

ENERGY PROCUREMENT RESILIENCE IN PANDEMICS

Maintaining Essential Energy Supplies during Pandemic Disruptions: A Procurement Resilience Framework

Damilola Grace Babayemi¹, Eromosele Asibor², Chineme Okonkwo³

¹Colossal Hub, Lagos State, Nigeria

²Nigeria Petroleum Development Company Ltd, Edo State, Nigeria

³PESO Energy Services Limited, Lagos, Nigeria

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Abstract

The COVID-19 pandemic exposed the fragility of the procurement and logistics systems that keep electricity, liquid fuels and gas flowing to hospitals, water utilities, emergency services and households. Unlike earlier supply shocks, the 2020 disruption combined a collapse in aggregate energy demand with localised spikes in critical demand, labour shortages at ports, depots and terminals, border controls that slowed crew changes and cargo clearance, and sharp price volatility that strained supplier finances. The result was a continuity gap: energy remained abundant at the global level while essential users faced delayed or interrupted deliveries at the local level. Conventional energy procurement, optimised for cost efficiency and for discrete, short-lived events, was not designed to close this gap. This conceptual paper develops a Procurement Resilience Framework (PRF) for maintaining essential energy supplies under pandemic conditions. Using a theory synthesis design, prior research published up to 2020 was thematically coded for disruption mechanisms, capabilities, enabling conditions and outcomes, and the resulting categories were organised into a conceptual model. The framework places a governance layer, which defines emergency procurement authority, an essential-user hierarchy and risk appetite, above four operational pillars. Emergency sourcing secures alternative supply through pre-qualified suppliers, framework agreements and volume-flexible contracts. Port delay mitigation keeps cargo moving through berth priority, alternate discharge options, pandemic-specific contract clauses and digital clearance. Inventory staging buys time through tiered and forward-positioned buffer stocks, storage capacity options and quality management. Fuel distribution continuity protects the last mile through priority allocation rules, reserve driver and depot capacity, alternate routing and safe delivery practices. Four cross-cutting enablers, namely end-to-end visibility, contractual flexibility, workforce protection and public-private coordination, support all pillars, and a learning loop allows arrangements to be revised as the disruption evolves. The paper advances eight testable propositions that link these capabilities to supply continuity, measured through availability, timeliness, cost containment and safety at essential-user sites. The propositions specify direct effects of governance, sourcing, port and inventory capabilities, a mediating role for distribution capabilities, moderating roles for visibility and coordination, diminishing returns to inventory, and improvement through learning across successive waves. A four-phase roadmap of preparation, response, recovery and adaptation translates the model into procurement actions. The framework offers utilities, national oil companies, fuel distributors, hospitals and public agencies a structured basis for designing and auditing pandemic-ready energy supply arrangements, and it highlights policy priorities such as recognising energy logistics workers as essential personnel. The model has not yet been tested empirically and is oriented mainly toward seaborne fuel and gas supply; it therefore sets out an agenda for case-based, survey and simulation research to validate and extend it.

Keywords: procurement resilience; energy security; COVID-19; emergency sourcing; port congestion; strategic inventory; fuel distribution; business continuity

1 Introduction

Energy is the input on which every other essential service depends. Hospitals require uninterrupted power and diesel for standby generation; water treatment relies on pumping and chemical dosing; food cold chains, telecommunications and emergency transport all assume that fuel and electricity will be available when needed. When the World Health Organization declared COVID-19 a pandemic in March 2020, governments across the world designated energy supply as an essential activity precisely because its failure would compound the public health emergency.

Yet the procurement systems behind essential energy supply were not designed for a prolonged, global, simultaneous disruption. Most energy procurement practice has been optimised for cost efficiency under normal conditions (Okonkwo et al., 2018a; Okonkwo et al., 2019), with business continuity planning focused on discrete, local events such as refinery outages, storms or single-supplier failures. The pandemic presented a different pattern. In the oil market, lockdowns triggered what the International Energy Agency (IEA) described as the largest demand contraction in the history of the industry, with expected 2020 demand falling by roughly 9 million barrels per day relative to 2019 (IEA, 2020a). Onshore storage approached its limits, floating storage expanded rapidly, and on 20 April 2020 the front-month West Texas Intermediate futures contract settled below zero for the first time. At the same time, demand for specific products and services, such as diesel for emergency logistics, liquefied petroleum gas for household cooking and reliable power for intensive care units, remained inflexible or increased.

These conditions created a paradox for procurement teams: an oversupplied global market co-existed with localised shortages caused by blocked logistics, absent workers, delayed vessels and financially stressed intermediaries. Physical availability, not price, became the binding constraint in many locations. Ports introduced quarantine requirements and restricted crew changes, which delayed vessel turnaround (UNCTAD, 2020). Depots and terminals operated with reduced staff. Road tanker drivers faced border checks and health screening. Smaller distributors struggled with liquidity as price swings eroded working capital.

An early wave of pandemic scholarship documented these dynamics across sectors. Studies reported demand-supply mismatches, panic buying, labour shortages and transport bottlenecks in food, healthcare and consumer goods chains (Hobbs, 2020; Sharma et al., 2020; Xu et al., 2020; Zhu et al., 2020), and argued that supply chain models had long privileged leanness over resilience (Golan et al., 2020; van Hoek, 2020a). Others proposed theoretical toolboxes for pandemic research (Craighead et al., 2020) and showed how logistics-enabled service models can sustain essential services during lockdowns (Choi, 2020). Simulation studies demonstrated that the speed of epidemic propagation and the duration of closures shape ripple effects across global networks (Ivanov & Das, 2020), while decision-support work addressed demand management and resource allocation in healthcare supply chains (Govindan et al., 2020; Mehrotra et al., 2020). Pre-COVID research on epidemic logistics, including influenza food distribution and Ebola response planning, had already shown that disease dynamics and logistics decisions must be modelled together (Büyüktaktın et al., 2018; Ekici et al., 2014; Liu & Zhang, 2016).

This paper responds to a practical and theoretical gap. Practically, energy buyers lacked an integrated model that connects upstream sourcing decisions with port operations, inventory positioning and last-mile distribution. Theoretically, supply chain resilience research has developed rich concepts of redundancy, flexibility, visibility and collaboration (Christopher & Peck, 2004; Sheffi & Rice, 2005; Pettit, Fiksel & Croxton, 2010), and early pandemic scholarship has highlighted the distinctive

features of epidemic disruptions (Ivanov, 2020; Ivanov & Dolgui, 2020; Queiroz et al., 2020). However, these insights have not been synthesised for the specific case of essential energy, where products are hazardous, storage is capital intensive, logistics are concentrated in a small number of nodes, and failure has immediate public safety consequences. Energy-sector studies have examined supply chain risk in engineering, procurement and construction (EPC) and gas processing projects (Agbabiaka et al., 2019), inventory availability and plant uptime in energy facilities (Okonkwo et al., 2018b), port logistics and demurrage (Okonkwo et al., 2020) and contractual resilience to force majeure events (Uchechi et al., 2020), but these strands have rarely been integrated into a single pandemic-ready procurement model.

The energy security literature provides a complementary lens. Energy security has been conceptualised in terms of availability, accessibility, affordability and acceptability (Kruyt et al., 2009), extended into multi-dimensional assessment frameworks (Ang et al., 2015; Sovacool & Mukherjee, 2011), and redefined as the low vulnerability of vital energy systems (Cherp & Jewell, 2014; Winzer, 2012). This literature has paid most attention to national supply adequacy and price shocks, and less to the organisational procurement and logistics routines that turn national availability into delivered supply at essential sites. Early pandemic energy studies also signalled that COVID-19 could reshape both short-run energy operations and longer-run transition pathways (Gillingham et al., 2020; Hosseini, 2020; Kuzemko et al., 2020).

Against this background, this paper develops a Procurement Resilience Framework (PRF) for maintaining essential energy supplies during pandemics. The framework explains how a pandemic disrupts essential energy supply, organises the procurement capabilities that counter these disruptions around emergency sourcing, port delay mitigation, inventory staging and fuel distribution continuity, and derives testable propositions and an implementation roadmap. Consistent with established approaches to conceptual articles, the contribution rests on theory synthesis and framework development rather than empirical testing (Jaakkola, 2020). The remainder of the paper describes the methodology, synthesises the relevant literature, presents the conceptual model and its propositions, and then discusses implications, limitations and directions for future research.

2 Methodology

This study adopts a conceptual research design. Conceptual papers develop new understanding by integrating and extending existing theory rather than by collecting primary data, and they are appropriate when a phenomenon is new, fast-moving or not yet observable at scale (Jaakkola, 2020). Both conditions applied to pandemic disruption of essential energy supply in 2020: the crisis was still unfolding, systematic operational data were not yet available, and relevant knowledge was dispersed across supply chain management, energy economics, maritime logistics, humanitarian operations and critical infrastructure research. The study therefore follows a theory synthesis approach, in which concepts from several literatures are combined into a single explanatory framework with explicit propositions.

2.1 Identification and selection of sources

Sources were identified through keyword searches of academic databases, publisher platforms and institutional repositories, supplemented by backward tracing of references in key articles. Search terms combined disruption concepts (pandemic, COVID-19, epidemic, disruption, ripple effect, resilience, business continuity) with domain concepts (procurement, sourcing, supplier, port,

shipping, demurrage, inventory, pre-positioning, strategic reserve, fuel distribution, petroleum, electricity, energy security). Sources were included when they were peer-reviewed articles, scholarly books or authoritative institutional reports; were published in 2020 or earlier; and addressed at least one of four domains: supply disruption and resilience, port and maritime logistics, inventory and pre-positioning, or downstream energy distribution. To reflect the operating context of emerging economies, the international literature was complemented by applied regional research on energy procurement, asset integrity, occupational safety, digital infrastructure, healthcare facilities and financial governance. The final corpus comprised 278 sources: 125 from the international literature and 153 from regional and applied research.

2.2 Analysis and synthesis

The selected sources were analysed thematically. Each source was coded for the disruption mechanisms it described, the capabilities or interventions it examined, the enabling conditions it identified and the outcomes it reported. Codes were then grouped iteratively into higher-order categories. Disruption mechanisms were consolidated into four pandemic-specific drivers, and capabilities were mapped against the segment of the energy supply chain in which they act, from upstream sourcing to last-mile delivery. This mapping produced the four operational pillars, while recurring conditions that supported several pillars at once were classified as cross-cutting enablers.

2.3 Framework development and proposition derivation

The conceptual model was developed abductively by moving between the coded literature and the observed features of the 2020 disruption. Relationships between constructs were specified where the literature provided consistent theoretical or empirical support, and these relationships were expressed as testable propositions. The implementation roadmap was derived from the readiness, response and recovery logic of resilience theory, extended with an adaptation phase. The model was assessed against three criteria commonly applied to conceptual work: internal consistency between constructs and propositions, parsimony in the number of components, and practical applicability for procurement decision-makers.

3 Literature synthesis

This section synthesises the literature in two parts. The first examines how pandemics disrupt essential energy supply, drawing on pandemic, energy, maritime and regional applied research. The second reviews the theoretical foundations in supply chain risk management, resilience, pandemic viability and procurement that inform the conceptual model.

3.1 Pandemic disruption mechanisms in essential energy supply

Pandemic disruptions differ from conventional supply shocks in four respects that matter for energy procurement. [Ivanov \(2020\)](#) notes that epidemic outbreaks are characterised by long duration, unpredictable scaling, and simultaneous disruption of supply, demand and logistics infrastructure. Each of these features has a specific expression in the energy sector.

3.1.1 Demand shocks that are both deep and uneven

Aggregate energy demand fell sharply in 2020. The IEA estimated that global energy demand would decline by about 6 percent over the year, with oil and coal most affected and electricity demand in locked-down economies falling noticeably ([IEA, 2020b](#)). Transport fuels, especially jet kerosene and

gasoline, saw the steepest declines. However, aggregate figures concealed sharp shifts in the composition and location of demand. Residential electricity use rose as people worked from home, healthcare facilities and data centres became more critical, and governments prioritised fuel for emergency services, freight and agriculture. For procurement teams, the problem was not simply less volume but different volume in different places, often at short notice.

Electricity system studies confirmed this compositional shift. Demand reductions in North America and Europe tracked case counts, mobility restrictions and the stringency of containment measures, while daily load profiles flattened and peaks moved (Abu-Rayash & Dincer, 2020; Bahmanyar et al., 2020; Ruan et al., 2020). In oil markets, COVID-19 news became a dominant driver of prices and volatility (Devpura & Narayan, 2020; Narayan, 2020), echoing longer-standing evidence that demand-driven and supply-driven oil shocks have distinct consequences and that oil prices remain difficult to forecast (Baumeister & Kilian, 2016; Hamilton, 2009; Kilian, 2008; Kilian, 2009). For essential users in emerging economies, these shocks interact with existing reliance on imported refined products and administered pricing (Siddig et al., 2014).

3.1.2 Workforce absence at critical nodes

Energy supply chains depend on specialised workers at refineries, terminals, ports, depots, control rooms and tanker fleets. Illness, quarantine, caring responsibilities and social distancing rules reduced effective capacity at these nodes. Because many roles require certification, such as hazardous goods drivers, marine pilots and control room operators, substitutes could not be recruited quickly. Workforce disruption therefore acted as a capacity constraint independent of physical asset availability, underscoring the importance of deliberate capability building across distributed supply chain operations (Falemi et al., 2020) and of support models that balance remote and on-site work without sacrificing operational continuity (Anyanwu, 2020).

Safety management research from energy and industrial settings reinforces this point. Pandemic controls add to an already demanding safety regime in drilling, maintenance, lifting and construction work, where contractor governance, human error, heat stress, hazard reporting and leadership-driven safety culture determine whether operations can continue safely (Arumosoye & Obriki, 2018; Arumosoye & Obriki, 2019; Arumosoye & Obriki, 2020; Nwangwu et al., 2018; Obogo et al., 2019a; Obogo et al., 2019b; Obogo et al., 2019c; Obogo et al., 2020a; Obogo et al., 2020b; Obogo et al., 2020c; Obriki & Arumosoye, 2018; Obriki & Arumosoye, 2019; Obriki & Arumosoye, 2020). Comparable lessons emerge from aviation safety oversight, where adaptive safety management and predictive compliance monitoring have been proposed for resource-constrained settings (Adeyelu, 2018; Adeyelu, 2019; Adeyelu, 2020). For maritime operations specifically, quarantine and border rules turned seafarers into frontline workers whose welfare became a precondition for continued shipping (Dombia-Henry, 2020). Workforce disruption is therefore both a health problem and a safety-critical capacity problem.

3.1.3 Port and border restrictions

Maritime transport carries the large majority of internationally traded crude oil, refined products, liquefied natural gas and coal. During 2020, ports and states imposed quarantine periods on arriving vessels, restricted shore leave and crew changes, and added health documentation to clearance procedures (UNCTAD, 2020). These measures lengthened port stays, disrupted vessel schedules and increased demurrage exposure, a cost burden that is already significant for energy importers in emerging economies under normal conditions (Okonkwo et al., 2020). Land borders introduced

checks that slowed cross-border tanker movements, which particularly affected landlocked and import-dependent countries.

Maritime research had long identified ports as points of concentrated vulnerability. Schedule unreliability caused by congestion and terminal delays propagates into hinterland supply chains and forces shippers to hold additional safety stock (Notteboom, 2006; Vernimmen et al., 2007). Port disruptions from strikes, accidents and natural hazards impose costs on multiple stakeholders and on nearby industry clusters (Lam & Su, 2015; Loh & Thai, 2015; Verschuur et al., 2020; Zhang & Lam, 2016), and formal vulnerability assessments show how failures in specific maritime functions reduce system throughput (Berle et al., 2011a; Berle et al., 2011b). Energy flows are particularly exposed because a small number of maritime chokepoints carry a large share of traded oil (Emmerson & Stevens, 2012), and the 2020 collapse in oil demand also unsettled tanker freight markets (Michail & Melas, 2020). In Nigeria, port reform improved productivity but infrastructure adequacy and service frequency remain central to port choice (Nwanosike et al., 2016; Ugboma et al., 2006), while legal and administrative barriers continue to complicate import and export activity (Jones & Ominyi, 2020).

3.1.4 Financial stress and supplier fragility

Extreme price volatility affected the solvency of traders, small distributors and service providers. Falling prices reduced the value of inventory and receivables, while margin calls and tighter credit restricted liquidity. Suppliers that appeared reliable before the crisis could fail or withdraw from markets during it, and many invoked force majeure provisions whose scope and evidentiary requirements differed widely across contracts (Uchechi et al., 2020). For buyers, counterparty risk rose at the same moment that switching suppliers became harder because of logistics constraints.

Financial governance research highlights why such stress translates into supply risk. Weak budget compliance, reconciliation controls and statutory reporting reduce organisations' ability to respond quickly and transparently to shocks (Bola-Sadipe et al., 2019; Dogbatsey & Ebhojie, 2018; Dogbatsey et al., 2019), while risk-based internal control, technology-enabled audit and integrated compliance strategies strengthen financial resilience (Akomolafe & Agu, 2018; Akomolafe & Agu, 2019a; Akomolafe & Agu, 2019b; Akomolafe & Agu, 2019c). Treasury and tax governance, transfer pricing risk and data-driven executive decision systems shape how multinational energy firms allocate liquidity across subsidiaries during crises (Lawal & Oduleye, 2018a; Lawal & Oduleye, 2018b; Lawal & Oduleye, 2019a; Lawal & Oduleye, 2019b), and fiscal measures such as finance bills can alter sector economics at short notice (Akinola et al., 2020). Bank capital adequacy rules and risk-weighted asset practices also shape how much credit lenders can extend to energy traders and distributors when risk perceptions rise (Mensah et al., 2019). Trade finance, distributorship finance and relationship banking models determine whether smaller fuel distributors retain access to working capital when prices swing (Agboada et al., 2018b; Agboada et al., 2020; Ezeako et al., 2019).

Two further features amplify these mechanisms. First, energy supply is interdependent with other critical infrastructures, so a failure can cascade through physical, cyber, geographic and logical linkages (Ouyang, 2014; Rinaldi et al., 2001). The users most exposed are essential services, especially health facilities. Diagnostic laboratories, hospitals and pharmacy-led primary care depend on reliable power and fuel for specimen storage, equipment and cold chains, and their infrastructure, design and financing models have been examined in resource-constrained settings (Aminu-Ibrahim et al., 2018; Aminu-Ibrahim et al., 2019; Aminu-Ibrahim et al., 2020; Ilodigwe & Adesemoye, 2019a; Ilodigwe & Adesemoye, 2019b; Ilodigwe & Adesemoye, 2020; Ogbete et al., 2018; Ogbete et al., 2019; Ogbete et al., 2020). Laboratory quality systems, infection detection, antimicrobial resistance

surveillance and disease surveillance networks all assume uninterrupted energy (Abdulrazaq et al., 2019; Ekemezie et al., 2018; Yusuf & Abdulrazaq, 2018; Yusuf et al., 2020), as do pharmaceutical manufacturing and distribution systems that rely on risk-based decision-making and chain-of-custody integrity (Aneke & Adesemoye, 2019; Aneke & Adesemoye, 2020). Second, procurement and logistics now run on digital infrastructure that must itself remain available. Electric utilities face operational technology security risks (Adegbite et al., 2020), and enterprise security research covers insider threats, intrusion detection, security audit, privacy engineering and data availability (Akeju et al., 2018; Dosunmu & Ogundele, 2019; Dosunmu & Ogundele, 2020; Fadayomi et al., 2019; Okoruwa et al., 2020; Onche et al., 2020). Cloud identity, access management, data protection and infrastructure governance (Mbonu et al., 2018; Mbonu et al., 2019a; Mbonu et al., 2019b; Mbonu et al., 2020b; Mbonu et al., 2020c; Oshoba et al., 2019; Oshoba et al., 2020), together with scalable cloud architectures, resource allocation and directory services (Ahmed & Odejebi, 2018a; Ahmed & Odejebi, 2018b; Ahmed et al., 2019; Ahmed et al., 2020; Ladapo et al., 2018; Ladapo et al., 2019; Odejebi & Ahmed, 2018a; Odejebi et al., 2019), determine whether remote procurement teams can operate when offices close.

Together these mechanisms produce what this paper terms a continuity gap: a divergence between the global availability of energy and the local, timely delivery of the right product to essential users. Closing this gap is the core purpose of procurement resilience in a pandemic.

3.2 Supply chain risk management

Supply chain risk management (SCRM) provides the starting point. Kleindorfer and Saad (2005) frame disruption risk management as a cycle of specifying sources of risk, assessing their likelihood and impact, and mitigating them through coordinated actions. Chopra and Sodhi (2004) emphasise that mitigation strategies must be tailored to specific risk categories because a strategy that reduces one risk, such as holding more inventory to protect against supply interruption, can increase another, such as obsolescence or holding cost. Tang (2006) distinguishes operational risks, which arise from routine uncertainty, from disruption risks, which arise from major natural or man-made events and require robust strategies that remain effective under severe conditions. Pandemics fall clearly into the disruption category but also persist long enough to transform operational conditions.

Subsequent work refined these foundations. Supply risk has been defined as the probability of inbound supply failure that prevents the buyer from meeting demand (Zsidisin, 2003), and supply chain risk management has been framed around risk sources, consequences, drivers and mitigation strategies (Ho et al., 2015; Jüttner et al., 2003; Manuj & Mentzer, 2008). Empirical evidence shows that disruptions produce large and persistent losses in shareholder value (Hendricks & Singhal, 2005), that supplier dependence and global sourcing raise supply-side vulnerability (Wagner & Bode, 2006), and that decoupling recurrent from disruption risks avoids over-reliance on cheap but unreliable suppliers (Chopra et al., 2007). Operations research models identify inventory, sourcing flexibility and network design as the main mitigation levers (Schmitt & Singh, 2012; Snyder et al., 2016; Tomlin, 2006), while proactive planning for catastrophic events and visibility-led confidence building help firms prepare (Christopher & Lee, 2004; Knemeyer et al., 2009; Simchi-Levi et al., 2014). In energy and engineering projects, data-driven risk evaluation and automated regulatory risk assessment extend these ideas to high-hazard settings (Gideon et al., 2019; Uchechi & Ominyi, 2020).

3.3 Supply chain resilience

Resilience literature shifts attention from avoiding disruption to sustaining and restoring performance. [Christopher and Peck \(2004\)](#) define resilience as the ability of a system to return to its original state, or move to a new and more desirable state, after being disturbed, and identify supply chain re-engineering, collaboration, agility and a risk management culture as its building blocks. [Sheffi and Rice \(2005\)](#) argue that resilience is achieved by creating redundancy or increasing flexibility, with flexibility generally providing more value because it also improves performance in normal times. [Ponomarov and Holcomb \(2009\)](#) describe resilience as an adaptive capability that spans readiness, response and recovery. [Pettit et al. \(2010\)](#) conceptualise resilience as a balance between vulnerabilities and capabilities, warning that excessive capability investment erodes profitability while insufficient investment leaves firms exposed. [Hohenstein et al. \(2015\)](#) synthesise this literature and identify flexibility, redundancy, collaboration, visibility, agility and a supportive culture as the most frequently cited resilience elements.

Further reviews and empirical studies have consolidated these elements ([Hosseini et al., 2019](#); [Kamalahmadi & Parast, 2016](#); [Tukamuhabwa et al., 2015](#)). Resilience has been operationalised through validated scales and assessment tools ([Ambulkar et al., 2015](#); [Chowdhury & Quaddus, 2017](#); [Pettit et al., 2013](#)), and linked to visibility, relational competencies and mitigation processes ([Brandon-Jones et al., 2014](#); [Scholten et al., 2014](#); [Wieland & Wallenburg, 2013](#)). Evidence from the global financial crisis showed that flexibility, velocity, visibility and collaboration reduced vulnerability ([Jüttner & Maklan, 2011](#)), and global supply base studies identified the enhancers and reducers of supplier resiliency ([Blackhurst et al., 2011](#)). Firms may respond to disruption by buffering or by bridging with partners ([Bode et al., 2011](#)), and resilience practices moderate the link between perceived risk and actual disruption ([Zsdisin & Wagner, 2010](#)). Flexibility need not be large to be valuable ([Tang & Tomlin, 2008](#)), and agile, adaptable and aligned supply chains outperform those designed only for speed and cost ([Lee, 2004](#); [Sheffi, 2005](#)).

3.4 Pandemic-specific perspectives and viability

Early pandemic scholarship extended resilience theory. [Ivanov \(2020\)](#) used simulation to show that the timing of facility closures and reopening, the duration of disruption and the speed of propagation across supply chain stages are decisive for impact. [Ivanov and Dolgui \(2020\)](#) introduced the concept of the intertwined supply network and its viability, meaning the ability to survive in a changing environment by redesigning structures and replanning performance over long horizons. [Queiroz et al. \(2020\)](#) mapped a research agenda that emphasises adaptation, digitalisation, preparedness and recovery. These perspectives suggest that pandemic resilience is less about absorbing a single shock and more about continuously reconfiguring supply arrangements while the disruption persists.

This view builds on research into the ripple effect, the propagation of disruption across supply chain stages, which identifies redundancy, flexibility and digital risk analytics as means of containing it ([Dolgui et al., 2018](#); [Ivanov et al., 2019](#); [Ivanov, 2017](#)). Early COVID-19 studies added that emergency sourcing, resource sharing and product simplification restore service levels for essential goods ([Paul & Chowdhury, 2020](#)), and that firms shifted towards total cost of ownership, supplier collaboration and diversification ([van Hoek, 2020b](#)). For energy, the collapse in fuel demand and negative oil prices renewed interest in domestic fuel options and strategic storage as instruments of supply security ([Chiaromonti & Maniatis, 2020](#)).

3.5 Procurement as a resilience lever

Procurement occupies a strategic position in this literature because it controls supplier selection, contract design, specification and relationship management. Kraljic (1983) argued that items with high supply risk and high business impact, which he termed strategic items, require dedicated supply strategies including long-term contracts, alternate sourcing and stockpiling. Essential energy is the archetypal strategic item for utilities, hospitals, transport operators and governments. Craighead et al. (2007) show that disruption severity depends on supply chain density, complexity and node criticality, and that recovery and warning capabilities moderate this severity. Within the energy sector specifically, strategic procurement optimisation (Okonkwo et al., 2018a), structured vendor governance and contract negotiation (Okonkwo et al., 2019) and project-level supply chain risk models (Agbabiaka et al., 2019) have been shown to influence cost, availability and delivery reliability. These insights justify a procurement-led framework that deliberately builds warning, response and recovery capabilities into the energy supply chain.

Public procurement scholarship adds that buyers must balance efficiency, accountability and policy goals within regulatory constraints (Thai, 2001), and contract theory shows that more flexible, cost-reimbursable arrangements suit complex and uncertain requirements because they ease adaptation after contract award (Bajari & Tadelis, 2001). In energy settings, statutory licensing and public bidding requirements, cross-border regulatory clearances and post-merger compliance integration all shape how quickly procurement can respond (Ominyi & Anichukwueze, 2020; Ominyi et al., 2020; Ominyi, 2020). Standardised legal workflows, financial exposure management and compliance training reduce disputes and support ethical conduct under pressure (Anichukwueze et al., 2019; Anichukwueze et al., 2020; Uchechi et al., 2018; Uchechi, 2018). Joint venture structures common in the energy sector also require multi-stakeholder governance alignment so that partners can agree emergency decisions (Eyetsemitan et al., 2020).

3.6 Synthesis of the literature

Three principles emerge from the literature and shape the framework. First, resilience capabilities should be matched to the specific disruption mechanisms identified in Section 3.1 rather than applied generically. Second, flexibility-based capabilities, such as pre-qualified alternate suppliers and optional storage contracts, are preferable where they also create value in normal operations, while redundancy should be reserved for the most critical exposures. Third, because pandemics are prolonged and evolving, the framework must include governance and learning mechanisms that allow procurement arrangements to be redesigned during the disruption, consistent with the viability perspective.

4 Conceptual model: The procurement resilience framework

The Procurement Resilience Framework (PRF) is presented in Figure 1. Pandemic disruption drivers act on a governance layer that sets emergency authority and priorities. The governance layer directs four operational pillars, each addressing a distinct segment of the energy supply chain. Four cross-cutting enablers support all pillars. The intended outcome is continuity of essential energy supply, defined across four dimensions: availability, timeliness, cost containment and safety. A learning feedback loop returns performance information to the governance layer so that arrangements can be revised as the disruption evolves.

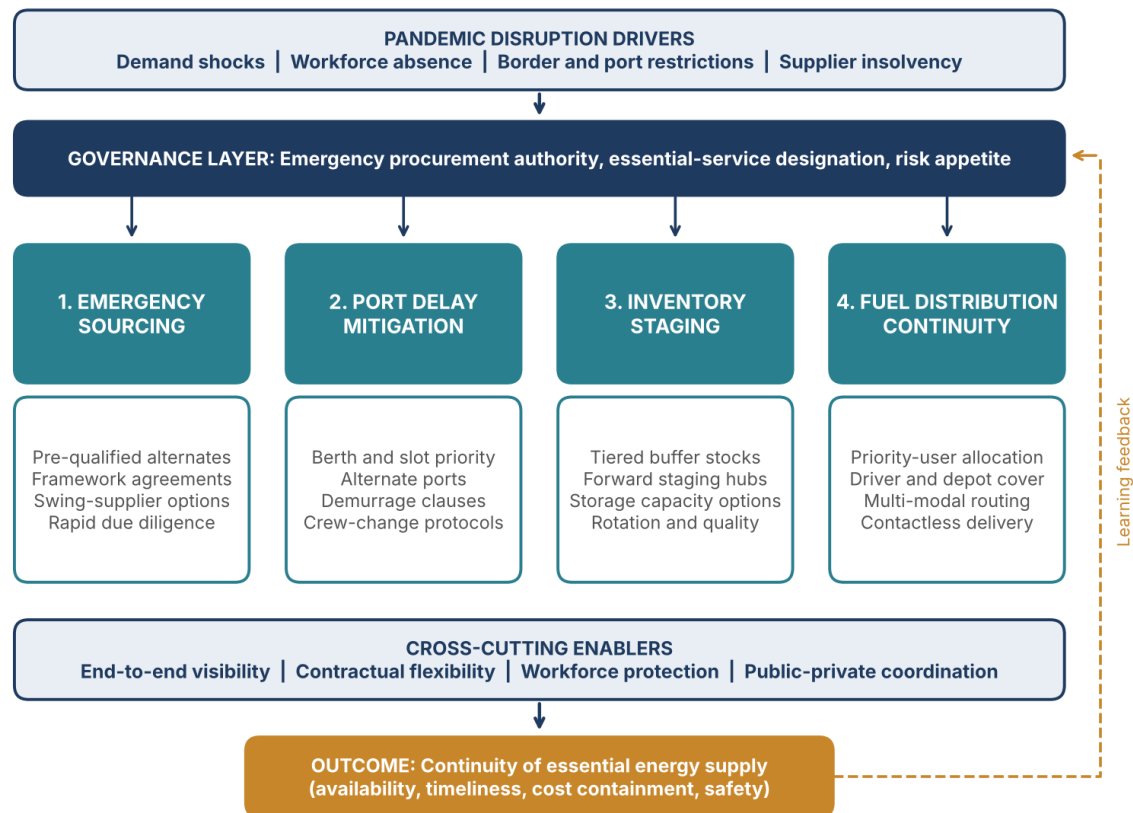


Figure 1. The Procurement Resilience Framework (PRF) for essential energy supply during pandemics.

4.1 Governance layer

Resilience fails when decisions cannot be made quickly. Normal procurement rules, including competitive tendering thresholds, multi-level approvals and standard credit limits, can delay action by weeks. The governance layer establishes in advance the conditions under which emergency procurement authority is activated, who holds it, which expenditure and credit limits apply, and how decisions are recorded for later audit. Experience in emerging energy markets shows that statutory bidding workflows can be streamlined without compromising compliance when reform is planned in advance rather than improvised (Uchechi et al., 2019). It also defines the essential-user hierarchy, a ranked list of users and sites that receive priority when supply is constrained, typically led by healthcare, water and sanitation, emergency services, food logistics and critical communications. Finally, it sets the organisation's risk appetite, for example the minimum days of cover tolerated for each product and site, which translates into concrete triggers for the operational pillars.

Business continuity management, which evolved from IT disaster recovery into an organisation-wide discipline (Herbane, 2010), provides the procedural backbone for this layer, and institutional pressures shape how purchasing functions adopt continuity planning (Zsidisin et al., 2005). Disaster operations research emphasises that preparedness decisions taken before an event largely determine response performance (Altay & Green, 2006; Van Wassenhove, 2006). Standard operating procedures can act as change infrastructure that sustains new routines once the acute phase passes (Agboada et al., 2019), and digital transformation of operations management supports faster, better documented decisions (Agboada et al., 2018a).

4.2 Pillar 1: Emergency sourcing

Emergency sourcing ensures that alternative supply can be activated quickly when a primary supplier, refinery, import route or trading counterparty fails. The central idea is to do the slow work of supplier qualification before the crisis so that only fast work remains during it. Key capabilities include:

- *Pre-qualified alternate suppliers.* Maintaining a panel of technically and financially vetted suppliers for each critical product and delivery point, with product specifications, safety documentation and know-your-customer checks already complete.
- *Framework and call-off agreements.* Establishing umbrella contracts with agreed terms, pricing formulas and quality standards that can be activated by a call-off order rather than a new tender. Disciplined vendor governance and pre-negotiated terms reduce both cost and activation time (Okonkwo et al., 2019).
- *Swing-supply and volume-flex options.* Negotiating rights to increase or decrease contracted volumes within agreed bands, which proved valuable in 2020 when demand fell overall but rose for specific products.
- *Geographic and modal diversification.* Avoiding dependence on a single refinery, terminal or import corridor for critical sites, and qualifying supply that can arrive by alternate routes such as pipeline, rail, coastal shipping or road.
- *Rapid counterparty monitoring.* Tracking supplier financial health and operational status during the disruption, so that buyers can shift volume before a supplier fails rather than after. Integrating geospatial data into enterprise resource planning (ERP) procurement processes helps buyers locate alternate suppliers relative to affected sites and corridors (Abiaek Patrick et al., 2020).

Emergency sourcing must be balanced against governance and integrity. Emergency procurement in 2020 created opportunities for price gouging and weakened controls in some sectors. The framework therefore couples speed with transparency: emergency awards should use pre-agreed pricing formulas, be recorded centrally and be subject to post-event review.

Research supports each of these capabilities. The optimal mix of inventory, dual sourcing and contingent rerouting depends on disruption length, frequency and supplier capacity (Tomlin, 2006), and modest flexibility yields substantial protection (Tang & Tomlin, 2008). Humanitarian logistics shows that supplier selection for framework agreements before a disaster improves post-event procurement speed and cost (Balcik & Ak, 2014), and that relief chains differ from commercial chains in ways that favour pre-established capability (Holguín-Veras et al., 2012; Kovács & Spens, 2007). Profitability analytics for procurement operations and environmental, social and governance criteria in supplier selection help buyers judge whether emergency awards remain good value and responsible (Akin-Oluyomi et al., 2020; Okojie & Abioye, 2020; Okojie et al., 2020).

4.3 Pillar 2: Port delay mitigation

Ports and terminals are the critical chokepoints for imported energy. A delay of several days in berthing, discharge or clearance can exhaust inventories at downstream sites. Port delay mitigation focuses on keeping cargo moving through these nodes and on limiting the financial and physical consequences when it does not. Prior work on port logistics in emerging economies shows that demurrage can be substantially reduced through pre-arrival documentation, coordinated berth planning and closer alignment between procurement and logistics functions (Okonkwo et al., 2020). The reliability of marine terminal equipment, such as offshore loading buoys, also conditions how

quickly cargo can be moved during a crisis (Obetta & Ninduwezuor-Ehiobu, 2018). Key capabilities include:

- *Berth and slot prioritisation.* Agreeing with port authorities and terminal operators, ideally through government designation of energy cargo as essential, that critical energy vessels receive berthing priority and expedited clearance.
- *Alternate discharge ports.* Pre-arranging the technical and commercial ability to divert cargoes to a secondary port, including compatible terminal infrastructure, customs arrangements and onward transport.
- *Pandemic-adjusted contract terms.* Reviewing laytime, demurrage and force majeure clauses so that the allocation of pandemic-related delay costs is clear in advance, reducing disputes and preserving supplier relationships (BIMCO and other industry bodies issued pandemic clauses during 2020 for this purpose). Clear liability allocation and dispute-prevention provisions are especially valuable in high-value energy contracts (Uchechi & Ominyi, 2019; Uchechi et al., 2020).
- *Crew-change and health protocols.* Coordinating with shipowners, port health authorities and agents on testing, quarantine and crew-change procedures, recognising that seafarers were unable to disembark for extended periods in 2020 and that crew welfare is a precondition of reliable shipping.
- *Digital clearance and documentation.* Using electronic bills of lading, digital customs submissions and remote inspection where regulations allow, to reduce person-to-person contact and processing time.

Policy and management studies offer guidance for these measures. Risk-based decision frameworks help port authorities rank cost-effective resilience investments (Mansouri et al., 2010), and combining risk, continuity and quality management improves port operational resilience (Loh & Thai, 2016). On the energy side, the integrity of offshore export and import infrastructure, including floating storage and offloading turret moorings, export buoys and corrosion-exposed marine equipment, determines whether cargo can move when it is most needed (Obetta & Ninduwezuor-Ehiobu, 2018; Obetta & Ninduwezuor-Ehiobu, 2019; Obetta et al., 2020).

4.4 Pillar 3: Inventory staging

Inventory is the most direct buffer against disruption, but it is costly to hold and, for energy products, subject to safety, quality and regulatory constraints. The framework therefore treats inventory as a staged system rather than a single stockpile. Key capabilities include:

- *Tiered buffer stocks.* Defining minimum days of cover for each product at three tiers: strategic or national reserves, regional or primary terminals, and site-level storage at essential users such as hospital generator tanks. Targets are set according to the essential-user hierarchy and expected replenishment lead times under disruption. Linking inventory availability targets to the uptime requirements of the facilities they serve gives these targets an operational rationale (Okonkwo et al., 2018b).
- *Forward staging hubs.* Positioning inventory closer to essential users before anticipated constraints, for instance moving diesel to regional depots ahead of border restrictions, so that last-mile distances are short when logistics capacity is scarce.
- *Storage capacity options.* Securing contractual access to third-party tankage that can be activated as needed. In 2020, when storage became scarce and costly, organisations with pre-arranged options were better placed to accept deliveries and avoid supply interruptions.

- *Rotation and quality management.* Ensuring that staged stocks remain usable through rotation, testing and treatment, since products such as diesel can degrade during long storage and contaminated fuel can disable standby generators.
- *Inventory visibility.* Maintaining near real-time data on stock levels across tiers, so that replenishment and reallocation decisions are based on actual positions rather than estimates. Predictive analytics can improve demand forecasts and reduce inventory inefficiencies, which is particularly useful when demand patterns shift abruptly (Aifuwa et al., 2020).

Inventory staging also creates a link with the market environment. The 2020 contango structure, in which future prices exceeded spot prices, made storing product financially attractive for traders and raised storage costs. Buyers with storage options could exploit the same structure to build buffers at low cost, illustrating how resilience investment can be partially self-funding.

Humanitarian logistics provides the most developed models for this pillar. Facility location and stock pre-positioning models allocate emergency supplies under budget constraints and uncertain disaster scenarios (Balcik & Beamon, 2008; Rawls & Turnquist, 2010), and applied studies show that pre-positioned stock shortens response times (Duran et al., 2011). Relief inventories differ from commercial stocks in acquisition, storage and distribution (Balcik et al., 2016; Whybark, 2007). At the national level, dynamic programming models of strategic petroleum reserves derive fill and drawdown rules under uncertain supply interruptions (Teisberg, 1981). Inventory is only useful if storage assets remain fit for service, so risk-based inspection, reliability-centred maintenance, integrity management of fired equipment, non-destructive testing, corrosion control and predictive maintenance form part of inventory staging. Risk-based process engineering that links hazard evidence, barrier condition and maintenance decisions across natural gas wells, processing units, pipelines and storage assets offers a system-level basis for prioritising this work (Asibor & Isong, 2019; Adaramola et al., 2018; Atta et al., 2018; Atta et al., 2020; Obetta, 2018; Obetta, 2019; Obetta, 2020; Sunday et al., 2020). Predictive analytics also improves demand forecasts that set buffer levels (Aifuwa et al., 2020), and long-range production forecasting informs upstream availability assumptions (Nwangwu et al., 2020).

4.5 Pillar 4: Fuel distribution continuity

The final pillar concerns the last mile: moving product from terminals and depots to essential users when labour, vehicles and access are constrained. Key capabilities include:

- *Priority-user allocation rules.* Translating the essential-user hierarchy into operational allocation rules for depots and fleets, including rationing protocols that specify how constrained volumes are shared and how exceptions are approved.
- *Driver and depot workforce cover.* Cross-training staff, maintaining reserve pools of certified hazardous goods drivers, arranging mutual aid with other distributors and, where necessary, engaging authorities to grant licence extensions or temporary permits.
- *Multi-modal and alternate routing.* Pre-planning alternative delivery routes and modes that avoid closed borders, checkpoints or congested corridors.
- *Contactless and safe delivery.* Adopting procedures such as electronic proof of delivery, scheduled drops and site health protocols that protect both drivers and recipients and keep delivery points open.

- *Retail and network continuity.* For fuel distributors, maintaining the minimum retail and wholesale network needed to serve essential users and communities, even when lower volumes make some outlets unprofitable in the short term.

Operations research on downstream petroleum logistics supports these capabilities. Multi-period replenishment heuristics plan tanker loading, routing and delivery timing to petrol stations (Cornillier et al., 2008), multimodal transport choices shape distribution centre location and cost (Kazemi & Szmerekovsky, 2015), and reviews identify gaps in downstream oil supply chain planning (Chima, 2007; Lima et al., 2016). Road network vulnerability analysis helps planners identify links whose closure would most raise delivery costs (Berdica, 2002; Jenelius et al., 2006; Mattsson & Jenelius, 2015). For household energy, scaling up liquefied petroleum gas depends on reliable production, distribution and pricing arrangements (Kojima, 2011; Puzzolo et al., 2019). Electricity continuity raises parallel issues: UAV-based inspection of power lines and pipeline corridors (Dagodzo & Ahiaeke Patrick, 2020; Dagodzo, 2018a; Dagodzo, 2018b), grounding design and voltage control in distribution networks (Adeniji et al., 2020; Oshevire et al., 2017), telecommunications quality for grid communications (Amayo & Popoola, 2017), and hybrid solar, microgrid and hydrogen options that diversify supply for essential users (Komi & Adeniji, 2020; Odejebi & Ahmed, 2018b; Shittu et al., 2019; Sunday & Omoegun, 2018; Sunday & Omoegun, 2019; Yeboah & Ike, 2020). Efficient building energy systems also reduce the load that must be secured at critical sites (Sunday et al., 2019).

4.6 Cross-cutting enablers

Four enablers support all pillars and correspond closely to resilience elements identified in the literature (Hohenstein et al., 2015).

- *End-to-end visibility.* Integrated information on supplier status, vessel positions, port queues, inventory levels and delivery performance. Visibility enables early warning, one of the capabilities that Craighead et al. (2007) identify as reducing disruption severity. Agile digital supply chain architectures with embedded IT risk controls (Mbonu et al., 2020a) and chain-of-custody traceability approaches developed for other critical goods (Aneke & Adesemoye, 2019) offer transferable design patterns.
- *Contractual flexibility.* Contract terms that allow volumes, delivery points, timing and payment to be adjusted under defined conditions without renegotiation. Flexibility clauses convert uncertainty into managed options.
- *Workforce protection.* Health and safety measures, shift segregation, testing and support arrangements that keep critical staff available across the procurement and logistics chain. In a pandemic, people are the most constrained resource, so cross-trained and distributed talent pools are a resilience asset (Falemi et al., 2020).
- *Public-private coordination.* Structured engagement with energy regulators, ministries, port authorities and emergency management agencies to secure essential-service status, share information and coordinate allocation. Energy supply is a shared responsibility, and many critical levers, such as border exemptions and reserve releases, sit with government.

The literature supports each enabler. Agile digital supply chain architectures, ETL and data integration, platform governance in regulated healthcare environments and DevOps tooling provide the technical base for visibility (Badmus et al., 2018; Badmus et al., 2019a; Badmus et al., 2019b; Badmus et al., 2020; Mbonu et al., 2020a). Analytics for demand measurement, churn prediction, geomarketing and product management in regulated service markets illustrate how organisations sense

shifting demand (Agyei et al., 2018; Agyei et al., 2019; Oziri et al., 2020; Sanni et al., 2020a; Sanni et al., 2020b; Sanni et al., 2020c; Seyi-Lande et al., 2020). Workforce enablers draw on research into recruitment, distributed talent development, industry-academia collaboration and IT support maturity (Akhigbe et al., 2020; Anyanwu, 2019; Nwangwu et al., 2019; Wikiri, 2019), and on wider evidence about cross-cultural communication, professional transitions, digital learning platforms and ICT-supported skills development, including offline-first designs that keep training and information systems usable where connectivity is intermittent and costly (Unamma et al., 2018; Boakye et al., 2020; Lilian et al., 2020; Ogbona et al., 2020; Orise & Niniola, 2020). Public-private coordination benefits from frameworks for efficient public infrastructure delivery and urban resilience planning (Nwafor et al., 2019a; Nwafor et al., 2019b).

The framework is summarised in Table 1, which links each pillar to the disruption mechanisms it addresses, its core capabilities and illustrative performance indicators.

Table 1. Framework pillars, targeted disruption mechanisms, capabilities and indicators.

Pillar	Disruption addressed	Core capabilities	Illustrative indicators
Emergency sourcing	Supplier failure, refinery outages, trader insolvency, sudden demand shifts	Pre-qualified alternates; framework agreements; volume-flex options; counterparty monitoring	Time to activate alternate supply; share of critical volume with qualified alternates
Port delay mitigation	Quarantine delays, crew-change restrictions, reduced terminal staffing, slow clearance	Berth priority; alternate ports; pandemic contract clauses; digital clearance	Average waiting time at berth; demurrage cost per cargo; cargo diversion lead time
Inventory staging	Replenishment uncertainty, storage scarcity, regional access restrictions	Tiered buffers; forward hubs; storage options; rotation and quality control	Days of cover by tier and site; stock-out incidents; off-specification product rate
Fuel distribution continuity	Driver shortages, border checks, depot closures, shifting essential demand	Allocation rules; workforce reserves; alternate routing; contactless delivery	On-time delivery to essential users; fill rate for priority sites; delivery cycle time

4.7 Research propositions

Consistent with the conceptual nature of this paper, the framework is expressed as a set of propositions that can be examined in future empirical research. The dependent construct in each case is essential energy supply continuity, measured through availability, timeliness, cost containment and safety at essential-user sites during a pandemic.

The governance layer determines how quickly operational capabilities can be deployed. Pre-defined emergency authority and an agreed essential-user hierarchy reduce decision latency and prevent conflict over scarce supply.

P1. Organisations with pre-established emergency procurement authority and an essential-user hierarchy will achieve higher energy supply continuity during pandemic disruptions than organisations that develop these arrangements reactively.

Emergency sourcing reduces dependence on any single supplier or route and shortens the time required to replace failed supply.

P2. The proportion of critical energy volume covered by pre-qualified alternate suppliers and framework agreements is positively associated with supply continuity, and this relationship is stronger when primary supplier failure rates are high.

Port delay mitigation addresses the chokepoint at which pandemic health controls most directly interact with energy logistics.

P3. Pre-arranged berth prioritisation, alternate discharge options and pandemic-specific contract clauses reduce the effect of port delays on downstream stock-outs.

Inventory staging provides time, which is the resource most valuable when other capabilities are being activated.

P4a. Tiered, forward-positioned inventory is positively associated with supply continuity for essential users.

P4b. The positive effect of inventory staging on supply continuity diminishes beyond a threshold of days of cover, beyond which holding costs and quality risks outweigh additional protection.

Last-mile distribution determines whether upstream availability translates into delivered supply.

P5. Priority allocation rules and reserve workforce arrangements in fuel distribution mediate the relationship between upstream availability and delivered supply to essential users.

Enablers amplify the effectiveness of operational capabilities by providing information, options and coordination.

P6. End-to-end visibility and public-private coordination positively moderate the relationships between each operational pillar and supply continuity.

Finally, because pandemics evolve, the ability to learn and redesign arrangements during the disruption is itself a capability.

P7. Organisations that systematically review continuity performance and revise procurement arrangements during a prolonged disruption will show improving continuity over successive waves of the pandemic, compared with organisations that maintain static arrangements.

5 Discussion

The framework extends existing knowledge in three ways. First, it contextualises general supply chain resilience theory for essential energy, a sector in which physical constraints such as hazardous handling, storage capital intensity and node concentration shape which resilience strategies are feasible. Second, it introduces the concept of the continuity gap to explain why global oversupply and local shortage co-existed in 2020, emphasising that procurement resilience in a pandemic is primarily about delivery to the right user at the right time. Third, it integrates the viability perspective into a procurement framework by treating governance and learning as explicit components rather than background conditions.

The model also clarifies how established resilience principles behave under pandemic conditions. Redundancy and flexibility remain the core levers, but in a pandemic their value depends on where they are located in the supply chain. Inventory held far from essential users offers little protection when ports, borders and depots are constrained, and alternate suppliers are of limited use if their cargo cannot be cleared or delivered. The four pillars therefore act as a chain whose weakest segment

sets the level of continuity, which is why the propositions treat distribution capabilities as a mediator and visibility and coordination as moderators. The model further suggests that governance is not merely a background condition: the speed at which emergency authority can be exercised determines how quickly any operational capability is activated. Finally, the emphasis on learning between waves reflects the extended duration of pandemic disruption, which turns resilience from a one-off response into a continuing process of reconfiguration.

6 Implications

6.1 Implications for practice

For procurement leaders in utilities, national oil companies, fuel distributors, hospitals and public agencies, the framework provides a diagnostic tool. Organisations can assess their maturity in each pillar and enabler, identify the weakest links for their critical sites, and prioritise investments accordingly. The framework also highlights that many resilience capabilities are contractual rather than physical: framework agreements, flex clauses, storage options and pandemic clauses can be negotiated at relatively low cost and deliver significant protection. Finally, it underlines the importance of relationships. Suppliers, shipowners, port authorities and regulators are partners in continuity, and arrangements that share pandemic costs fairly are more likely to hold under stress.

6.2 Implementation roadmap

The framework can be implemented through four phases aligned with the readiness, response and recovery logic of [Ponomarov and Holcomb \(2009\)](#), extended with an adaptation phase reflecting the viability perspective of [Ivanov and Dolgui \(2020\)](#). Table 2 summarises the key procurement actions in each phase.

Table 2. Phased implementation roadmap.

Phase	Objective	Key procurement actions
1. Prepare	Build capabilities before disruption	Map critical sites and products; set essential-user hierarchy; qualify alternate suppliers; negotiate framework, flex and storage option contracts; agree pandemic clauses; define inventory targets and triggers; establish emergency authority and reporting.
2. Respond	Protect essential supply in the acute phase	Activate crisis governance; confirm essential-service status with authorities; raise buffers at priority sites; call off alternate supply where needed; prioritise berths and expedite clearance; apply allocation rules; protect and redeploy critical workforce.
3. Recover	Restore normal service levels efficiently	Rebalance inventory and release excess storage; normalise supplier mix; settle demurrage and force majeure claims fairly; review emergency awards for value and integrity; restore suspended delivery services.
4. Adapt	Embed learning and redesign	Conduct after-action reviews; update risk registers and inventory targets; renegotiate contracts with lessons learned; invest in visibility systems; institutionalise public-private coordination mechanisms; test plans through scenario exercises.

Two practical observations apply across phases. First, the phases overlap in a pandemic. Successive waves of infection meant that many organisations in 2020 were recovering in one region while responding in another, so the roadmap should be applied at the level of individual sites and supply

corridors rather than the enterprise as a whole. Second, the cost of preparation should be assessed against the cost of failure at essential sites. A single hospital or water plant losing power can generate public health and reputational costs that far exceed the annual cost of maintaining alternate supplier panels or storage options.

6.3 Implications for policy

Governments influence energy continuity through essential-service designations, border and port health policies, strategic reserve management and emergency regulatory relief. The framework suggests that policies should explicitly recognise energy logistics workers, including seafarers and tanker drivers, as essential personnel, provide clear and consistent health protocols at ports and borders, and coordinate reserve releases with private inventory positions. Import-dependent and landlocked economies may benefit from regional cooperation on transit corridors and shared storage.

7 Limitations

As a conceptual paper, the framework has not been empirically validated, and its propositions require testing. Its components draw on the 2020 experience, which was still unfolding at the time of writing, and later evidence may reveal additional mechanisms. The framework is also oriented toward liquid fuels and gas imported by sea; power systems with domestic generation, and renewable energy supply chains dependent on equipment imports, may need adaptations.

8 Future research

Future research could test the propositions through multi-case studies of utilities and fuel distributors, survey-based measurement of resilience capabilities and continuity outcomes, simulation models of inventory staging and port delay scenarios, and comparative studies across countries with different regulatory and market structures. Research on the cost-effectiveness of specific capabilities, such as the value of storage options relative to physical reserves, would be particularly useful to practitioners.

Future research could also draw on adjacent fields represented in the regional literature. Studies of agribusiness finance and entrepreneurial education (Michael & Ogunsola, 2019a; Michael & Ogun-sola, 2019b) point to the role of local enterprises in last-mile fuel retail, while work on housing affordability, building envelope design and local building materials (Gil-Ozoudeh et al., 2018; Nwafor et al., 2018; Nwafor et al., 2019c) bears on the energy needs of essential facilities. Environmental risk models for subsurface contamination and climate-induced watershed vulnerability (Azeez & Badmus, 2018; Badmus & Olamide, 2019; Lamidi & Olamide, 2018) are relevant to the siting and protection of staged fuel inventories.

9 Conclusion

The COVID-19 pandemic demonstrated that essential energy supply can be threatened even when energy is globally abundant. Disruptions to workforces, ports, borders and supplier finances opened a gap between availability and delivery that conventional, efficiency-oriented procurement was not designed to close. The Procurement Resilience Framework proposed here addresses this gap through a governance layer, four operational pillars of emergency sourcing, port delay mitigation, inventory staging and fuel distribution continuity, and four cross-cutting enablers. By pairing these elements

with testable propositions and a phased roadmap, the paper offers both a practical guide for organisations responsible for keeping essential services powered and a foundation for empirical research on procurement resilience in the energy sector. The central lesson is that resilience must be built before it is needed: the arrangements that matter most during a pandemic are those negotiated, qualified and rehearsed in calmer times.

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