Designing a Productivity Model for an Agile and Digital Supply Chain in the Oil and Gas Industry: A Thematic Analysis Approach

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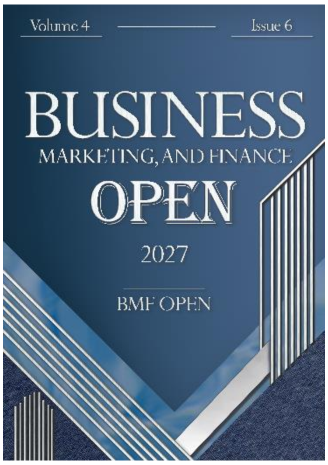

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Abstract: Under conditions of volatility in the global energy market and pressures arising from sanctions, improving supply chain productivity in Iran's oil and gas industry has become a strategic imperative. This study aimed to design a supply chain productivity model for this industry based on an integrated approach combining agility and digitalization. The research employed a qualitative methodology using systematic thematic analysis based on the six-phase framework developed by Braun and Clarke (2006). The required data were collected and analyzed through 18 in-depth semi-structured interviews with industry experts (11 participants) and academics (7 participants). Based on the findings, a multilayer conceptual model comprising 5 main themes and 13 subthemes was developed. The main themes were: (1) operational agility and resilience, (2) digital integration and data-driven intelligence, (3) human resource and organizational enablers, (4) coordination and collaboration within the supply chain network, and (5) governance and sustainability. The final model demonstrates that achieving sustainable productivity requires the dynamic and systematic interaction of these dimensions. Digital integration and organizational enablers provide the necessary foundation for operational agility and network collaboration, while the entire system is guided within a governance and sustainability framework. This model can provide a framework for planning and evaluating digital transformation and agility initiatives in this strategically important industry.

Keywords: supply chain productivity, agility, digitalization, oil and gas industry, thematic analysis

1. Introduction

The oil and gas industry occupies a pivotal position in national economies, global energy security, industrial development, and the continuity of numerous downstream economic activities. Its supply chains are among the most complex industrial networks because they encompass exploration, extraction, processing, transportation, storage, refining, distribution, equipment procurement, technical services, and extensive interactions with domestic and international suppliers. The performance of these interconnected activities directly influences production continuity, operating costs, service levels, asset utilization, and ultimately the competitiveness of oil and gas enterprises. Consequently, supply chain productivity has evolved from a predominantly operational concern into a strategic management priority. Contemporary supply chains are expected not only to minimize costs and utilize resources efficiently but also to maintain responsiveness, continuity, adaptability, and value creation under increasingly uncertain conditions. Studies concerned with productivity and supply chain performance emphasize that productivity improvement depends on the coordinated optimization of resources, processes, relationships, and decision mechanisms rather than isolated improvements in individual organizational units [1-3].

These requirements are particularly significant in the oil and gas sector, where capital intensity, geographically dispersed operations, specialized equipment, stringent safety requirements, long procurement cycles, and dependence on global logistics networks create substantial operational complexity. Disruptions in the availability of critical equipment, transportation capacity, spare parts, technical services, or information can generate cascading consequences across production and distribution systems. Accordingly, effective supply chain management has become essential for controlling operational costs, improving logistics efficiency, increasing resource utilization, and protecting continuity of operations. Research specifically addressing the oil and gas industry has demonstrated the strategic relevance of logistics optimization, supply chain coordination, inventory management, procurement improvement, and integrated operational planning for organizational performance [4-7]. In such a context, productivity should be understood as a multidimensional organizational capability involving the efficient conversion of resources into outputs while simultaneously preserving responsiveness, reliability, resilience, and strategic flexibility.

The contemporary operating environment further complicates this challenge. Energy supply chains increasingly function under geopolitical tensions, trade restrictions, volatile commodity prices, technological transitions, regulatory changes, environmental pressures, and sudden disruptions in transportation and sourcing networks. Geopolitical events can alter the accessibility, cost, and reliability of supply routes and can directly affect both oil prices and the sustainability of supply networks [8]. For the Iranian oil and gas industry, these challenges are intensified by sanctions and restrictions affecting international procurement, financial transactions, technology acquisition, transportation arrangements, and access to specialized suppliers. Under such circumstances, conventional supply chain structures characterized by lengthy planning cycles, rigid contracts, concentrated sourcing, hierarchical decision-making, and limited visibility may be inadequate. Supply chain productivity therefore increasingly depends on the ability to adapt rapidly to environmental changes while maintaining essential operations and deploying resources efficiently.

Agility has consequently emerged as a fundamental capability for modern supply chain management. Supply chain agility generally refers to the capacity to sense changes in demand or operating conditions and respond rapidly through flexible sourcing, production, logistics, and coordination mechanisms. It encompasses responsiveness, adaptability, speed, flexibility, and the capability to reconfigure resources and relationships when environmental conditions change. Recent research demonstrates that digitalization can strengthen supply chain agility and that innovation capabilities play an important role in converting digital transformation into responsive operational performance [9]. Similarly, the development of big data analytics capabilities can enhance agility by enabling organizations to interpret changing conditions more quickly and make more informed adjustments to supply, production, and distribution arrangements [10]. A digitally supported agile supply chain can therefore move beyond reactive crisis management toward continuous sensing, rapid interpretation, and timely operational adaptation.

Agility alone, however, is insufficient when organizations confront severe and prolonged disruptions. Supply chain resilience complements agility by emphasizing the capacity to anticipate disruptions, absorb their effects, adapt operations, and recover while maintaining critical functions. Resilient supply chains combine preparedness, redundancy, flexibility, visibility, risk management, and collaborative capacity. Empirical research has shown that supply chain robustness and the intensity of disruptions substantially influence organizational resilience, particularly in resource-constrained environments [11]. Digital capabilities can further support resilience by improving information availability, integration, real-time monitoring, and coordination across organizational boundaries [12, 13]. Thus, productivity in turbulent environments is not merely a matter of accomplishing more with fewer resources; it also concerns maintaining productive capacity despite disruption and reducing the time, cost, and resource losses associated with operational instability.

The rapid development of digital technologies has simultaneously transformed the mechanisms through which supply chain agility and resilience can be achieved. Digital supply chains increasingly rely on enterprise resource planning systems, cloud platforms, artificial intelligence, the Internet of Things, big data analytics, advanced forecasting, automation, blockchain, and integrated decision-support systems. These technologies can provide real-time information about orders, inventories, assets, transportation, equipment condition, supplier performance, and operational risks. In the oil and gas sector, digital transformation has particularly important implications because operational decisions often involve costly assets and geographically dispersed activities. Digital transformation of ERP environments and the use of real-time analytics can strengthen visibility and managerial decision-making across oil and gas supply chains [14]. Evidence from the sector also suggests that digital supply chain capabilities are associated with improved business performance by enabling greater coordination, information availability, and operational responsiveness [15].

Artificial intelligence represents another increasingly important component of supply chain digitalization. AI-based forecasting, predictive maintenance, optimization, anomaly detection, and decision-support applications enable organizations to analyze complex datasets and identify patterns that may not be readily detectable through traditional managerial processes. In the oil and gas industry, AI can support supply chain productivity by improving demand forecasting, maintenance planning, inventory decisions, logistics scheduling, and risk assessment [16, 17]. The integration of AI-based supply chain management with ERP systems can additionally improve production productivity by linking predictive intelligence with operational information and resource-planning processes [18]. These developments indicate a transition from digitally recorded supply chains toward digitally intelligent supply chains in which data are increasingly used not merely for reporting past performance but also for anticipating future conditions and recommending operational actions.

Big data and advanced analytical capabilities are similarly important because digital technologies create value only when organizations can convert large volumes of fragmented data into actionable knowledge. Research indicates that big data adoption can contribute to organizational performance through mechanisms such as innovation, supply chain integration, and resilience [19]. Digital intelligence may also improve decision optimization by strengthening innovation capability and supply chain resilience, demonstrating that the relationship between technology and performance frequently operates through complementary organizational capabilities rather than through technology alone [20]. At the same time, digital integration capabilities depend on the effective connection of information and communication technologies across organizational processes and supply chain partners. Their performance effects can be influenced by organizational perceptions, managerial constraints, and the wider institutional environment [21]. Therefore, investment in technology without corresponding integration, analytical capability, organizational readiness, and decision redesign may fail to produce substantial productivity gains.

The human and organizational dimensions of digital transformation are consequently critical. Digital technologies alter not only technical infrastructures but also managerial roles, employee competencies, decision rights, patterns of collaboration, and organizational culture. Successful implementation requires leadership commitment, digital literacy, continuous learning, employee participation, decentralized problem-solving, and a culture receptive to experimentation and change. Emerging Industry 5.0 perspectives extend this argument by emphasizing human–machine synergy rather than purely technology-centered automation, suggesting that superior organizational performance depends on combining computational capabilities with human judgment, creativity, contextual understanding, and adaptive decision-making [22]. Within energy-related supply chains, productivity strategies associated with Industry 4.0 similarly underscore the role of technological integration, intelligent operations, and management practices in improving energy and supply chain performance [23]. Accordingly, the productivity benefits of digitalization depend on organizational capabilities that allow technology to be adopted, interpreted, governed, and effectively embedded in operational routines.

Supply chain productivity is also inherently interorganizational. Oil and gas companies rarely control all resources and capabilities required for their operations; instead, they depend on extensive networks of suppliers, contractors, logistics providers, technology partners, distributors, and customers. Productivity at the focal-firm level can therefore be constrained by poor coordination elsewhere in the network. Information asymmetry, fragmented planning, adversarial contracting, delayed communication, and low trust may generate inventory excesses, procurement delays, duplicated activities, and slow responses to disturbances. Conversely, supply chain integration and collaborative planning can improve information quality, synchronize decisions, and reduce uncertainty. Research linking digitalization to supply chain viability further indicates that certain digital and organizational practices may function as essential capabilities in dynamic environments rather than merely optional performance enhancements [24]. Thus, network coordination should be treated as a central component of an agile and digital productivity architecture.

The relationship between agility, digitalization, and performance is also increasingly examined through sustainability-oriented perspectives. Contemporary organizations are expected to enhance economic performance while simultaneously addressing environmental and social consequences. Sustainable supply chain management therefore integrates efficiency, resilience, environmental stewardship, stakeholder responsibility, and long-term value creation. Evidence suggests that sustainable supply chain practices can contribute to organizational performance when they are systematically incorporated into management structures and performance models [25]. Research has likewise highlighted relationships between sustainable marketing and supply chain productivity, reflecting the need to connect market orientation, resource efficiency, and responsible supply chain practices [26]. In energy-intensive sectors, these considerations are especially important because productivity improvements that disregard energy use, emissions, waste, or environmental risks may generate short-term efficiencies while undermining long-term organizational and societal performance.

Digital technologies can contribute to this sustainability agenda by supporting resource visibility, traceability, circularity, waste reduction, and more efficient resource allocation. Research addressing circular supply chains has emphasized the contribution of digital technologies to both sustainability and productivity by improving information flows and enabling more effective use and recovery of resources [27]. Similarly, digitally enabled agility has been incorporated into sustainable performance measurement frameworks, demonstrating the importance of evaluating not only conventional cost and efficiency indicators but also adaptive and sustainability-related outcomes [28]. Broader supply chain research has also shown that digital platforms can facilitate sustainable development pathways through improved connectivity, market access, information sharing, and structural coordination [29]. These developments suggest that future productivity models need to incorporate sustainability as a governing dimension rather than treating it as an external or secondary consideration.

A further challenge concerns the measurement and conceptualization of productivity itself. Traditional productivity assessment often focuses on ratios between inputs and outputs, cost efficiency, or technical efficiency. Such methods remain important, and advanced approaches such as cross-efficiency analysis, inverse data envelopment analysis, and productivity indices provide valuable mechanisms for evaluating resource utilization and comparing operational units [3]. In the petrochemical and energy context, productivity assessment based on approaches such as the Cost Malmquist Productivity Index has likewise demonstrated the relevance of systematic performance evaluation across energy supply chains [30]. Nevertheless, purely quantitative performance measures may not fully capture the dynamic capabilities that enable productivity under conditions of uncertainty. The ability to reconfigure suppliers, obtain real-time information, collaborate with partners, develop digital competencies, comply with changing regulations, and recover from disruptions can be difficult to represent through conventional efficiency indicators alone. This creates a need for conceptually broader models that explain not only the level of productivity achieved but also the organizational and technological mechanisms through which sustainable productivity is generated.

This issue is especially relevant to the oil and gas sector, where operational efficiency is closely intertwined with logistics continuity, technological reliability, risk exposure, and working capital. Supply chain optimization can improve cash flow and operational efficiency by reducing delays, improving inventory management, and aligning procurement and logistics activities with operational requirements [5]. Oil and gas supply chain strategies more broadly influence organizational performance through sourcing, inventory, logistics, supplier management, and coordination practices [7]. Literature on logistics transformation in the sector likewise emphasizes the importance of optimizing operational processes and reducing avoidable costs [4, 6]. These findings provide a strong basis for considering productivity as an outcome of mutually reinforcing operational, technological, relational, and governance capabilities.

Despite growing attention to digital supply chains, agility, resilience, sustainability, and productivity, important conceptual fragmentation remains in the literature. Many studies investigate individual relationships, such as digitalization and performance, big data and resilience, AI and efficiency, or agility and sustainable performance, without integrating these elements into a unified architecture. For example, research on digital supply chain capabilities demonstrates their capacity to mitigate disruptions and generate competitive advantage [12], while research on digitalization and resilient supply chain practices identifies important performance relationships [13]. Other studies emphasize the interaction between digitalization, innovation, and agility [9], or between analytics, integration, resilience, and organizational performance [19]. These contributions are individually valuable, yet they indicate that digital transformation operates through a system of interdependent capabilities rather than through a single technological pathway.

The same integration problem is evident within productivity research. Studies of industrial supply chains have identified multiple organizational, operational, and environmental determinants of productivity [2], while operations research approaches have highlighted the importance of optimizing resource allocation for productivity improvement [1]. In parallel, Industry 4.0-oriented research has connected energy and supply chain productivity to technological advancement [23], and AI–ERP integration studies have demonstrated the potential of intelligent systems to enhance production productivity [18]. Collectively, this literature suggests that a comprehensive productivity model should connect technological infrastructure with human capabilities, operational agility, interorganizational coordination, resilience, and governance rather than considering productivity as an isolated operational outcome.

Moreover, the institutional and geopolitical conditions surrounding the oil and gas sector make context-sensitive modeling particularly necessary. Global evidence cannot simply be transferred into environments characterized by extensive sanctions, restricted access to international technologies, volatile procurement channels, and elevated geopolitical risk. Supply chain sustainability under geopolitical uncertainty requires diversification, adaptability, strategic risk management, and the ability to redesign network configurations when conventional routes become unavailable [8]. At the same time, digital transformation itself may be constrained by institutional and cognitive barriers, illustrating that technology adoption is shaped by managerial and contextual conditions [21]. Therefore, understanding how oil and gas experts conceptualize the interaction among agility, digital capability, human resources, network coordination, governance, and sustainability can provide insights that are difficult to obtain through models imported from less constrained operating environments.

A comprehensive framework is thus needed in which digital integration and data-driven intelligence provide informational visibility and analytical capacity; human resource and organizational enablers create the leadership, competencies, and culture required to use these technologies; operational agility and resilience convert these foundations into adaptive action; supply chain coordination and collaboration extend responsiveness beyond organizational boundaries; and governance and sustainability establish the rules, strategic orientation, security requirements, and long-term responsibilities within which the entire system operates. Such a systems perspective is consistent with the emerging recognition that supply chain viability, competitiveness, and productivity depend on combinations of capabilities rather than individual practices [24, 28]. It also reflects the transition toward digitally intelligent and human-centered organizational systems in which technological and human capabilities are complementary rather than substitutive [22].

Accordingly, the aim of this study was to design a comprehensive productivity model for an agile and digital supply chain in the oil and gas industry through thematic analysis of the perspectives and experiences of industry and academic experts.

2. Methodology

In terms of its purpose, this study is exploratory-applied, and in terms of its nature and methodology, it is qualitative. Thematic Analysis was employed to identify and provide an in-depth explanation of the components of the proposed model. This method was selected as an appropriate approach for addressing the research question because of its flexibility, transparent structure, and ability to identify meaningful patterns within rich qualitative data (Braun & Clarke, 2006). The study population consisted of all experts and specialists in supply chain management, logistics, and information technology within Iran's oil and gas industry, as well as relevant university faculty members. Purposive sampling was used, with the inclusion criterion of having at least 10 years of managerial or research experience in the relevant field. The sample size was determined upon reaching theoretical saturation in the eighteenth interview and consisted of 11 industry experts (4 senior managers and 7 logistics and technology specialists) and 7 university professors. The data collection instrument was an in-depth semi-structured interview. The interview guide was designed around five principal areas: (1) productivity indicators, (2) the definition and components of agility, (3) the role of digitalization, (4) implementation barriers, and (5) dimensions of a comprehensive model.

The average duration of each interview was 45 minutes. Following the acquisition of informed consent, the interviews were recorded and subsequently transcribed verbatim for analysis. Data analysis was conducted inductively, using a data-driven approach, based on the six-phase framework of Braun and Clarke (2006). These phases consisted of: (1) familiarization with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the final report. To enhance credibility and dependability, the coding and theme-generation processes were conducted independently by two researchers and subsequently compared, with disagreements resolved through discussion and consensus. NVivo software was also employed to manage the data and facilitate the coding process. The analytical process is presented in Figure 1.

Thematic Analysis

Thematic Analysis (TA) is a method for analyzing qualitative data and belongs to a family of approaches that focus on identifying patterns of meaning within a dataset. It involves the process of identifying patterns or themes within qualitative data. Braun and Clarke regard thematic analysis as a foundational method that provides core qualitative analytic skills. The fact that thematic analysis is primarily considered a method rather than a methodology represents an advantage from the perspective of learning and teaching. This means that, unlike many qualitative approaches, it is not inherently tied to a particular epistemological or theoretical perspective. This characteristic makes thematic analysis a highly flexible method, which constitutes a considerable advantage given the diversity of research conducted in educational and learning contexts.

In the present study, the six-phase framework proposed by Braun and Clarke (2006) was followed. This approach is arguably one of the most influential approaches, at least within the social sciences and management research, probably because it provides a clear and practically applicable framework for conducting thematic analysis.

The purpose of thematic analysis in this study was to identify themes—that is, patterns within the data that were important or noteworthy in relation to the research problem concerning supply chain productivity—and to use these themes to construct a conceptual model. This involves substantially more than merely summarizing information. A rigorous thematic analysis seeks to understand and interpret the data meaningfully and to position the findings within a coherent analytical structure. A common mistake is to use the main interview questions directly as themes. Typically, such an error indicates that the data have merely been summarized and organized rather than subjected to rigorous analysis.

Validity (Credibility) in Thematic Analysis

In this study, multiple strategies were employed to ensure the validity, or credibility, of the findings derived from thematic analysis. First, member checking was conducted by providing a summary of the extracted themes to a number of interview participants and obtaining their confirmation that the themes accurately reflected their perspectives. Second, the coding and theme-generation processes were independently conducted by two researchers and were subsequently compared; disagreements were resolved through discussion and consensus, thereby contributing to the internal consistency of the analysis. Third, in reporting the findings, selected verbatim excerpts from the interviews were presented as documentary evidence for each theme and subtheme, enabling readers to trace and evaluate the inferential path from the raw data to the abstract concepts. Fourth, a comprehensive and transparent description of the analytical process, from the interviews to the final model, was provided in the research method section, thereby enhancing the reproducibility and auditability of the study. Finally, analytical review was conducted by a reviewer familiar with qualitative methodology through peer debriefing. Collectively, these measures provide assurance that the identified themes constitute a credible and meaningful representation of the collected data and are appropriately aligned with the research question.

Reliability (Dependability) in Thematic Analysis

To assess and enhance the reliability, dependability, and consistency of the analytical process, emphasis was placed on procedural stability and transparency. The principal approach involved the use of the systematic and well-established framework developed by Braun and Clarke (2006), accompanied by a detailed step-by-step description of progression through each phase. To increase the objectivity of the coding procedure, the initial code list and theme matrix were systematically documented and retained. In addition, an intercoder agreement coefficient was calculated for a sample of the data, yielding a value greater than .80, thereby indicating an acceptable degree of objectivity and relative consistency during the initial coding stage. Furthermore, the researcher's reflexive notes, which documented the rationale underlying analytical decisions such as merging or separating themes, were maintained as an audit trail. These documents enable the review and tracing of the researcher's analytical reasoning. Overall, although the interpretive nature of qualitative analysis makes absolute replicability impossible, adherence to these procedures maximized transparency, procedural coherence, and traceability throughout the research process and ensured an appropriate level of dependability within the qualitative research paradigm.

Analytical Procedure

Braun and Clarke (2006) provided a six-phase guide that offers a highly useful framework for conducting this type of analysis (Figure 1). To gain a better understanding of the analytical stages, this framework is best considered in conjunction with a worked example. Throughout the analytical process, researchers move from one phase to the next; however, the phases are not necessarily linear. Researchers may move back and forth between them several times, particularly when dealing with large amounts of complex information.

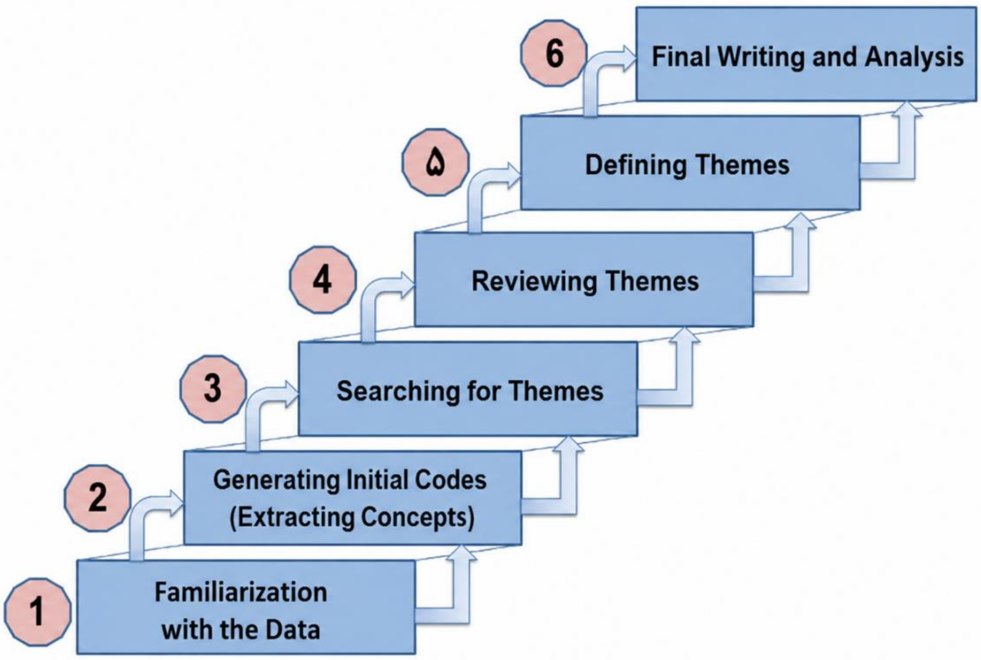

Figure 1. Braun and Clarke's Six-Phase Framework for Conducting Thematic Analysis

3. Findings and Results

Phase 1: Familiarization With the Data

The first step in any qualitative analysis is reading and rereading the transcripts. For example, in the present study, once the interviews had been conducted and transcribed, the transcripts were reviewed and reread to achieve familiarity with the data. Familiarization with the data was achieved by examining and recording statements derived from the interviews.

Before progressing further in the research process, researchers must become thoroughly familiar with the body of data or written transcripts, including all interviews. At this stage, taking notes and setting aside initial assumptions is useful because pre-existing assumptions can negatively influence the research process. Some of the preliminary and potentially inappropriate assumptions that could have been present at the outset of this study included:

- Digitalization simply means purchasing expensive software.
- Agility refers only to speed of action.
- A productivity model must necessarily be quantitative and numerical.

Phase 2: Generating Initial Codes (Extracting Concepts From Meaningful Statements)

At this stage, the data began to be organized in a meaningful and systematic manner. Coding reduces large volumes of data into smaller meaningful segments. Generating initial codes involves extracting preliminary concepts from the recorded meaningful statements. At this stage, the analysis focused on specific research questions and on examining the data in relation to those questions; therefore, every segment of data that was relevant to the research problem or appeared noteworthy in relation to the subject under investigation was coded. Open coding was used in the present study, meaning that no predetermined codes were established; rather, the codes were progressively developed and refined throughout the coding process. Once Phase 1 had been completed, preliminary ideas concerning potential codes emerged, such as "rerouting an oil tanker within 24 hours" or "AI-based failure prediction." The textual material was examined separately and subsequently organized. During the coding of each transcript, every segment of text that appeared relevant to the research topic was reviewed and coded. This process was conducted manually using Microsoft Word. Table 1 presents an example of expert identification coding, while Table 2 provides a concise example of initial code generation.

Table 1. Identification Coding of Experts

Criteria	Identification Code	Types/Categories
Field of activity	A	Industry (I), University (U)
Position	P	Senior manager (S), Expert (E), Professor (P)
Experience	Y	More than 15 years (H), 10–15 years (M), Less than 10 years (L)

Table 2. Brief Example of Initial Code Generation (Concept Extraction)

Meaningful Statement	Initial Code (Concept)
"We need to have a supply network across several countries; dependence on a single route means failure under sanctions."	Geographic diversification of the supply base
"An integrated dashboard displaying the real-time location of all shipments would transform decision-making."	Real-time operational information transparency
"Resistance among long-serving employees to new systems is the greatest barrier."	Cultural resistance to technological change
"Long-term contracts no longer work; they need to become agile and short-term."	Necessity of agile contracts

Phase 3: Searching for Themes

As previously stated, a theme is a pattern that captures something important, such as a meaningful aspect of the data, in relation to the research question. The phase of searching for themes involves exploring the data to identify subthemes that encompass one or more categories of extracted concepts, followed by the identification of main themes that subsume one or more subthemes. In the present study, several of the examined concepts clearly clustered within a particular theme. For example, several concepts or codes were related to the capability to respond rapidly and adapt to changing conditions; these were aggregated into an initial theme entitled "operational agility characteristics." Ultimately, following review, 5 main themes and 13 subthemes were identified. The preliminary structure is presented in Table 3.

Table 3. Identified Initial Themes and Subthemes

Subthemes	Examples of Related Initial Codes (Concepts)
Supply and procurement flexibility	Geographic diversification of suppliers; use of short-term and flexible contracts; ability to rapidly change logistics routes
Responsiveness and customization	Ability to rapidly adjust production quantity and quality; provision of services and products tailored to specific customer requirements; short response time to market requests
Resilience and proactive risk management	Establishment of strategic inventories of raw materials; scenario-based planning for sanctions conditions; simulation of disruptions and development of recovery solutions
Integrated digital infrastructure and platforms	Deployment of advanced and integrated ERP systems; development of a private cloud platform; integration of upstream and downstream data
Predictive and analytical intelligence	Use of artificial intelligence for equipment failure prediction and predictive maintenance; big data analytics for tanker-route optimization; simulation models for demand forecasting
End-to-end transparency and traceability	Real-time shipment tracking using GPS and IoT; inventory visibility in terminal storage facilities; use of blockchain to ensure the authenticity of commercial documents
Transformational and agile leadership	Senior management commitment to digital transformation; delegation of authority and decentralized decision-making; support for innovation and acceptance of calculated risks
Digital competencies and continuous learning	Implementation of digital skills training programs for employees; recruitment of personnel familiar with emerging technologies; establishment of a continuous learning culture
Agile and collaborative organizational culture	Promotion of trust and information sharing across organizational units; reduction of organizational silos and silo mentality; encouragement of teamwork and cross-functional collaboration
Strategic collaboration with suppliers	Development of long-term partnerships with key suppliers; information sharing and joint planning with business partners; collaboration in technology research and development
Customer integration and trust	Establishment of direct and transparent communication channels with end customers; sharing information regarding order status; continuous feedback collection and service improvement based on feedback
Adaptability to legal and security requirements	Ability to rapidly adapt to new international sanctions; compliance with stringent cybersecurity protocols; implementation of domestic regulations related to energy and the environment
Sustainability and green productivity	Reduction of carbon emissions in transportation and production operations; optimization of energy consumption in refineries and pipelines; responsible recycling and waste management

Phase 4: Reviewing Themes

This phase examines whether the developed subthemes adequately represent the concepts assigned to them and whether the main themes appropriately encompass the subthemes under their respective domains. During this phase, the initial themes identified in Phase 3 are reviewed, refined, and further developed. At this stage, the aggregation of subthemes into broader semantic domains leads to the formation of the main themes.

For example, "information technology" and "data analytics" were initially considered as separate main themes. However, after reviewing the themes, it became evident that these concepts represented components of a broader concept entitled "digital integration and intelligence." Similarly, the themes of "leadership," "culture," and "skills" were found to belong within a broader main theme entitled "human and organizational enablers." Ultimately, the final main themes were developed as presented in Table 4.

Table 4. Themes at the End of Phase 4: Final Structure

Main Theme	Subthemes	Initial Codes/Concepts
Operational agility and resilience	Supply and procurement flexibility	The ability to rapidly modify sourcing resources, logistics routes, and supply partners in response to external shocks and market fluctuations.
Operational agility and resilience	Responsiveness and customization	The capability to rapidly adapt the quantity, quality, and specifications of production and services to the specific and changing needs of domestic and international customers.
Operational agility and resilience	Resilience and proactive risk management	The capacity to anticipate, absorb, adapt to, and rapidly recover from major disruptions, such as sanctions and natural disasters, through planning and strategic reserves.
Digital integration and data-driven intelligence	Integrated digital infrastructure and platforms	The existence of an integrated technological foundation, including networks, cloud infrastructure, and software, enabling the smooth, secure, and reliable flow of data across all links of the value chain.
Digital integration and data-driven intelligence	Predictive and analytical intelligence	The use of technologies such as artificial intelligence, big data analytics, and simulation modeling to generate insights, predict trends, and optimize decision-making.
Digital integration and data-driven intelligence	End-to-end transparency and traceability	The ability to track in real time the location, status, and history of physical and informational assets throughout the supply chain, from origin to final destination.
Human resource and organizational enablers	Transformational and agile leadership	The presence of management characterized by a clear vision, facilitation of decentralized and rapid decision-making, support for innovation, and familiarity with the requirements of digital transformation.
Human resource and organizational enablers	Digital competencies and continuous learning	The possession and continuous enhancement of employees' technical, analytical, and cognitive skills for effective interaction with new and complex technologies.
Human resource and organizational enablers	Agile and collaborative organizational culture	The prevalence of an organizational culture based on trust, knowledge sharing, cross-functional collaboration, accountability, and adaptability to change.
Coordination and collaboration within the supply chain network	Strategic collaboration with suppliers	The development and maintenance of deep, long-term collaborative relationships based on mutual trust and transparency with critical and key suppliers.
Coordination and collaboration within the supply chain network	Customer integration and trust	Establishment of direct, transparent, and two-way communication with end customers to develop an in-depth understanding of their needs, coordinate plans, and increase satisfaction.
Governance and sustainability	Adaptability to legal and security requirements	The ability to adapt and act rapidly within complex domestic and international laws and regulations while maintaining high standards of cybersecurity and physical security.
Governance and sustainability	Sustainability and green productivity	Integration of sustainable development principles and social responsibility into the core strategy and operations of the supply chain, with an emphasis on reducing the carbon footprint and resource consumption.

Phase 5: Defining Themes

This phase represents the final refinement of the themes and aims to "identify the essence of what each theme is about." What does the theme convey? If subthemes exist, how do they relate to the main theme? What types of relationships exist among the themes? In the present analysis, agile and digital supply chain productivity is conceptualized as an overarching system rooted in the other themes.

This phase involves defining, clarifying, and establishing the conceptual boundaries of each identified main theme. The objective extends beyond naming and categorization to provide an operationally meaningful and comprehensive definition of the nature of each theme, the internal relationships among its constituent components or subthemes, and its role within the overall model. In this analysis, agile and digital supply chain productivity is conceptualized as an integrated and dynamic system whose existence and realization depend on the coordinated functioning and interaction of the five main themes. The final definition of each theme is presented below.

1. Operational Agility and Resilience

This theme refers to the dynamic and responsive capabilities of the supply chain when confronting uncertainty and disruption. Its central essence is not merely speed but rather the ability to detect change, respond rapidly and effectively, and recover to a stable state. This theme consists of three pillars: flexibility, referring to changes in inputs and routes; responsiveness, referring to adaptation of outputs to market requirements; and resilience, referring to the capacity to absorb shocks and return to normal operations. This theme represents the tangible operational output of the model and constitutes an objective criterion for assessing the success of transformation initiatives.

2. Digital Integration and Data-Driven Intelligence

This theme constitutes the technological backbone and information-processing nervous system of the model. Its focus is on establishing an integrated, intelligent, and transparent digital foundation that facilitates data flows, insight generation, and optimized decision-making throughout the supply chain. This theme comprises three layers: integrated infrastructure, including hardware and software; analytical intelligence, involving the transformation of data into knowledge; and traceability transparency, involving real-time visibility. This theme strengthens and enables operational agility; without it, responses would be slow and largely based on assumptions rather than evidence.

3. Human Resource and Organizational Enablers

This theme encompasses the soft, cultural, and competency-based foundations necessary to successfully guide and absorb technological and operational transformations. It emphasizes that technology and agile processes cannot be realized in isolation; rather, they require an organization that is prepared, effectively led, and appropriately empowered. This theme comprises three key components: transformational leadership, representing strategic commitment and direction; digital competencies, representing implementation-related skills; and an agile culture, representing beliefs and norms supportive of change. This theme functions as the driving force and facilitator for the adoption and effective utilization of the preceding two themes.

4. Coordination and Collaboration Within the Supply Chain Network

This theme emphasizes the quality of relationships and degree of integration with external partners, including suppliers and customers. From this perspective, productivity and agility are network-level and collective properties rather than exclusively internal organizational attributes. The theme emphasizes the need to move from traditional transaction-oriented relationships toward strategic collaboration based on trust and information sharing with key suppliers, together with direct and transparent communication with end customers. It extends the scope and effects of agility and digitalization beyond organizational boundaries and targets the efficiency of the entire supply chain ecosystem.

5. Governance and Sustainability

This theme defines the overarching framework, long-term objectives, and fundamental constraints within which the entire system must operate. It functions as both a compass and a balancing mechanism, ensuring that agility and digitalization are not achieved at the expense of legal requirements, national security, ethical considerations, or environmental commitments. This theme comprises two critical pillars: adaptability, referring to the ability to operate within complex and changing regulatory environments, and sustainability, referring to the integration of social and environmental responsibility into the core of the business. This theme ensures that the productivity model is not only efficient and agile but also responsible, secure, and sustainable.

Overall Relationship Among the Themes: Themes 2, digital integration, and 3, human and organizational enablers, function as the infrastructural and enabling layers that provide the necessary foundation for the realization of Theme 1, operational agility, and Theme 4, network collaboration, which constitute the core capability and value-creation layers. All of these levels operate under the overarching influence and direction of Theme 5, governance and sustainability, as the higher-order and guiding layer. This hierarchical-interactive relationship forms the overall agile and digital supply chain productivity model.

Phase 6: Final Writing and Analysis

The endpoint of research is typically some form of report. The phase of final writing and analysis involves preparing the final report derived from the thematic analysis and presenting the findings and final model.

Once the themes had been defined and the conceptual map developed, the researcher was able to prepare the final report. Based on the relationships among the themes, the final research model was developed as a three-layer structure, as illustrated in Figure 2.

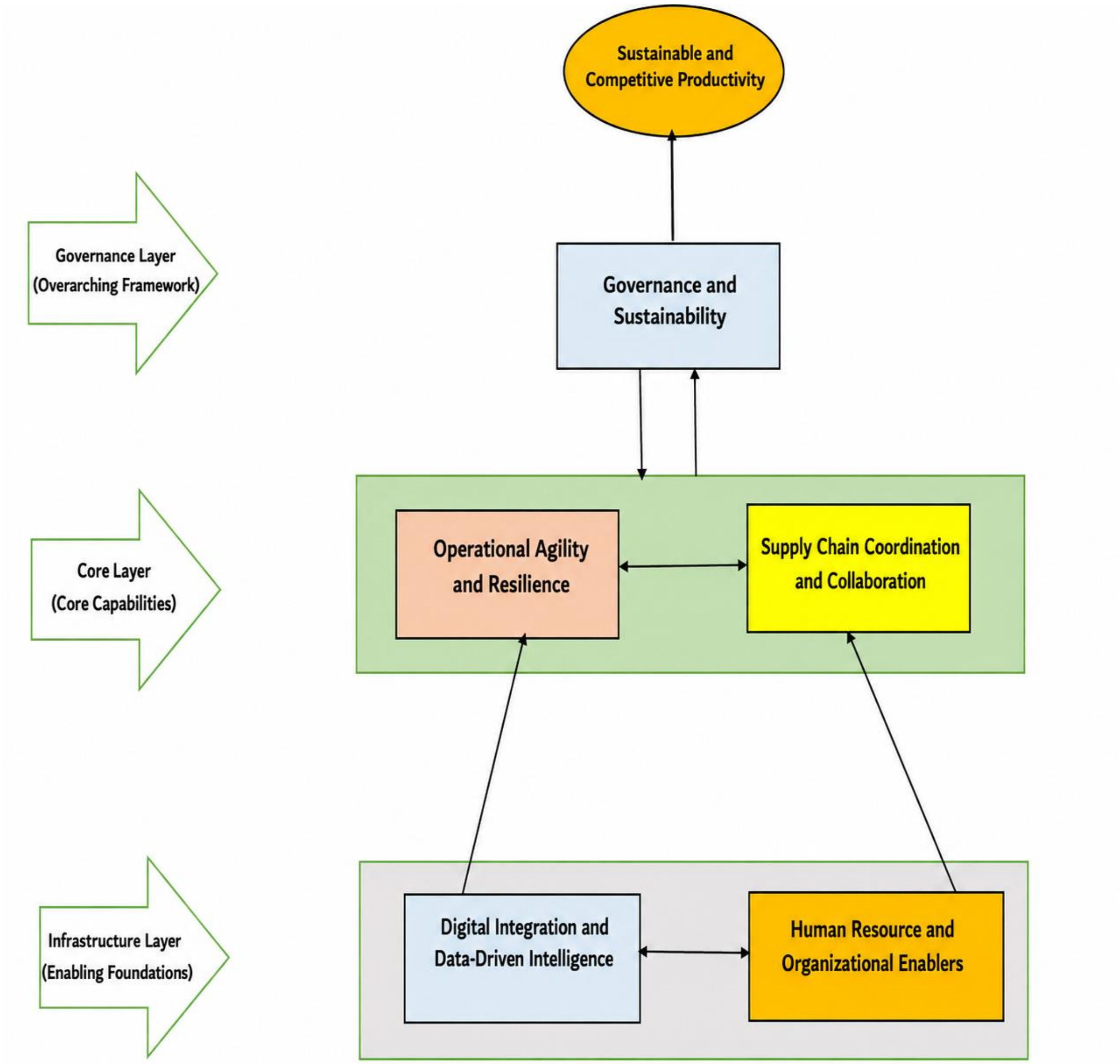

Figure 2. Final Research Model

The model demonstrates that Themes 2 and 3 function as the infrastructural layer, Themes 1 and 4 constitute the core capability layer, and Theme 5 operates as the governance layer. Through their interaction, all of these layers collectively produce the outcome of "sustainable productivity."

4. Discussion and Conclusion

The present study was conducted to design a productivity model for an agile and digital supply chain in the oil and gas industry through thematic analysis of expert perspectives. The findings resulted in a multilayer model composed of five main themes and 13 subthemes: (1) operational agility and resilience, including supply and procurement flexibility, responsiveness and customization, and resilience and proactive risk management; (2) digital integration and data-driven intelligence, including integrated digital infrastructure and platforms, predictive and analytical intelligence, and end-to-end transparency and traceability; (3) human resource and organizational enablers, including transformational and agile leadership, digital competencies and continuous learning, and an agile and collaborative organizational culture; (4) coordination and collaboration within the supply chain network, including strategic collaboration with suppliers and customer integration and trust; and (5) governance and sustainability, including adaptability to legal and security requirements and sustainability and green productivity. The overall structure of the model indicates that sustainable and competitive productivity is not generated by a single operational practice or technological intervention but emerges from the systemic interaction of technological, organizational, relational, operational, and governance capabilities.

The first main finding concerned **operational agility and resilience**, which represents the visible operational capability of the proposed model. The findings suggest that productive oil and gas supply chains must be able to rapidly change sourcing options, logistics routes, contractual arrangements, production quantities, and service specifications in response to environmental fluctuations. This result is consistent with studies that have conceptualized agility as a key mechanism through which organizations respond to uncertainty and maintain performance under changing conditions. Wang showed that supply chain digitalization can enhance agility and that organizational innovation is instrumental in converting digital investments into agile supply chain behavior [9]. Similarly, Ma reported that big data analytics capabilities can promote supply chain agility and performance by improving the ability to recognize and respond to dynamic market conditions [10]. The present findings therefore reinforce the view that agility should not be reduced to operational speed alone; rather, it involves flexible reconfiguration, responsive decision-making, and the capability to adapt supply and production structures to rapidly changing circumstances.

The resilience component of this theme is equally important. Participants emphasized strategic reserves, scenario-based planning, disruption simulation, and rapid recovery capabilities, indicating that supply chain productivity under turbulence depends on the ability to maintain continuity and restore operations after shocks. This interpretation corresponds with previous research showing that resilience is a central mechanism connecting organizational capabilities to sustained performance in disruptive environments. Nakandala demonstrated that supply chain robustness and disruption intensity are important determinants of resilience, particularly when firms face severe environmental disturbances [11]. Yadav similarly reported that resilient supply chain practices interact with digitalization to improve organizational outcomes [13]. Nayal also found that digital supply chain capabilities can mitigate disruptions and contribute to competitive advantage [12]. Consequently, the current findings suggest that resilience should be treated as a productivity-preserving capability: it reduces the operational losses, delays, and inefficiencies associated with disruption and thereby supports sustainable productive performance.

The second major theme, **digital integration and data-driven intelligence**, emerged as the technological backbone of the model. The findings indicate that integrated digital infrastructure, predictive analytics, and end-to-end transparency collectively create the informational foundation required for agile and productive decision-making. The importance of integrated platforms such as ERP systems, private cloud infrastructure, connected databases, and real-time monitoring systems reflects the need to eliminate information fragmentation across upstream, midstream, and downstream operations. This result is consistent with Tulli, who emphasized the role of digital transformation in ERP systems for enabling real-time analytics and improving decision-making in the oil and gas industry [14]. Jusoh likewise demonstrated that digital supply chain capabilities can contribute to business performance in the oil and gas sector by improving information flow, integration, and operational responsiveness [15]. These studies support the present conclusion that integrated information architecture is not merely an IT function but a strategic requirement for supply chain productivity.

Within the same theme, predictive and analytical intelligence emerged as a critical subdimension. Participants highlighted applications such as artificial intelligence for predictive maintenance, big data analytics for tanker-route optimization, and simulation models for demand forecasting. These findings are strongly supported by recent studies focusing on AI and advanced analytics in supply chain management. Orajaka and Orajaka found that artificial intelligence can enhance supply chain performance in the oil and gas sector by improving forecasting, decision quality, and operational efficiency [16]. Onukwulu similarly emphasized the role of automation and AI in increasing supply chain productivity within oil and gas operations [17]. Allahyar and colleagues also linked AI-based supply chain management and ERP integration to improvements in production productivity [18]. At a broader level, Kumar and Raj demonstrated that big data adoption influences performance through innovation, supply chain integration, and resilience [19], while Ma identified innovation capability and resilience as mediating mechanisms between digital intelligence and decision optimization [20]. These studies substantiate the current finding that the value of digital technologies derives primarily from their capacity to convert raw operational data into timely, predictive, and actionable intelligence.

The subtheme of **end-to-end transparency and traceability** further illustrates the role of digitalization in reducing uncertainty and coordination costs. Real-time shipment tracking, inventory visibility, IoT-enabled monitoring, and blockchain-supported document verification were identified as essential mechanisms for increasing supply chain visibility. Greater visibility allows managers to detect disruptions earlier, coordinate corrective action more rapidly, and improve accountability across organizational boundaries. Zhao and Liu found that supply chain digital integration capability is associated with improved firm financial performance, although its effectiveness can be shaped by contextual constraints surrounding digital transformation [21]. Similarly, Tetteh and Kwateng emphasized that digital practices can serve as essential pathways to supply chain viability in dynamic environments [24]. These findings align with the current model by demonstrating that transparency is a functional bridge between digital capability and operational responsiveness.

The third theme, **human resource and organizational enablers**, indicates that technological capability alone is insufficient for achieving sustainable supply chain productivity. The findings emphasize transformational and agile leadership, digital competencies, continuous learning, and an organizational culture characterized by trust, information sharing, collaboration, and openness to change. This result reflects the organizational reality that digital transformation requires corresponding changes in managerial behavior, employee competencies, decision-making structures, and cultural norms. Zhou's discussion of human–machine synergy in Industry 5.0 supports this interpretation by emphasizing that organizational value increasingly emerges from complementarity between human expertise and advanced technologies rather than from technology replacing human judgment [22]. Ahmadi and colleagues similarly linked energy productivity strategies in supply chains to Industry 4.0-related management practices and technological capabilities [23]. Therefore, the present findings extend digital supply chain research by positioning leadership, competencies, and culture as enabling conditions through which technological investments can be transformed into productive outcomes.

The importance of an agile organizational culture is particularly noteworthy because participants identified resistance to technological change and organizational silos as major barriers. The model therefore suggests that productivity improvements depend on reducing structural and cultural fragmentation. Digital integration may technically connect systems, but organizational silos can continue to restrict knowledge exchange, coordination, and decision speed. This interpretation is compatible with findings showing that innovation capability and supply chain integration are mechanisms through which digital technologies influence performance [19]. It is also consistent with Wang's conclusion that firm innovation shapes the relationship between supply chain digitalization and agility [9]. In practical terms, these findings imply that digital transformation programs should be accompanied by leadership development, reskilling, collaborative work structures, and mechanisms that encourage decentralized and informed decision-making.

The fourth theme, **coordination and collaboration within the supply chain network**, demonstrates that agility and productivity are not exclusively internal organizational characteristics. The findings emphasize strategic relationships with suppliers, information sharing, joint planning, technology collaboration, customer integration, and continuous feedback. This network-level perspective is highly relevant in the oil and gas sector because focal companies are dependent on suppliers, contractors, logistics providers, technology firms, and customers for operational continuity. Onukwulu identified collaborative and optimized logistics practices as important for improving efficiency and reducing operational costs in oil and gas supply chains [4]. Jaradi and Ayadi likewise emphasized logistics and supply chain efficiency as central determinants of performance in the sector [6]. Ogbaini also showed that supply chain management strategies are associated with the performance of oil and gas companies [7]. These studies support the present finding that productivity is produced through coordinated network relationships rather than solely through internal optimization.

Supplier collaboration may be particularly important under sanctions and geopolitical uncertainty, because organizations require alternative sourcing mechanisms, trusted partnerships, joint problem solving, and flexible contractual arrangements. The finding that geographic diversification and collaborative supplier relationships contribute to supply chain productivity is consistent with the broader argument that geopolitical factors strongly affect oil prices and supply chain sustainability [8]. In unstable environments, dependence on a limited number of supply routes or suppliers can increase vulnerability and reduce negotiating and operational flexibility. The present results therefore suggest that supplier relationship management should combine long-term trust with sufficient network diversification to preserve adaptability.

The fifth theme, **governance and sustainability**, emerged as the overarching layer that directs and constrains the operation of all other dimensions. Participants stressed compliance with domestic and international regulations, adaptation to sanctions, cybersecurity, physical security, environmental responsibility, carbon reduction, energy efficiency, and responsible waste management. This theme indicates that productivity should not be conceptualized solely as economic efficiency. Rather, sustainable productivity requires organizations to achieve operational efficiency while maintaining legal compliance, security, environmental responsibility, and long-term viability. Bagherpasandi and colleagues demonstrated that sustainable supply chain management practices can improve organizational performance when incorporated into an integrated performance model [25]. Litoui and colleagues likewise identified a relationship between sustainability-oriented management and supply chain productivity [26]. These findings correspond closely with the present model by suggesting that sustainability is an intrinsic component of long-term productivity rather than an external constraint.

The subtheme of **green productivity** is further supported by studies emphasizing the role of digitalization in improving circular and sustainable supply chain performance. Arabioon and Malayeri highlighted the contribution of digital technologies to circular supply chain sustainability and productivity [27]. Ramos also demonstrated that digital technologies and supply chain agility can be incorporated into sustainable performance measurement systems, indicating that agility, digital transformation, and sustainability should be considered jointly rather than independently [28]. Wang's analysis of sustainable development pathways in digitally enabled supply chains likewise supports the view that technological integration can contribute to environmental and economic sustainability simultaneously [29]. These findings reinforce the present study's conceptualization of sustainability as a governing orientation shaping how productivity gains should be achieved.

The overall structure of the proposed model is perhaps the most important contribution of the study. The findings indicate that **digital integration and data-driven intelligence** and **human resource and organizational enablers** constitute the foundational layer; **operational agility and resilience** and **supply chain coordination and collaboration** represent the core capability layer; and **governance and sustainability** function as the higher-order guiding layer. This hierarchical-interactive configuration implies that digital infrastructure and organizational readiness provide the conditions for agile operations and network collaboration, while governance ensures that these capabilities are exercised within acceptable legal, security, and sustainability boundaries. The interaction of all these dimensions ultimately produces sustainable and competitive productivity. This systemic interpretation is compatible with Tetteh and Kwateng's argument that supply chain viability in dynamic environments depends on combinations of digital and organizational practices [24]. It also corresponds with evidence that performance effects from digitalization are mediated through agility, innovation, resilience, and integration rather than arising automatically from technology adoption [9, 19, 20].

The model also expands conventional understandings of productivity measurement. Traditional productivity analysis often emphasizes efficiency ratios or quantitative performance indices. Such approaches remain valuable, as demonstrated by Liu and Chan's application of cross-efficiency analysis and inverse DEA models to supply chain efficiency [3] and Karampour and colleagues' evaluation of energy supply chain productivity through a Cost Malmquist Productivity Index [30]. However, the findings of the present study indicate that productivity under dynamic conditions also depends on qualitative and capability-based factors such as digital readiness, leadership, cultural adaptability, resilience, collaboration, and governance. Thus, quantitative productivity measures may explain the level of observed efficiency, whereas the present model contributes to explaining the organizational architecture through which such efficiency can be generated and sustained.

The findings are also consistent with research emphasizing the relationship between supply chain optimization and financial and operational outcomes. Roshan reported that supply chain optimization can improve operational efficiency and cash flow in the oil and gas sector [5], while Mirzaei and Bagheri emphasized productivity improvement through optimized resource utilization and operations research approaches [1]. Radfar and colleagues similarly identified multiple determinants of productivity in industrial supply chains [2]. The present study integrates these perspectives by suggesting that efficient resource utilization should be embedded within a broader dynamic capability framework that incorporates digitalization, agility, resilience, organizational readiness, network coordination, and sustainability.

This study has several limitations that should be considered when interpreting its findings. First, the qualitative design was based on the perspectives of 18 experts, including industry practitioners and academics, and although theoretical saturation was achieved, the findings remain context-dependent and may not represent all segments of the oil and gas industry. Second, the study was conducted within the specific institutional and operational environment of Iran, where sanctions, regulatory conditions, procurement constraints, and technological access may influence expert perceptions in ways that differ from other oil-producing countries. Third, the thematic analysis relied on participants’ experiences and interpretations rather than direct longitudinal observation of supply chain performance, and therefore the proposed relationships among themes should be understood as conceptual rather than causal. Fourth, although independent coding, intercoder agreement, member checking, peer debriefing, and an audit trail were used to strengthen the trustworthiness of the analysis, qualitative interpretation inevitably involves researcher judgment. Finally, the proposed model has not yet been tested quantitatively in terms of construct validity, relative importance of dimensions, causal pathways, or predictive power for objective productivity indicators.

Future studies should quantitatively validate the proposed model using large samples of managers, supply chain specialists, technology experts, and operational personnel across upstream, midstream, downstream, refining, petrochemical, and distribution activities. Researchers could develop a standardized measurement instrument for the five main dimensions and 13 subdimensions and test its psychometric properties through exploratory and confirmatory factor analyses. Structural equation modeling could subsequently be employed to evaluate the direct and indirect relationships between digital integration, organizational enablers, agility, collaboration, governance, and sustainable productivity. Comparative studies across countries, public and private organizations, or different energy industries could determine the extent to which the model is context-specific. Longitudinal research could investigate how the proposed capabilities evolve during digital transformation programs and whether changes in these capabilities predict measurable improvements in cost, lead time, reliability, resilience, energy efficiency, or return on assets. Future studies may also examine moderating variables such as organizational size, sanctions intensity, supply chain complexity, technological maturity, environmental uncertainty, and regulatory pressure.

Oil and gas organizations should apply the proposed model as an integrated transformation framework rather than implementing isolated digital or operational initiatives. Managers should first strengthen foundational capabilities by integrating data platforms, ERP systems, real-time monitoring tools, analytics, and cybersecurity while simultaneously developing digital competencies, agile leadership, decentralized decision-making, and a collaborative culture. These foundations should then be translated into operational capabilities through diversified sourcing, flexible logistics, scenario planning, strategic reserves, predictive maintenance, and rapid-response mechanisms. Organizations should establish long-term but adaptable partnerships with critical suppliers, create shared planning and information systems, and develop transparent channels for customer communication and feedback. Governance mechanisms should define clear responsibilities for digital transformation, risk management, data security, legal compliance, and environmental performance. Finally, performance assessment systems should combine traditional productivity indicators such as cost, time, asset utilization, and output efficiency with measures of resilience, agility, digital maturity, collaboration, carbon reduction, and resource efficiency so that productivity improvement is pursued as a sustainable and competitive organizational capability rather than as a narrow cost-reduction objective.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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