. On the other hand, a company with not enough data on their suppliers can misestimate their exposure.

Supply chain digitalization

Supply chain digitalization is the application of digital technologies to connect information and synchronize activities in the supply chain. It encompasses the use of digital tools as well as their application in organizational decision making.

ERP systems can integrate the information for purchasing, production, finance, inventory, and sales. Manufacturers and suppliers can communicate using cloud platforms. Digital tracking systems can offer information on shipments, and predictive analytics can assist companies forecast demand changes and potential supply issues.

AI and machine learning can be used to help predict, assess suppliers, and interpret intricate operational data. Their value is based on the information available, its quality, timeliness, and completeness. Inaccurate data can lead to inaccurate forecasts, while digital systems can only offset the shortcomings of weak systems of management.

The linkages between technology adoption, visibility, resilience and operational performance have been a growing focus of research on digital supply chain transformation. Alzaubi et al. (2024) studied digitalization and performance along the supply chain from the perspective of visibility and survivability in manufacturing companies. They offer a relevant base to understand how digital technologies can assist with performance when disturbance occurs.

In the same way, studies on Pakistani manufacturing companies have accounted for digital technologies, supply chain skills, and the performance of the firms. For instance, Kiran et al (2024) investigated the relationship between implementation of big data and digital technology with firm performance in manufacturing sector in Pakistan. Such research is useful for giving a national context to the potential benefits of digital information capabilities.

But the adoption of technology should not be the same as the successful digital transformation. A company can employ electronic accounting software but still handle supplier selection, inventory planning and disruption response by hand. To be effective, supply chain digitalization should involve embedding technology into the processes of gathering, analysing, disseminating and responding to operational information.

Firm Performance in Manufacturing

The performance of the firms is a multi-dimensional construct. Financial performance includes aspects like profit, revenue growth and cost control. Operational performance is related to production efficiency, reliability of deliveries, product quality, inventory management and meeting customer requirements.

The dimensions are correlated but not exactly the same. The profitability of a company can be reduced but its production efficiency can be increased due to the increase in the cost of imported inputs. A different company could have flat top-line revenue and poor performance in the delivery metrics and higher inventory expenses.

In the current study, the performance of the firm needs to be evaluated by the operational and financial indicators. Production continuity, delivery reliability, inventory turnover, defect rates, and order fulfilment are among the indicators that can be used for operations. Profit margin stability, cost efficiency, sales growth and return on investment are among the financial indicators.

If confidential financial statements aren't available, respondents may be asked to compare their firm's performance with that of their competitors during a specific time frame. However, perceptual measures must be recognized as such and not be confused with audited financial data.

One of the key analytical differences between the average performance of a firm and its ability to perform in a crisis is critical. A profitable firm can be the one that is most susceptible to supply disruption, and a less profitable firm can have greatest recovery potential. Resilience-oriented measures are thus complementary to traditional financial indicators. This section examines the relationship between geopolitical risk and the performance of the firms.

This section will analyze the data on geopolitical risk and the firms' performance. There are a number of ways geopolitical risk can affect firm performance.

One is the disruption in procurement which can lead to higher input costs or even the temporary unavailability of necessary materials. Second, logistics uncertainty can extend lead times and decrease the predictability of production schedules. Third, the uncertainty can drive firms to keep extra stock to buffer themselves against supply chain disruptions and reduce their working capital requirements and storage expenses. Fourth, exporters may find adjustments to market conditions, trade requirements or

demands from overseas customers to be challenging.

Such mechanisms may occur in a cumulative manner. If a critical part is not available, production could cease. The interruption may lead to missed customer orders, higher contract price and hurt business relations. The company may also see a reduction in its profit margin if it has to buy the replacement materials at higher prices.

But geopolitical risk does not necessarily result in the same effects on firms. Businesses with many suppliers, flexible manufacturing processes, different transportation options and sufficient capital buffers have a greater chance of weathering the crisis.

This variant indicates that geopolitical risk-performance link relies on some extent on firm-level capabilities. One such capability could be supply chain digitalization, which can help to enhance the timeliness and quality of information that is available to managers making decisions.

Supply Chain Digitalization as a Moderating Variable

A moderating variable is a variable that either changes the intensity or the direction of the relationship between two other variables. Geopolitical risk is considered as the independent variable for this study, while firm performance is the dependent variable, and supply chain digitalization is the proposed moderator.

The thesis is that geopolitical risk could be negatively associated with performance of firms that have weak digital capabilities compared to other firms with digital supply chain systems (else the same).

There are three key pathways by which digitalization can be the source of this buffering effect.

First, visibility enables managers to keep track of inventory, supplier orders, shipment movements and production needs. Early warning information can shorten the time cycle from warning to action.

Second, it helps to coordinate the work of purchasing, production, logistics and finance. It can assist companies to modify output plans, realign buying priorities and inform clients of alterations.

Third, decision support enables companies to more thoroughly consider alternative suppliers, inventory needs, transportation alternatives, and the potential disruption which may arise from these options.

A recent study on economic uncertainty and digital transformation also investigates the ability of digital transformation to decrease the risk of disruption of the supply chain and increase resiliency in firms (see research published in the journal Economics Letters in 2025).

However, it is not guaranteed to have a buffering effect. Digital systems could be costly to deploy, hard to integrate, and easy to hack. Firms can also be provided with precise details about the disruption without them having financial or supplier options to deal with it. Digitalization, therefore, could be seen as a potential capability to mitigate risk rather than a risk-mitigation cure-all for geopolitical uncertainty.

Theoretical Framework

Three complementary theories—resource-based view, dynamic capabilities theory and organizational information processing theory—are used to explain the proposed relationship.

Resource-Based View

The resource-based view (RBV) is one that states that firms create competitive advantages by becoming unique in their resources and capabilities, which are valuable, inimitable and organized effectively (Barney, 1991). Technical knowledge, information systems, supplier relations, operational knowledge and management skills are some of the relevant resources for manufacturing.

When integrated into the process of organizations, digital technologies can be strategically valuable. For instance, an ERP platform could integrate procurement, production and inventory data so that managers can make informed decisions. But, buying the

same software as competitors does not always give a sustainable advantage. The benefits will vary based on the efficacy the firm is able to enjoy from the technology, in terms of up-skilling its employees, and incorporating information into business strategy.

In the case of manufacturing companies in Lahore, the view is that digitalization should be viewed as a set of technological resources and capabilities. Organisations with a healthy digital procurement and monitoring culture might be better prepared to deal with external uncertainty.

It is therefore useful to look at the RBV as a basis for explaining why digitalization can have an impact on performance even if the theory itself does not imply that digitalization statistically reduces the impact of geopolitical risk.

Dynamic Capabilities Theory

Dynamic capabilities theory focuses on the capacity of an organization to adapt, combine and transform its resources in order to manage the changing environments (Teece et al., 1997). Teece (2007) also provides a description of dynamic capabilities in terms of the processes of sensing opportunities and threats, seizing opportunities, and transforming organizational resources.

These processes are pertinent to geopolitical uncertainty.

The process of sensing includes identifying new supply risks by supplier monitoring, shipment tracking, market intelligence and demand forecasting. When seizing, you choose the right answer(s): change procurement timing, discuss alternative supply options, build up stock on key inputs etc. Transformation could be reworking existing processes, sourcing new suppliers, adjusting production structures, or adopting new digital systems.

Digitalization can make these processes more robust, create timely information and facilitate quick coordination. However, companies need to have managerial control, financial means and flexibility to take action based on the information. For instance, an engineering manufacturer that is based in Lahore could detect a new shortage of imported components by looking at digital records of procurement. The information is strategically valuable when managers are able to qualify an alternative supplier, adjust production plans and communicate revised delivery schedules.

Digital information therefore is not being accumulated within an information system, but is being transformed to adaptive action through the lens of Dynamic capabilities theory.

Organizational Information Processing Theory

Organizational information processing theory suggests that the effectiveness of an organization relies on a part of the relationship between the information-processing needs of a task and the organization's ability to process information (Galbraith, 1974).

Geopolitical uncertainty boosts the need for information as companies need to track evolving supplier situations, transportation options, input costs, trade policies, and customer demand. In situations where information is scattered across levels or departments or delivered too late to be useful in decision making, traditional communication structures might not be sufficient.

Digital systems can enable information to be processed in larger quantities, with the ability to link departments, bring together operational records, and communicate with supply chain partners. This enhanced capability could be beneficial in understanding disruptions and in response planning.

The value of digital information, however, relies on the quality of the data, the skills of the employees, system integration and decision-making processes. Too much information, with no clear priorities, can also make managerial decisions difficult.

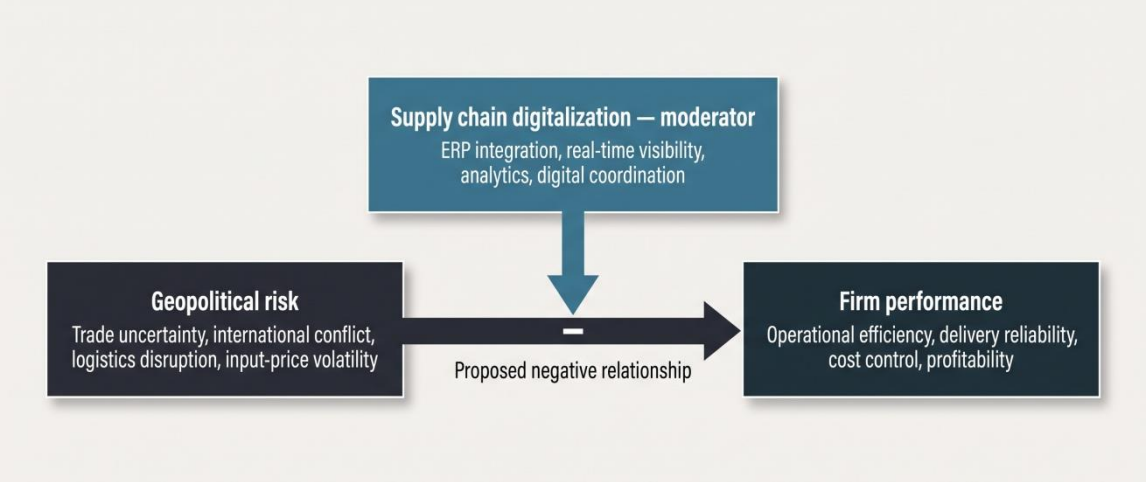
The theory implies that digitalization could mitigate geopolitical risk if it decreases the information needed to manage uncertainty and the firm's ability to gather and utilize that information.

Integration of the Theoretical Perspectives

Theoretical perspective	Principal explanation	Relevance to this study
Resource-based view	Strategic value of resources and capabilities	Explains the potential performance benefits of digitalization
Dynamic capabilities theory	Adaptation and reconfiguration under uncertainty	Explains how firms respond to geopolitical disruptions
Organizational information processing theory	Matching information-processing capacity to uncertainty	Explains how digital visibility supports risk-related decisions

Together, these perspectives suggest that supply chain digitalization may strengthen performance under geopolitical pressure when technological resources are converted into effective information-processing and adaptive capabilities.

Conceptual Model and Research Hypotheses



Conceptual model

The study proposes a model in which geopolitical risk negatively influences firm performance, while supply chain digitalization moderates the strength of this relationship. The moderator is hypothesized to weaken the negative relationship between geopolitical risk and firm performance. This is a proposed model, not an empirically tested result from Lahore data.

The model assumes that geopolitical risk can reduce firm performance, but the magnitude of this relationship may vary according to the digital capabilities of individual firms.

Geopolitical Risk and Firm Performance

International disruptions may increase costs, reduce the availability of inputs, delay production, and weaken customer service. These effects provide a theoretical basis for expecting a negative relationship between geopolitical risk and firm performance.

H1: Geopolitical risk is negatively associated with the performance of manufacturing firms in Lahore.

Supply Chain Digitalization and Firm Performance

Digital integration can improve coordination, inventory monitoring, forecasting, and resource allocation. These capabilities may reduce avoidable costs and improve operational responsiveness.

H2: Supply chain digitalization is positively associated with the performance of manufacturing firms in Lahore.

The Moderating Role of Supply Chain Digitalization

Digital capabilities may enable firms to identify emerging disruptions, assess alternatives, and adjust operations more quickly. Consequently, geopolitical risk may have a weaker negative association with performance among firms with higher levels of effective supply chain digitalization.

H3: Supply chain digitalization weakens the negative relationship between geopolitical risk and firm performance in Lahore's manufacturing sector.

The Role of Organizational Capabilities

The benefits of digitalization may depend on management commitment, employee skills, financial resources, and supplier diversification. Digital systems may have limited value when organizations lack the resources or authority to implement the decisions they support.

H4: The potential buffering effect of supply chain digitalization is stronger when manufacturing firms possess adequate managerial support, digital competence, and supply chain flexibility.

H4 is an additional proposition for future empirical testing; it should not be interpreted as a verified result.

Research Methodology

Research design

This article uses an analysis-based research design to develop and examine a theoretical framework for manufacturing firms in Lahore, Pakistan. The analysis draws on established theoretical literature and relevant empirical studies concerning geopolitical risk, supply chain digitalization, organizational resilience, and firm performance.

The design is appropriate for examining the conceptual mechanisms through which digital capabilities may influence the relationship between external uncertainty and organizational outcomes. It does not claim to report a completed primary survey of Lahore manufacturers.

A future empirical extension could employ a quantitative, cross-sectional survey of manufacturing firms in Lahore and its surrounding industrial areas. That extension would allow the hypotheses to be tested using firm-level responses and appropriate statistical techniques.

Research Setting

The geographical focus is Lahore and its surrounding manufacturing areas in Punjab, Pakistan. Potential industry groups include textiles and garments, engineering, pharmaceuticals, food processing, plastics, electrical equipment, and other manufacturing activities.

These sectors should not be assumed to have identical levels of geopolitical exposure. Their dependence on imported inputs, international customers, transport networks, and specialized machinery may differ substantially.

For an empirical study, firms should be selected according to clear eligibility criteria, such as active manufacturing operations, a defined minimum period of operation, and responsibility for procurement, production, logistics, or supply chain decisions.

Target Population and Sampling Strategy

The target population for the proposed empirical extension would consist of manufacturing firms operating in Lahore and nearby industrial areas. Suitable respondents would include supply chain managers, procurement managers, operations managers, production managers, and senior executives with direct knowledge of supply chain practices.

A stratified sampling strategy could be used to represent different manufacturing industries and firm sizes. Stratification would reduce the risk of drawing conclusions from a sample dominated by one industrial category.

A sample size of approximately 250–350 completed firm-level responses could be considered as an initial planning target, subject to a formal power analysis, the number of model parameters, expected effect sizes, and practical access to firms. This is a proposed target, not a statement that these responses have been collected.

Where several employees from the same firm participate, their responses should not be treated as independent firm-level observations without an appropriate aggregation or multilevel-analysis strategy.

Data Sources

The present analysis relies on secondary literature and theoretical sources. Relevant evidence includes:

- Foundational research on organizational resources, dynamic capabilities, and information processing.
- Empirical research on supply chain digitalization and manufacturing performance.
- Research examining geopolitical uncertainty, supply chain disruption, and organizational resilience.
- Published studies addressing digital transformation in emerging economies and Pakistan's manufacturing sector.

For a future Lahore-based survey, primary data could be collected through a structured questionnaire. Firm-level indicators could be obtained from respondents and, where possible, corroborated through company records.

Published literature provides a foundation for model development, but it cannot substitute for original Lahore firm-level observations when estimating local statistical relationships.

Measurement of Variables

The proposed variables can be operationalized as follows.

Variable	Role	Suggested indicators
Geopolitical risk	Independent	Perceived trade uncertainty, international disruptions, cross-border logistics risk, imported input-price instability
Supply chain digitalization	Moderator	ERP integration, digital procurement, real-time tracking, predictive analytics, electronic information sharing
Firm performance	Dependent	Cost efficiency, production continuity, delivery reliability, profitability, sales performance
Organizational capabilities	Additional explanatory factors	Management support, employee digital skills, supplier diversification, financial flexibility

A five-point Likert scale could measure respondents' agreement with statements ranging from 1 (strongly disagree) to 5 (strongly agree). Items should be adapted from established scales where suitable, reviewed for relevance to the Lahore manufacturing context, and pilot-tested before full data collection.

Firm performance should ideally include objective indicators, such as delivery times, production downtime, operating costs, or profitability, where firms are willing to provide them. If subjective assessments are used, the questionnaire should identify them as perceptual measures.

Analytical Procedure

A future quantitative study could use descriptive statistics, reliability analysis, construct validity assessment, and regression-based moderation analysis. Structural equation modelling could also be appropriate if the sample size and measurement model support it.

The primary moderation equation would be:

$$FP_i=\beta_0+\beta_1GPR_i+\beta_2SCD_i+\beta_3(GPR_i\times SCD_i)+\gamma'X_i+\varepsilon_i$$

Where:

- FP_i = firm performance of firm i
- GPR_i = geopolitical risk exposure
- SCD_i = supply chain digitalization
- $GPR_i \times SCD_i$ = interaction between geopolitical risk and digitalization
- X_i = control variables, such as firm size, age, industry, and import dependence
- ε_i = error term

H1 predicts a negative β_1, while H3 predicts a positive β_3, assuming higher

values represent greater risk, stronger digitalization, and better performance. The interaction coefficient must be estimated from actual data before either hypothesis can be accepted or rejected.

A statistically significant positive interaction would be consistent with a buffering relationship. It would not, by itself, establish causality, particularly in a cross-sectional study. Reverse causality is possible because better-performing firms may have more resources to invest in digitalization.

Reliability, Validity, and Ethical Considerations

The proposed empirical study should evaluate internal consistency and construct validity before interpreting relationships between variables. Reliability measures such as coefficient alpha or composite reliability may be reported where appropriate, alongside evidence of convergent and discriminant validity.

Common-method bias should be considered if the same respondent reports geopolitical risk, digitalization, and firm performance in a single questionnaire. Researchers could reduce this risk through clear item wording, confidentiality assurances, multiple data sources, and separation of measurement procedures where feasible.

Participation should be voluntary, informed consent should be obtained, and company-sensitive information should be protected. Results should be reported in aggregate where possible. Researchers should not fabricate responses, company records, coefficients, significance levels, or survey participation rates.

The analytical findings and discussion has been provided.Analytical findings and discussion has been provided.

The findings presented below are analytical conclusions based on the theoretical framework and published literature. These are not statistical results of a survey of the completed manufacturing companies in Lahore.

In this section, geopolitical risk is identified as a source of manufacturing vulnerability.In this section, geopolitical risk is identified as a source of manufacturing vulnerability.

It is possible that geopolitical uncertainty can affect manufacturing performance in any or all of the following ways: procurement, logistics, manufacturing, and market channels. The effects are important where firms rely on inputs which are not readily available in local markets.

Manufacturers based in Lahore will feel the impact depending on the firm's place in the supply chain. The risks may be different for a business with a textile line compared to a food processor buying the majority of its raw materials. Likewise, when a key component of a manufacturing company becomes unavailable, it can cause a halt in production.

Three specific mechanisms are identified particularly important.

First, the uncertainty about the costs of input may negatively affect the financial performance. Increased prices of foreign materials can mean increased manufacturing costs. These increases may not be able to be passed through to customers immediately for fixed price firms.

Secondly, disturbances in the supply can affect the efficiency of operations. The delayed components can result in underutilized workers and machinery, delayed orders and greater production scheduling costs.

Thirdly, uncertainty in the international arena can enhance working capital requirements. Companies may have to keep extra stock, cover the cost of other transport facilities or place orders for materials ahead of schedule. These decisions have the potential to increase continuity and may involve financial commitments.

These mechanisms suggest that the theoretical expectation that geopolitical risk is negatively related to firm performance may be realized. But the intensity of the link should be gauged on a tested basis rather than assuming it is the same in all manufacturing industries of Lahore.

Food Safety and Quality Assurance

The second analytical finding relates to the role that digitalization could play with regard to supply chain visibility. The term visibility describes a firm's capacity to access relevant

information on inventory, orders, suppliers, production activities and shipment.

Without integrated information systems, managers might use out-of-date e-mails, phone calls, spreadsheets, or disjointed departmental information. This can make it challenging to detect shortages early or assess the impact of altered delivery dates.

The digital platforms can facilitate the flow of information between purchasing, inventory, production and logistics. For instance, a manufacturer could leverage the inventory data to know which production orders are dependent on a late production order for a component that comes from abroad. Managers can then select materials available, make adjustments to production plans, and provide realistic delivery dates.

Alzaubi et al. (2024) share pertinent empirical research on digitalization, supply chain visibility and supply chain performance. They argue that understanding the mechanisms of digital systems' effect on operational outcomes - rather than simply focusing on technology adoption as an end in itself - is important.

The impact for the manufacturing companies in Lahore is practical. Better visibility doesn't have to be costly and built on an expensive artificial intelligence platform. When suitable for the size and business of the firm, a well-maintained inventory database, as well as integrated purchasing records and a reliable digital communication process can offer significant advantages.

The analytical conclusion is that the potential to make better supply chain decisions through digitalization is plausible, via its ability to enable greater visibility. The benefits it brings to profitability will depend on the cost of implementation, the skill level of employees putting the systems in place and the firm's capacity to act on the information gained.

Digitalization and Operational Responsiveness

Managers can spot problems with visibility while being responsive to the situation they reacted to. Digitalization can help with responsiveness by streamlining the speed of information sharing, comparing options, approving procurement decisions and updating production plans.

Suppose a manufacturing company in Lahore finds that an imported production factor is in short supply for the company. A digitally integrated procurement system can help the company identify which orders are impacted, determine available inventory, and look at supplier data to determine how much inventory is available to keep projects going.

Managers can then explore options such as qualification of another supplier, reallocation of existing inventory, changes in production priorities and/or renegotiate delivery schedules.

This is a typical capability example from a typical event in any particular firm in Lahore. Its significance is to showcase the potential of digital information to enable coordinated action in the face of uncertainty.

However, there are limits to responsiveness. Not everything a firm cannot replace on the spot is necessarily of an unusual or specialized type.When a firm finds itself without an immediately available replacement for a very specialty part, there isn't always a clone of it available from any other supplier, especially if it needs to be technically approved or even certified. Digitalization can enhance the quality of the decision, but will not remove the constraint.

It is therefore not the total elimination of disruption that is expected. It is the potential elimination of unnecessary delay, inefficient decision making, and costs.

The moderating effect of supply chain digitalization (SCD) is considered. The moderating effect of SCD is taken into account.

This study's main argument is that digitalization could reduce the adverse effect of geopolitical risk on firm performance.

For a low-visible-digital manufacturer, the disruption can only be realized after materials are not delivered. The manager may then have limited time to assess the alternatives and this may lead to delays in production and emergency purchasing.

A digitally enabled manufacturer could potentially spot the same disruption earlier,

determine which orders are impacted, reach out to alternate suppliers, and make adjustments to its inventory and production planning. The external shock can still happen, and the impact on operations might also be milder.

This is in line with the concept of firm's dynamic capabilities (Teece, 2007) that focuses on the capability of adapting firm resources and processes to the changing environment.

The proposed moderating relationship is, however, contingent. Digitalization has a greater chance of success if the information is accurate, systems are connected, employees are trained and other responses are possible. Digital information might offer some level of protection in cases that the firm has no cash flow, relies on a single supplier for some materials, or is unable to access alternative materials.

Another factor is the distinction between digital adoption and digital capability. Buying software does not equal effective digital supply chain. Businesses need to make sure that technology is embedded within procurement processes, inventory strategies, supplier assessment and management decisions.

The conceptual contribution is therefore to differentiate between the direct performance benefits of digitalization and the function of risk buffering that is proposed. The first question is whether digitalization is linked to an improvement in performance overall, and the second one is if the adverse correlation between geopolitical risk and performance is reduced with greater digitalization.

Why the buffering effect may differ between organizations

It is unlikely that digitalization will have the same effects on all manufacturing companies. The size of firm and availability of funds. Larger companies may have more resources available to them to invest in integrated information systems and in specialist employees. Implementation costs, subscription fees, training needs and restricted access to technical support are some of the challenges faced by smaller companies.

Import dependence. Firms with a very high import reliance may be more vulnerable to geopolitical risk. They need to rely on digital monitoring to detect risks, but there is a need for substitutes as well.

Supplier Diversification: A combination of good suppliers could be more advantageous for companies in a situation where one source is unreliable. A single digital supplier database can help in comparison, but diversification needs to be done with a commercial and technical preparation.

Management commitment: Organizational assistance is needed for digital systems. Managers need to plan for available resources, motivate staff to utilise available information and incorporate digital data into purchasing and manufacturing processes.

Employee Competence: Employees and supervisors must be trained to analyze the dashboards, keep accurate records, and act on alerts. If these are not provided then even the best of systems may be of limited use.

Given these aspects, there is a need for further empirical research on whether the moderation effect of digitalization is different across industry, firm size, import intensity and management ability.

Implications for Lahore's Manufacturing Environment

The analysis indicates that the digitalization strategy should be designed on a company-by-company basis and not according to the "one-size-fits-all" model of technology.

A realistic first step for companies that are less technologically advanced may be the introduction of electronic inventory management, electronic purchase-order records, and a centralized supplier database. These systems can enhance basic coordination even when there is not a lot of investment in advanced analytics.

One step forward for companies with existing digital systems could be the integration of procurement data into the production planning, logistics notification and demand planning. This can assist managers in determining the impact of any delay in one input across a number of production orders.

For more sophisticated organizations, predictive analytics, automatic risk alerts and supplier risk dashboards could also be a consideration. Investments should be supported by measurable operational needs and against implementation and maintenance costs.

Even industrial companies in Lahore should not solely depend on technology. Digitalization should be included as a part of a suite of measures for supplier diversification, contingency planning, financial readiness, employee development, and appropriate inventory management.

The overarching takeaway message is that supply chain resilience involves having digital information, organizational flexibility and resources to deal with disruption.

Managerial and Policy Implications

The manufacturing managers are advised as follows:

Based on the analysis, six practical recommendations are presented.

1.2. Identify risk exposure in supply chains. Determine critical materials, supplier locations, reliance on imports, alternative sources, and activities that are production processes most likely to be delayed.

2. Create secure digital documents. Ensure timely, accurate information on inventory levels, purchase orders and delivery dates, supplier performance, and production requirements.

3. Integrate operational information. Integrate procurement, inventory, production and logistics information wherever possible and reasonable.

4. Make other supplier arrangements. Determine and prequalify alternate suppliers if applicable, for critical materials. Technical qualification cannot be replaced by digital supplier records – but it can assist in.

5. Create disruption-response procedures. Identify the persons who are to be alerted to risks, who has the power to approve changes to procurement and what happens to production plans if supplies are not certain.

6. Evaluate ROI on digital. Track the impacts of delivery reliability, stockouts, procurement lead times, production downtime and administration costs to check if digitalization is adding operational value.

7. The recommendations should be adopted depending on the size of the firm, industry of the firm and what is available.

Recommendations for Policymakers

To enhance the manufacturing's resilience, it is essential to create more favorable conditions for the firms' adoption and use of digital technologies, a job for industrial and economic policymakers.

Firstly, low cost digital infrastructure and effective connectivity can ease the adoption path, especially for SMEs.

Second, training programmes can enhance digital literacy of procurement, logistics, production and operations staff. Investing in technology is more likely to benefit the organization when the employees can utilize the technology effectively.

Thirdly, appropriate technical support and skilled financial assistance can be provided to make it easier for smaller manufacturers to integrate with inventory-management systems, digital procurement platforms and business software.

Fourth, industry associations and relevant public institutions can help share information on the various requirements of international trade, transport disruptions, supplier opportunities and risks that are emerging in the market.

Last, but not least, digitalization programmes must be judged on measurable operational parameters and not the number of companies that acquire software. The goal should be to achieve better decision making, resilience and sustainable industrial performance.

Limitations and Directions for Future Research

This study was conducted with some limitations.

The article does not report the results of an original survey in Lahore but rather offers a framework for analyzing the issue. It therefore is unable to show whether the proposed relationships are statistically significant, how strong they are, nor whether they are cause or effect.

Secondly, the limitation of the conclusions by geographical focus. Lahore manufacturing firms

might have different supplier relations, export presence, technology use, etc. compared to other industrial centres such as Karachi, Faisalabad, Sialkot, Gujranwala, etc.

Thirdly, digitalization is multi-faceted. Each of the ERP integration, predictive analytics, electronic tracking, and electronic procurement might make a unique contribution to organizational resilience. If they are collated together, they may mask significant differences.

Third, there is no one universal geopolitical risk indicator at the firm level. Actual uncertainty, such as reliance on trade routes or suppliers in politically volatile places, has to be separated from perceived uncertainty.

Fifth, cross-sectional survey data would be difficult to use for establishing causation. The benefits of digitalization could be an improvement in performance, but successful companies could also be better positioned to allocate resources to technology. Longitudinal research would be useful to understand the changes of these relationships over time.

Future studies should gather primary data from manufacturing firms, stratified sampling of industrial sectors and firm sizes in Lahore. Researchers should validate the proposed moderation model, provide effect size and confidence intervals, and differentiate between statistical significance and practical significance.

If possible, the survey items should be supplemented by objective data from the firm, including production downtime, delivery performance, inventory turnover, operating costs, etc. A comparison between digitalization and the benefits for import dependent manufacturers and domestic manufacturers could also be made.

Last, but not least, future studies could examine whether organizational agility, supplier diversification, and commitment to management further enhance the link between digitalization and resilience. These investigations would enable us to gain a better understanding of whether digitalization is relevant and the conditions under which it is of the greatest practical use.

Conclusion

The present study investigates the buffering effect of supply chain digitalization on the geopolitical risk on firm performance in the case of manufacturing firms in Lahore, Pakistan. It builds a framework based on the three theories—resource-based view, dynamic capabilities, and organizational information processing—to link external uncertainty to digital supply chain capabilities and organizational outcomes.

The analysis highlights four possible pathways by which geopolitical risk can impact manufacturing performance: procurement uncertainty, logistics disruption, input-cost volatility, and supplier dependence. Digital technologies can support companies to gain greater visibility, align decisions, find alternative suppliers and make procurement and production adjustments. These capabilities offer a theoretical framework to anticipate that digitalization will reduce the negativity exhibited between GE and firm performance.

But digitalization cannot be seen as a panacea. The effectiveness of it relies on the degree of implementation, managerial commitment, competence of employees, financial flexibility, and alternative supply arrangements. Companies with a good, although not exhaustive, bank of digital data but without the ability to react could still be extremely susceptible to events that are out of their control.

A holistic approach to building supply chain resilience for the manufacturing industry in Lahore hinges on integrating digital solutions, diversifying suppliers, ensuring contingency planning, and developing the workforce rather than relying on technology.

The main point of this article is a set of theoretically based guidelines for empirical test in the future. An industry-level study in Lahore is required to help confirm if there is a significant moderating effect of supply chain digitalization on the geopolitical risk-performance link, and if this relationship is different among industries and organisations capabilities.

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