



A Pharmaceutical Incumbent's Resource Reinvention for Crisis Resilience

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Abstract

Consistent and continuous shocks across the world from pandemics to geoeconomic trade conflicts are posing existential challenges to even the most entrenched companies. The master's thesis examines how a top pharmaceutical incumbent, MGJ Group, weathered the COVID-19 pandemic, India's abrupt API export prohibition, and nascent US–China trade conflict. It determines the strategic responses that MGJ Group used to maintain its market competitiveness through intense supply-chain interruptions and market turbulence.

An extensive review of the literature synthesizes evidence from the Resource-Based View, the Dynamic Capabilities theory as updated by Barreto (2010), and recent crisis-management theory to underpin the theoretical context of the study.

Based on semi-structured interviews with MGJ senior executives and industry experts and rich secondary material, the author builds a detailed case study of MGJ Group's crisis recovery. Adaptations involved the rapid spin-out of its European API manufacturing business to localize strategic inputs, deployment of a real-time digital control tower to establish end-to-end supply-chain transparency, the fast development of dual-sourcing agreements and extended safety stocks, and redeployment of its single-use plant modular capacity. On aggregate, these actions allowed MGJ Group to absorb shocks, capture nascent opportunities, and reconfigure its resource base with unparalleled speed.

Findings highlight the critical importance of strategic adaptation - in tangible assets and routines of problem-solving - to maintaining enduring resilience. The thesis concludes with instructional notes that combine the review of literature and case information, enabling teachers to lead students through the MGJ Group case in courses in strategic management.

Title: A Pharmaceutical Incumbent's Resource Reinvention for Crisis Resilience

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Key words: Strategic Adaptation, Crisis Management, COVID-19 Pandemic, API Export Ban, Supply-Chain Resilience, Dynamic Capabilities, Resource-Based View, API Localization, Digital Control Tower, Dual Sourcing, Competitive Advantage

Resumo

Choques globais contínuos — de pandemias a conflitos comerciais geoeconômicos — têm imposto desafios existenciais até às empresas mais consolidadas. Esta dissertação de mestrado analisa como o Grupo farmacêutico MGJ enfrentou a pandemia de COVID-19, a proibição abrupta de exportação de IFAs pela Índia e o conflito comercial emergente entre EUA e China, identificando as respostas estratégicas adotadas para manter a competitividade em meio a intensas interrupções na cadeia de suprimentos e à turbulência do mercado.

A revisão da literatura combina a Visão Baseada em Recursos, a teoria de Capacidades Dinâmicas (Barreto, 2010) e conceitos recentes de gestão de crises, fundamentando o referencial teórico.

Com base em entrevistas semiestruturadas com executivos sêniores do MGJ e especialistas setoriais, além de fonte secundária, o estudo de caso detalhado mostra adaptações como a cisão rápida da unidade europeia de fabricação de IFAs para localizá-los estrategicamente; a implantação de uma torre de controle digital em tempo real para maior transparência na cadeia; o desenvolvimento ágil de acordos de duplo abastecimento e estoques de segurança ampliados; e o reuso da capacidade modular da planta de uso único. Essas ações permitiram ao MGJ absorver choques, aproveitar oportunidades emergentes e reconfigurar seus recursos com velocidade inédita.

Os resultados destacam a importância da adaptação estratégica — em ativos tangíveis e rotinas de resolução de problemas — para assegurar resiliência duradoura. A dissertação encerra com notas instrucionais que auxiliam professores a conduzir alunos pelo caso do MGJ em cursos de gestão estratégica.

Título: Reinvenção dos recursos de um operador farmacêutico para resistir a crises

Autor: Malte Langeloh

Palavras-chave: Adaptação estratégica, gestão de crises, pandemia de COVID-19, proibição de exportação de API, resiliência da cadeia de abastecimento, capacidades dinâmicas, visão baseada em recursos, localização de API, torre de controle digital, abastecimento duplo, vantagem competitiva

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List of Abbreviations

Abbreviation	Definition
AI	Artificial Intelligence
API	Active Pharmaceutical Ingredient
BTK	Bruton's Tyrosine Kinase
CDMO	Contract Development and Manufacturing Organization
CEO	Chief Executive Officer
COVID-19	Coronavirus Disease 2019
CPFR	Collaborative Planning, Forecasting, and Replenishment
DC	Dynamic Capabilities
DNA	Deoxyribonucleic Acid
ERP	Enterprise Resource Planning
EU	European Union
ESG	Environmental, Social, and Governance
FDA	Food and Drug Administration
GATT	General Agreement on Tariffs and Trade
GBU	Global Business Unit
I/O	Industrial Organization
IL	Interleukin
IoT	Internet of Things
IPO	Initial Public Offering
IT	Information Technology
MRP	Material Requirements Planning
mRNA	Messenger Ribonucleic Acid

Abbreviation	Definition
PMO	Project Management Office
PESTEL	Political, Economic, Social, Technological, Environmental, legal
R&D	Research and Development
RBV	Resource-Based View
RNA	Ribonucleic Acid
SoS	System of Systems
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SWOT	Strengths, Weaknesses, Opportunities, Threats
US	United States
USD	United States Dollar
VSC	Vaccine Supply Chain(s)
VRIN	Valuable, Rare, Inimitable, Non-substitutable
VRIO	Valuable, Rare, Inimitable, Non-substitutable, Organization
WTO	World Trade Organization

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1 Introduction

1.1 Motivation and Problematization

“The greatest danger in times of turbulence is not the turbulence; it is to act with yesterday’s logic” (Drucker, 1980, p. 14).

The COVID-19 pandemic has not only reshaped public health priorities worldwide but has also initiated unprecedented disruptions in supply chains and consumer behaviour. Nowhere is this more evident than in pharmaceutical sectors, where sudden demand swings and extreme logistical congestion forced companies to reassess their strategic operations. Such unprecedented shifts indicate not only short-term crisis effect but also a lasting effect on industry resilience.

Seminal studies carried out by Pettit et al. (2013) and Wenzel et al. (2020) point out that resilience is not achieved through shock absorption but through adapting operations in an agile and responsive manner. Agile strategies such as regionalizing supplier bases, speeding digital transformation, and employing flexible production processes have enabled firms to quickly adjust their sourcing, production, and distribution processes to meet fast-changing demands (de Montgolfier et al., 2020). Supplementing such crisis management measures, both Dynamic Capabilities (DC) and Resource-Based View (RBV) theories provide a sound theoretical framework for explaining how firms can establish sustainable competitive advantage in a crisis. Based on the RBV, a firm’s unique pool of resources is ranging from specialized knowhow to brand name and inimitable production processes can be a strategic resource and, in misalignment, a crisis liability. At the same time, dynamic capabilities which are ranging from perceiving new opportunities and dangers to capturing favourable opportunities and converting internal resources play a crucial role in converting such unique resources to suit turbulent market environments (Barreto, 2010; Danneels, 2011). Fundamentally, while the RBV focuses on firm-specific resources, DC focuses on a need for flexibility and rapid strategic renewal. Taken collectively, then, such theories point to a synergy between a firm’s resource pool and dynamic ability to adapt being essential to building supply chain resilience.

1.2 Expected outcome of the thesis

The primary research aim of this thesis is to investigate how companies in the pharmaceutical sector have reconfigured their business strategies to build resilience during and after the COVID-19 pandemic. This study will critically examine the transformation of supply chains through agile reconfigurations, digital acceleration, and innovative adaptation and assess how these changes interact with firm-specific resources and dynamic capabilities to sustain competitive advantage. To achieve this, the thesis will employ a case study approach that integrates interviews with industry experts and leaders with a robust review of contemporary literature, thereby offering both theoretical insights and practical guidance.

This research is supported by the most significant strategic-management conceptual frameworks and scholarship. Its core consists of an in-depth case study of MGJ Group¹, analysing the company's adaptive responses during times of crisis and companion teaching notes to help instructors incorporate the case into their courses in management. The final chapter summarises the study's limitations, condenses its main findings, and outlines future research directions.

2 Methodology

This research adopts a case study approach to explore how MGJ Group has strategically redrawn its operations and supply chain in response to unprecedented disruption from the COVID-19 pandemic. Employing frameworks from Dynamic Capabilities and Resource-Based View, the research determines how MGJ Group leveraged internal resources and flexible adaptation processes to develop resilience and continuity in response to global supply disruptions. A case study is a qualitative research method that looks at a single, unique context in real settings and requiring new qualitative data to achieve greater understanding of the firms past, present and future strategy and extensive research of the phenomenon (Crowe et al., 2011).

This study used a combination of primary and secondary data collection methods. Primary Data was sourced from ten interviews with a semi-structured design to gain a rich understanding of MGJ Group strategic responses to COVID-19. This sample included eight

¹ The name of the company has been anonymised for reasons of confidentiality.

members from MGJ Group strategy team and two external industry experts. A semi-structured design was selected due to a balance between being structured and flexible and being able to investigate different topics in detail while ensuring that important areas such as strategic decision-making, market foresight, and steps to adjust were always discussed (Adams, 2015).

Each interview, conducted through a video call, was 45 to 60 minutes in length, and respondents were requested to elaborate in detail on the impact and efficacy of MGJ Group strategic reforms. Once data collection was completed, significant interpretations were provided to respondents for confirmation to establish accuracy and to provide further clarification or detail on specific points.

Table 1: Anonymised Interview Overview (Own Figure)

Interview #	Date and Time Interview	Role of the Interviewee
1	February 26 th , 2025 – 14:30	Corporate Communications Head for Eurasia
2	February 26 th , 2025 – 16:00	Medical Manager
3	February 26 th , 2025 – 17:30	PMO Pharma Eurasia
4	March 3 rd , 2025 – 14:30	PPH Head Eurasia
5	March 3 rd , 2025 – 16:00	Immunology Franchise Head
6	March 3 rd , 2025 – 17:00	Head of Rewards & Performance
7	March 5 th , 2025 – 13:00	Launch Lead
8	March 5 th , 2025 – 16:30	Transformation Lead
9 - Expert	March 12 th , 2025 – 16:00	University Professor: International Political Economy

10 - Expert	March 14 th , 2025 – 17:00	Manager Supply Chain Infrastructure from Peer Group
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To keep information confidential and to protect participants' privacy, all interviews were anonymized. In addition, the name of the firm has been kept anonymous to prevent any possible competitive disadvantage and reduce the digital footprint.

Secondary data was sourced from a range of diverse sources, from market research to industry reports and internal MGJ Group documents. Not only were these sources providing background information, but they were utilized to corroborate and provide depth to information gathered from interviews. Industry publications provided detailed information on market trends, technological advancements, and competition, while internal materials such as strategic plans, finance reports and consultancy reports shed light on MGJ Group decision-making processes.

Transcriptions from interview audio recordings were originally transcribed using OpenAI's Whisper system to produce verbatim, exact records (Radford et al., 2023). These were then summarized to capture themes and insights into strategic actions by MGJ Group during COVID-19 disruptions. Summaries were systematically organized by interview questions and emerging themes to provide clarity into MGJ Group responses in comparison to broader industry trends. Interview insights were cross-checked with industry reports and company reports to triangulate the data and enhance credibility in findings. Objectivity was ensured by regular peer review of draft analysis, and key findings were cross-checked with secondary data to minimize bias and enhance study robustness.

There are a few limitations that need to be highlighted. The concentration on a single organization in the pharmaceutical industries for this case study could constrain generalizability of the findings to other industries. In addition, there is the risk of bias in the primary data collection process, with responses in the interview that constitute personal opinion or selective recall. To mitigate such issues, multiple sources of information were incorporated, and methods for triangulation were applied to make the findings more credible.

Overall, this methodological approach ensures a robust and nuanced understanding of the strategic dynamics at play in a rapidly evolving industry and provides valuable insights into the resilience and adaptability required to thrive in today's pharmaceutical sector.

3 Research Note

The research note includes the concepts and frameworks that students should ideally be taught before reading the case study. The concepts are essential for students to be able to answer the questions that are provided in the teaching notes. See Appendix A - E for additional theoretical depth.

3.1 Foundations of the Resource-Based View (RBV) in Strategic Management

Whereas scholars such as Porter (1980; 1985) emphasized the prominence of exogenous market forces, with reference to industry structure, competitive rivalry, and entry barriers, the Resource-Based View (RBV) redirects the discussion by postulating that the success of a firm is primarily contingent upon its internal resources and capabilities. Formulated originally by Wernerfelt (1984) and later developed by Barney (1991) and Peteraf (1993), the RBV argues that competitive advantage occurs when a firm uses a unique combination of assets (tangible and intangible) that are valuable, rare, difficult to imitate, and non-substitutable (VRIN). This internal emphasis is especially pertinent in the contemporary dynamic and rapidly changing business environment, in which firms are compelled to incessantly innovate either to achieve cost advantages or to deliver superior benefits to customers. Empirical studies have increasingly demonstrated the central role played by intangible assets such as human capital, brand equity, and organizational culture in sustaining firm performance (Kamasak, 2017; Molloy & Barney, 2015), and also suggested that tangible resources, in combination with intangibles, can be effectively used to augment competitive positioning (Galbreath & Galvin, 2008).

3.2 Resources: Tangible and Intangible

The core premise underlying the RBV is the contention that the success of a firm is accounted for in terms of the resources it holds and controls. Wernerfelt (1984) conceptualized resources as any asset that is a firm's strength or weakness, while Barney (1991) extended the definition to encompass all assets, capabilities, procedures, and knowledge that are relevant to the effective execution of the firm's strategy. Resources are generally categorized into two simple categories. Physical and financial assets such as technology, machines, real estate, and cash reserves are the tangible resources (Grant, 1991). These are quantifiable and recorded on the balance sheet of the firm. Tangible assets are easier to standardize and imitate and hence may create limited sustainable benefit in and of themselves. Intangible resources are non-physical

assets such as intellectual property rights, brand name, organizational culture, and proprietary knowledge (Ambrosini & Bowman, 2009; Molloy & Barney, 2015). Such assets take time to create, become deeply embedded in the firm's procedures, and are much more difficult to replicate (Barney, 1991). Although firms rarely compete based on any single intangible asset, the cumulative effect of multiple intangibles may create a distinctive competitive position (Sirmon et al., 2011).

3.3 The VRIN Framework

One of the key principles of the RBV is the VRIN framework providing a rigorous framework for evaluating whether a firm's capabilities and resources can create sustainable competitive advantage. According to Barney (1991) and Peteraf (1993), a resource needs to be valuable, rare, inimitable, and non-substitutable to create competitive advantage. For instance, a firm's brand reputation is valuable and rare but if the organization is not structured to be able to leverage the asset, the potential competitive advantage will be lost. The evaluative framework is now a valuable tool for both academics and practitioners and is applied in resource auditing and strategic decision-making to emphasize the fact that it is only the assets meeting such rigorous criteria that can be the source of sustainable competitive advantage (Barney, 1991; Teece, 2007; Peteraf & Barney, 2003).

3.4 Dynamic Capabilities (DC)

3.4.1 From the RBV to Dynamic Capabilities

Dynamic capabilities extend the resource-based view (RBV) by not only defining the means by which firms leverage valuable, rare, imitable, and non-substitutable (VRIN) resources, but also the means by which firms reconfigure and recombine these resources on a continuous basis, keeping competitive advantage alive even with turbulent and volatile markets. But the static nature of RBV is not sufficient for those environments of continuous change. Dynamic capabilities fill the gap by focusing on the means whereby firms renew, reconfigure, and even alter their resource base as a response to external change (Teece, Pisano, & Shuen, 1997; Helfat & Peteraf, 2003). This evolutionary perspective responds to the earlier criticisms of the RBV, i.e. the absence of a mechanism bridging resources with competitive advantage (Mosakowski & McKelvey, 1997; Priem & Butler, 2001a, 2001b).

3.4.2 Key Dimensions: Sensing, Seizing, Reconfiguring, and Transformation

At the centre of the dynamic capability's framework are several interconnected processes. Sensing is the structured scanning of the external world for opportunities and threats (Teece, 2007). Seizing is the rapid mobilization and deployment of resources with the aim of seizing emerging opportunities with flexible, market-driven decision making (Eisenhardt & Martin, 2000). Reconfiguring is the ability to reconfigure the firm's existing resource base integrating, reassembling, or abandoning assets to compete (Zollo & Winter, 2002). Transformation reflects the ability of the firm to reconfigure its resource configurations and core competences fundamentally in response to disruptive change (Eisenhardt & Martin, 2000). The process is not just an extension of everyday reconfiguration, but is rather deep, strategic renewal. Barreto (2010) introduced a refined definition, defining dynamic capability as "*the firm's ability to systematically resolve problems created by its tendency to sense opportunities and threats, make timely and market-driven decisions, and modify its resource base*" (p. 271). Not only does this multidimensional, collective approach capture the principal dimensions of sensing, seizing, reconfiguring, and transformation, but it also rejects the reductionism of a have it or not binary by recognizing that dynamic capabilities exist on a continuum.

3.4.3 Dynamic Capabilities as a Mechanism for Crisis Adaptation

Barreto's (2010) problem-solving approach captures the potential of the firm for rapid, market-driven decision making that enables on-time redefinition of resources, hence competitive advantage even under extreme conditions. While the RBV highlights the importance of unique bundles of resources for competitive success, it is the dynamic capabilities that uncover the processes of evolving these resources over time. During crisis, the alignment of dynamic capabilities with agile operational systems, such as Agile Supply Chain Management, is critical. Agile supply chains show the power of rapid reconfiguration of resources, facilitated by dynamic capabilities, for enhancing responsiveness and flexibility. The alignment not only strengthens the theoretical linkage of resource-based advantages with dynamic adaptation but also provides practical guidance for handling disruptions in extremely volatile environments (Christopher & Peck, 2003).

3.5 Supply Chains

3.5.1 Different Perspectives on Supply Chains

Beamon (1998) has defined a supply chain as “*a structured manufacturing process wherein raw materials are transformed into finished goods, then delivered to end customers*” (p. 283).

Supply chains can be conceptualized in at least three ways: as a logistics network, a sequence of processes, and an engineered system (Simchi-Levi et al., 2008; Jacobs & Chase, 2018). When conceptualized as a logistics network, the supply chain is a network of nodes such as suppliers' facilities, manufacturing facilities, warehouses, and retail outlets connected by physical or virtual links, such as transport, information, and financial networks (Simchi-Levi et al., 2008; Jacobs & Chase, 2018). In the process view, the supply chain is a series of interrelated processes and flows product, information, and cash flows within and between organizations. They are customer order, replenishment, manufacturing, and procurement cycles (Chopra & Meindl, 2007; Jacobs & Chase, 2018; Coyle et al., 2017). Finally, as an engineered system, the supply chain is represented as a complex, integrated system with defined boundaries. This perspective emphasizes that modern supply chains involve numerous entities linked by strong relationships and advanced technologies into a highly integrated system of systems (SoS) (Simchi-Levi et al., 2008).

3.5.2 Nature and Causes of Supply Chain Disruption

In the last several years, supply chains have become increasingly susceptible to disruptions due to globalization, lean inventories, and absence of redundancies (Ivanov, 2020).

Disruptions are defined as disturbances to the regular flow of goods and services caused by failures at the nodes or links of a supply chain. These failures may be due to natural disasters, geopolitical uncertainty, surges in demand, quality failures, or abrupt regulatory change (Simchi-Levi et al., 2008; Jacobs & Chase, 2018). Although risk events sometimes have beneficial consequences, their negative consequences are the focus here. A supply chain risk event is one that adversely impacts the ability to deliver customer orders on time, threatens life or safety, or otherwise prevents the achievement of expected performance outcomes (Ivanov, 2020).

3.5.3 Strategies for Mitigating Disruptions

To explain and address disruptive events, researchers suggest the identification and categorization of potential risks. Solutions vary from building buffer inventories, developing diversified supplier bases, enhancing supply chain visibility, and developing contingency plans such as dual sourcing or backup logistics channels. Such preparations in advance are required to provide shock absorption and continuity in situations of high uncertainty. A systemic approach, as suggested by several authors, is necessary to address large-scale disruptions and build resilience across the supply chain (Ivanov, 2020).

3.6 SWOT

The SWOT approach is noted to be one of the longest-serving and most used strategic-planning tools, valued for being easy to use yet potent in assessing an organisation's capabilities and limitations in terms of resources, opportunities, and external threats to prospects (Thompson et al., 2007; Puyt et al., 2023). By consolidating factors in four quadrants (Strengths, Weaknesses, Opportunities, and Threats) it allows businesses to chart internal resources like proprietary know-how or intangible talent that grant competitive edge, as well as internal deficiencies that negatively impact performance (Gürel & Tat, 2017). At the same time, external analysis pinpoints areas for expansion in new markets, advanced technology, regulatory changes that as well as risks like declining economics or rising competition (Gürel & Tat, 2017). This dual perspective informs organisations about which capabilities and resources likely represent sources of lasting advantage, and those that need to be bolstered or divested. Most importantly, SWOT is not an isolated one-time task but an ongoing aspect of strategic management, requiring ongoing surveillance both of internal processes and the wider competitive landscape to ensure that strategy remains in tune with unfolding realities (Pickton & Wright, 1998). Its impact is also increased when combined with qualitative and quantitative techniques such as internal benchmarking, competitor analysis, and scenario planning in order that conclusions drawn from a SWOT matrix can be tested and enriched using data-driven approaches. Finally, an effectively conducted SWOT analysis allows organisations to exploit their strengths, address their weakness, exploit new opportunities, and guard against pending threats in an orderly, evidence-based fashion.

3.7 PESTEL Analysis

PESTEL, divides the macro-environment along six inter-related areas, offering managers a structured system for anticipating future risks and opportunities (Akbalık & Çitilci, 2019).

Political considerations include governmental stability, regulatory mechanisms, tax regulations, trade regulations, and public initiatives. In highly regulated industries like pharmaceuticals, shifts in health-care reimbursement, patents, or export controls have dramatic impacts on cost structures as well as on access to markets (Rahman & Mishra, 2023).

Economic indicators encompass gross domestic product growth, inflation, fluctuations in exchange rates, trends in interest rates, and consumer confidence. These factors have an influence on availability of capital, purchasing ability, and overall demand climate.

Social considerations include demographic changes, patient expectation, cultural orientation, and human dynamics. Within healthcare and life sciences, increased need for individualized treatments, an aging demographic, or increased concern for the environment can create new markets to pursue and make existing products obsolete (Yüksel, 2012). Technological factors range from incremental process advancements to disruptive breakthroughs: from digital "control towers" and automation to advances in bioprocessing and AI-based drug discovery. Companies that track such trends can shorten their time-to-market, reduce costs, and achieve first-mover advantages (Akbalık & Çitilci, 2019). Environmental considerations like sustainability requirements, carbon-pricing, resource constraints, and climate-based regulations have become focal for strategic planning. The firms must analyse their energy mix, emission profile, waste streams, and logistics in supply chains to satisfy stakeholder demands as well as to circumvent regulatory fines (Rahman & Mishra, 2023). Legal considerations embrace an array of local and foreign laws that regulate product safety, intellectual property, labour standards, and data privacy. Anticipatory legal monitoring guarantees compliance, reduces litigation risk, and informs market-entry or deployment-of-capital decisions (Pickton & Wright, 1998). PESTEL analysis is not an ad hoc endeavour, but part of an on-going capability built into governing processes.

3.8 Active Pharmaceutical Ingredients (API)

APIs are the active pharmaceutical ingredients that deliver the therapeutic action of a drug, which are synthesized through multi-step chemical or biological processes and subsequently mixed with inert excipients to provide stability, delivery, and absorption (Kumar et al., 2022). Their manufacture is under strict regulatory and quality-control procedures in order to provide consistency, safety, and potency (Ternes & Joss, 2006). The international API market has moved away from Western manufacturers to Indian and Chinese cost-effective, large-scale facilities due to cost pressures and specialization in technology (Kumar et al., 2022). This geographical repositioning is challenging for ensuring affordable access and maintaining product quality particularly for developing regions demanding continuous monitoring of sustainability, quality, and pricing in every API segment (Kumar et al., 2022).

4 Case Study – Strategic Resilience in a Turbulent Pharmaceutical Landscape

Please note that the author will use abbreviated references, such as “I1” and “I2” instead of “Interviewee 1” and “Interviewee 2” and similar for reasons of readability.

4.1 Introduction: Global Pharma at a Crossroad

Over the past two decades, the pharmaceutical industry has witnessed dramatic change fuelled by constant innovation: global commerce grew from USD 113 billion in 2000 to USD 629 billion by 2019, driven by DNA - and RNA-based treatments following Covid-19 vaccine success and the coming of cell and gene therapies (Bain & Company, 2020; Stark et al., 2022). To reduce cost, firms transferred production of APIs and intermediates to regions of scale advantage; China and India now account for nearly forty percent of API-manufacturing sites and China supplies about eighty percent of volumes (Stark et al., 2022).

These gains to efficiency, however, have come at the cost of resilience. The Covid-19 pandemic ruthlessly revealed the vulnerabilities of hyper-globalized networks: global air cargo capacity collapsed by more than ninety percent in April 2020, large ports faced debilitating congestion, and borders shut down disrupted movement of raw material and finished dosage forms (Stark et al., 2022). Shortages followed: the U.S. Food and Drug Administration received 118 new drug-shortage reports for the month of August 2020, nearly half due to record-breaking demand surges for critical-care medications (Foster, Patel, & Skiba, 2021).

In addition to the immediate shocks of a global pandemic, supply chains must cope with a range of chronic strains: India's 2020 prohibition of 26 critical drug products, rising trade conflicts and anti-dumping tariffs pushing raw-material costs up to fifteen percent, and mounting public and investor demands to decarbonize energy-intensive syntheses and long-haul logistics (Kaltenbach, 2021). Faced with fast-changing technologies, unstable geopolitical environments, and expanding environmental pressures, leading healthcare organizations are compelled to change management paradigms.

4.2 Corporate Profile of MGJ Group

4.2.1 Evolution and Milestones

Since the last decade, MGJ Group's history is one of deliberate balance between disciplined organic development and acquisitions tailored to reshape its portfolio. In 2015, it booked annual revenues of €34.1 billion, roughly the same level through 2017 as some legacy products confronted patent losses and currency pressures. Since 2021, however, MGJ Group has seen significant turning point: revenue has grown from €37.8 billion to €43.0 billion from 2021 to 2022, fuelled by commercial success of novel specialty therapies combined with the boon of the euro exchange. Although 2023 sales came to stand at reported €43.1 billion, the underlying and indeed driving growth of 11 percent constant currency reinforced the reorientation of the company. Through 2024, revenues reached €41.1 billion, slightly off due to the carve-out of Consumer Healthcare, as MGJ Group refocused on vaccines and biopharmaceuticals.

Over this period, MGJ Group transformed its portfolio with hallmark deals. In 2016 it closed an epoch-defining asset exchange, trading Animal Health for a best-in-class consumer-healthcare company in a deal worth around €20 billion (I3). The transaction propelled MGJ Group to the world number one position immediately for over-the-counter medicine. In 2018, the company reinforced its pipeline of rare diseases by buying a Biogen spin-off focused on haemophilia therapies for \$11.6 billion and then added to this by consolidating a nanobody specialist for €3.9 billion, securing both rare haemophilia factor replacement and first-in-class nanobodies. Under new management in 2020 and 2021, MGJ Group pursued this bolt-on strategy again, acquiring an BTK inhibitor into its multiple-sclerosis portfolio translating its capabilities into its vaccine's portfolio, each for multi-billion-dollar valuations. In 2023, it bought BTK inhibitor for multiple sclerosis to give MGJ Group the first disease-modifying treatment for Type 1 diabetes, adding to its specialty care ambitions. And finally, the carve-out

to create MGJ Group Consumer Healthcare arm, at the beginning of 2024 was the culmination of ten years of portfolio refinement to establish MGJ Group as an innovation-led, pure-play vaccines and biopharma company.

4.2.2 Operating Model: Business Divisions & Global Footprint

Organizational structure at MGJ Group reconciles the independence of specialist units with the synergies derived from one corporate system. At the pinnacle is the CEO plus an efficient Executive Committee made up of the executives of four global business units (GBUs) together with main corporate functions of R&D, Industrial Affairs, Finance, and Human Resources. Each GBU has autonomous leadership of its own along with profit-and-loss responsibility, while common services for compliance, IT, and supply chains provide uniformity and efficiency throughout the company.

The Specialty Care GBU, covers innovative biologics as well as high-value therapies across immunology, neurology, oncology, and rare diseases. Vaccine production and development are covered by the MGJ Group Pasteur unit, using both legacy and next-generation platforms to deliver seasonal flu, paediatric vaccines, and pandemic-response vaccines. The General Medicines segment combines primary care assets, such as insulins, cardiovascular products, and established products subject to generic competition, with a focus on emerging-market brands. Until separation in 2024–2025 as previously planned, Consumer Healthcare marketed best-in-class over-the-counter products across pain relief, allergy, and nutritional supplements. The four-pillar framework, supported by global governance mechanisms as well as performance-based incentive systems, facilitates MGJ Group to drive focused growth initiatives with strict oversight of risk, ethical considerations, and sustainability.

Geographically, the footprint of MGJ Group extends to about 70 manufacturing locations and several R&D centres across Europe, North America, Asia, and emerging regions. About one-third of revenues accrue from the US, one-third from Europe, with the remaining portion from other regions such as China, Brazil, and sub-Saharan Africa. The global footprint not only diversifies the revenue streams of the company but also imbues product development, regulatory strategy, and commercial execution with local market expertise (I3). *“In Latin America, our local offices can green-light trials in under three weeks - no need to wait for head office.”* (I2). By balancing centralized strategy with regionally enabled teams, MGJ Group has

the capability to evolve quickly to changing healthcare needs, regulatory landscapes, and competitive forces globally.

4.2.3 Spotlight: Specialty Care - Role, Metrics & Strategic Imperatives

Its Specialty Care business has been the cornerstone of the company's transformation as an innovation-driven, biopharmaceutical firm, expanding over the past 10 years to account for nearly half of MGJ's biopharma sales in the form of first-in-class therapy for Type 2 inflammatory diseases. From launch in 2017, annual sales have accelerated from more than €2 billion to €10.7 billion in 2023 at a rate of compounded greater than 30 % following a "*pipeline in a product*" (I6) thesis in the company's acquisition of the asset, with approvals in six indications for atopic dermatitis, asthma, chronic rhinosinusitis with nasal polyps, eosinophilic esophagitis, and additional Type 2 immune diseases, alongside additional indications in late-stage development. Financially, Specialty Care reported 13.7 % constant-currency sales growth in 2023, compared with MGJ's mid-single-digit portfolio and operating margins over 30 %, double the company average. These margins have supported high-end R&D investment, with an estimated R&D intensity of around 18 % of sales by end-2024 (I6). Its deep pipeline now features nine mid-range assets aimed at €2–5 billion peak sales and three potential blockbusters over €5 billion, in addition to a next-generation BTK inhibitor, an IL-2 immunotherapy platform, and an advanced T cell engager. Improved Phase III-to-approval success and a one-wave launch plan, leveraging cross-functional teams and real-time dashboards helped its monoclonal antibody enter over 50 countries in two years, ahead of IL-4/IL-13 peers. The data-driven agility of leadership can be seen in weekly review of prescription trends, patient adherence, inventory turnover, and net promoter scores, enabling fast course corrections, and in collaborative arrangements for creating real-world evidence for the benefit of payers and health-system stakeholders (I2). With a view towards the future, Specialty Care occupies the central place in the Play-to-Win strategy of MGJ: maximizing value through stage-by-stage extension of labels and maintaining a cadence of major approvals beyond the company's established portfolio—making MGJ a high-margin, streamlined innovator poised for the decade to come (I1).

4.3 Building Sustainable Innovation

4.3.1 ESG Imperatives in Pharma

The environmental footprint of the pharmaceutical industry has become an issue of concern to regulators, investors, and civil society. Large quantities of solvent usage, high-energy chemical syntheses, and elaborate cold-chain logistics are responsible for high greenhouse-gas emissions (Stark et al., 2022). In response to this, stakeholders require transparent disclosure as well as concrete reductions in the intensity of carbon emissions. Some companies have attempted to decouple economic development from environmental footprint by restructuring process designs to be more atom-efficient, adopting solvent-recycling loops, and investing in renewable power generation at manufacturing sites. *“Solvent-use reduction is now a hard stop in project approvals - if you can’t show improvements, you don’t get funding.”* (I8). Redressing an industry founded on large-scale batch chemistry and global distribution is an uphill task, however (Stark et al., 2022).

4.3.2 The “Sustainable Futures 2030” Roadmap

In response to these needs, MGJ Group introduced *“Sustainable Futures 2030”* (I1) an enterprise-wide initiative that incorporates environmental metrics into every aspect of product development and manufacturing. New facility investments under this strategy are filtered through a green filter of carbon footprint, water usage, and waste production. The targets are to reduce process-related emissions by twenty percent by 2028 through upgrades to equipment, including energy-efficient distillation towers, as well as by increasing the proportion of electricity generated from on-site solar panels and wind turbines (I7).

4.3.3 R&D for Tomorrow

MGJ Group research laboratories integrate into the molecule-selection process green by design principles. Not only are synthetic pathways assessed based on yield and selectivity but also on solvent use, hazardous-waste profiles, and total mass intensity. Flow-chemistry platforms with high-throughput screening make possible rapid screening of scalable, low-waste process pathways, lowering solvent volumes up to half of those used by conventional batch operations (I4). In the case of the biologics segment, the company has adopted single-use bioreactor

technologies that avoid cleaning-validation cycles and save water and chemicals (Bain & Company, 2020).

4.3.4 Regional Tailoring

Addressing variability across regional regulatory and infrastructure environments, MGJ Group has implemented market-tailored programs. Within the European Union, where there is carbon pricing for high-emission facilities, the company has retrofitted one of its showcase fills-finish plants with heat recovery to run on 100 percent renewable power (Stark et al., 2022). In sub-Saharan Africa and some of Asia, the firm is testing mobile manufacturing units solar-hybrid, containerized manufacturing modules that quickly bring local capacity on-line with reduced land requirements and grid dependency (Stark et al., 2022).

4.4 Navigating Crises: Pandemic & Beyond

4.4.1 Covid-19 Shock

Early in 2020, the outbreak of SARS-CoV-2 brought on an unparalleled crisis for the pharmaceutical industry. *“On Day 1 of Wuhan’s lockdown, our primary API route vanished.”* (11). MGJ Group was faced with an unprecedented surge of demand for vaccines and critical-care treatments even as its global supply chains unravelled under competing pressures. Exports of key active pharmaceutical ingredients (APIs) came to an abrupt standstill with lockdowns in China and India, while global air-cargo availability dissolved by over 90 percent, more than quadrupling freight rates (Stark et al., 2022). Producing sites across the world were forced to operate with reduced staffing and tightly implemented social-distancing practices but still found themselves stymied by severe shortages of single-use bio containers and sterile filters inputs necessary to the manufacturing of biologics. Regulatory agencies acted at record speed to fill gaps, but the U.S. Food and Drug Administration alone recorded 118 drug-shortage notifications in the month of August 2020, nearly half caused by unexpected jumps in demand for anaesthetics, antivirals, and analgesics (Foster et al., 2021).

Apart from supply bottlenecks, MGJ Group development programs for the clinic similarly bore the brunt: travel limitations and site shutdowns threatened patient recruitment as well as continuity of established trials. However, by quickly putting into place telemedicine platforms as well as remote data-capture infrastructure, the firm was able to retain 98 percent of patients

enrolled in key studies - performance that other competitors failed to match (I2). In parallel, regulators at the country level issued serial updates of guidance on releases of lots, quality-control analysis, and emergency-use approvals, requiring manufacturing and compliance processes to be flexible at the level of near-real-time. Meanwhile, changing epidemiological patterns along with changing consumer habits from panic hoarding of over-the-counter cold reducers to sudden drops in elective-treatment prescriptions compelled MGJ Group to reprioritize on an almost daily basis to adjust its product offerings. All told, the COVID-19 shock was no mere supply-chain breakdown or trial disruption but an across-the-board system-wide stress test of MGJ Group global operations (Stark et al., 2022; Foster et al., 2021).

4.4.2 Rapid Response Playbook

As reports in the early-2020 period indicated Chinese lockdowns were curtailing API supplies, MGJ's 69-site, 32-country purchasing network faced the danger of falling short of intermediates for tens of essential medicines. Thankfully, six-twelve months' supplies of APIs were in inventory, buffering the immediate blow and enabling plants to produce uninterrupted (European Pharmaceutical Review, 2020). As MGJ's PMO Pharma Eurasia subsequently noted, "*We operated uninterruptedly throughout the pandemic at our production centres and at our warehouses.*" (I3). Realizing the reserves would not be a sustainable length of time, MGJ's buying team mobilized sourcing alternative API vendors in India and Europe, and shipping by chartered freighter and overland routes (European Pharmaceutical Review, 2020). When India subsequently imposed exports restraints on 26 APIs such as paracetamol, as well as critical antibiotics (Congressional Research Service, 2020), MGJ redirected stock throughout its global footprint, supplying stockpiles of antivirals and painkillers for the purpose of preventing stockout in individual patients while elective treatment volumes were scaled back. This was based on an unmatched cadence of communication and planning: MGJ's global CEOs met daily with officials and industry counterparts to exchange real-time insights on bottlenecks and pre-empt panic buying (I5). Supply-chain, procurement, and manufacturing staff, meanwhile, met by the hour in video briefings at the site level making last-minute adjustments in production schedules up to the minute as inputs became available and matched up with critical clinical demand (I1). With its newly implemented end-to-end planning system, MGJ redirected inventory from underutilized warehouses into high-priority hotspots, getting critical-care medicines into the hands of patients without delay (The Medicine Maker, 2021). As MGJ's

Eurasia's PPH Head stated, "*the pandemic underlined the value of combined demand planning for resilient operations*" (I4). Collectively, these strategies, strong stock cushions, flexible re-sourcing, accurate coordination, and combined planning preserved uninterrupted production and supply throughout the crisis (European Pharmaceutical Review, 2020).

4.4.3 Strategic Capital Expenditures

Soon after the outbreak of pandemic, MGJ Group stepped up EUR 500 million in investment in capital projects to increase production capacity for vaccines and biologics. Additional single use bioreactors were installed in European sites, with modular construction designed to cut commissioning times and avoid lengthy cycles for cleaning validation (I7). At the same time, modular fill finish suites were installed at key locations in Asia and North America, allowing for parallel scale-up to produce mRNA boosters without interfering with existing operations (Stark et al., 2022). These quick investments built worldwide surge capacity at a point when it was not feasible to wait months for fixed expansion capacities.

4.4.4 Contractual and Digital Supply

Acknowledging the constraints of spot buying, MGJ Group redesigned relationships with suppliers by putting in place flexible volume portfolio agreements with multiple tier 1 and tier 2 suppliers. These agreements ensured allocatable capacities that could be stepped down or stepped up depending on changing conditions, essentially establishing an array of on call resources. Concurrently, the company utilized a digital "control tower" platform that merged inventory levels, shipment status, and batch release metrics on one dashboard in real-time. "*Our AI forecast flagged a filter shortage five days out. We switched suppliers two days later.*" (I8). AI powered forecasting and shipment tracking powered by IoT enabled this to highlight upcoming bottlenecks days ahead of time and suggest mitigating measures, such as rerouting stock or expediting air charters (Foster et al., 2021). Further, MGJ Group increased its safety stock policy from an old pre pandemic standard of two to four months' supplies to 7.6 months by 2023, adding insurance against future world shocks.

4.4.5 Workforce and Operational Continuity

MGJ Group protected essential personnel and ensured unimpeded production with rotating shift teams augmented by in location rapid test centres. Cross training plans equipped workers to run

multiple production lines, establishing redundancy in critical skill sets and allowing for quick redeployment of human resources to areas affected by localized outbreaks. Remote monitoring tools for key process parameters insured real time quality control and compliance in situations where travel bans compromised in location oversight. Concurrently, the quick shift of 70 percent of office-based personnel to digital collaboration tools insured those strategic operations ranging from clinical trial management to executive management decision making operated without disruption (I7). Rigorous PPE procedures, social distancing, and “workforce bubbles” reduced infection risk and avoided plant wide quarantines, keeping lifesaving therapies in motion to treat patients across the globe.

4.4.6 Organizational Agility & Culture

In addition to these technical fixes, MGJ Group decentralized but highly interdependent company structure was invaluable. Regional teams were able to make high stakes, time-sensitive decisions in real-time such as re-routing API sourcing from Asia to an in-market European API manufacturing arm cutting lead times down to days from more than 50 (up to 112 days in periods of peak disruption). Leaders compared the company's manufacturing culture to that of a racing team pit crew: high intensity cross-functional choreography, swift problem solving, and an environment of constant improvement. Early missteps that are, communications breakdowns in the Corporate Communications department and misaligned incentivizing plans were used as learning points. Within weeks, streamlined processes and nimble review mechanisms fixed shortfalls, reaffirming that failure, if addressed openly and in a timely manner, is an innovation catalyst. Interestingly, cross-functional partnerships were plentiful: supply chain, R&D, clinical operations teams in Turkey sourced alternate APIs in combination, while digital, marketing, regulatory, and logistics units partnered to conduct successful virtual product launches.

4.4.7 Localizing API Production

In the immediate aftermath of the COVID-19 supply shocks, MGJ Group's leadership recognized that long lead times and concentrated sourcing of active pharmaceutical ingredients posed an existential risk. In February 2020, the company announced plans to spin off its European API manufacturing arm as a standalone entity whose sole mission would be to reinforce regional production capacity (I1). By bringing together six of MGJ Group's existing API sites across France, Germany, Italy, the United Kingdom, Hungary and the Netherlands

under this new structure, the arm immediately became Europe’s largest small-molecule API producer and the world’s second-largest overall supplier. Leadership appointed an experienced CEO to guide the venture from concept to independent operation, tasking her with focusing on complex, high-value ingredients whose production in Europe would yield both quality assurance and dramatically shorter, more reliable supply chains.

Over the ensuing two years, the European API manufacturing arm pursued targeted capacity expansions at key sites. In northern France, a century-old vitamin B₁₂ plant received process-engineering upgrades and a modern biomass boiler, substantially increasing output while cutting CO₂ emissions (I8). In Central Europe, a major prostaglandin facility underwent an equipment investment that doubled its output of these essential intermediates by 2027. Each of these projects received support from national recovery funds and underscored the public-private synergy behind the initiative (I1).

When the arm was spun off via an IPO on Euronext Paris in mid-2022, MGJ Group retained a significant shareholding and a long-term offtake agreement, ensuring both continuity of supply and alignment of interests. The proceeds and governance structure which included a strategic investment by a sovereign innovation fund validated the market’s confidence in the regional-sourcing model.

From a resilience perspective, the creation of the European API manufacturing arm slashed ingredient leads times from an industry average of 50–60 days (and peaks of up to 112 days during crises) to a matter of days for many proprietary compounds. This localization not only buffered MGJ Group’s own drug supply chains against future geopolitical or logistic disruptions but also positioned the arm as a contract supplier to other pharmaceutical companies, further deepening Europe’s self-sufficiency in critical drug components. In the words of MGJ Transformation Lead, *“By bringing API production home, we have created a resilient cornerstone that ensures patients across Europe and beyond always have access to the medicines they need, whenever they need them.”* (I8).

4.5 Geopolitical Disruptions & Trade Barriers

The contemporary pharmaceutical supply chain is an achievement of global integration, but this interconnectedness has become an acute vulnerability to geopolitical shocks (I9). In March 2020, as the SARS-CoV-2 pandemic unfolded, India - long the world’s leading exporter of

generic medicine - restricted exports of twenty-six critical APIs and finished drugs (e.g., paracetamol and common antibiotics), covering roughly 10 % of its shipments and exposing U.S./European dependence on Indian manufacture and India's reliance on China for about 70 % of API precursors, many halted by Chinese lockdowns (The Guardian, 2020). A single upstream or downstream break thus ripples across global supplies.

Even before COVID, the 2018–19 U.S.–China tariff war raised fears that essential drugs could become collateral in trade hostilities, though governments largely exempted finished pharmaceuticals (I10). Nevertheless, by 2025 over 80 % of Europe's antibiotic APIs still came from Asia, mainly China prompting eleven European health ministers to warn that three decades of lowest-cost sourcing had driven out local producers and left the region exposed to external shocks. MGJ Group's 2020 risk report identified reliance on Indian suppliers and Sino-Western decoupling as major threats warning that a regional export ban could trigger cascading shortages worldwide and management acted swiftly to rebalance the supply chain (I1). In February 2020, MGJ spun off six European facilities into an independent API subsidiary to mitigate Asian concentration risk and stabilize supply. This structural response onshored peptide intermediates, specialty corticosteroids, and high-potency small molecules shortening lead times and shielding the chain from potential future export restrictions or protectionism. As MGJ's Pharma Eurasia PMO noted, it would “*assure greater stability in delivering life-saving medicines to millions of patients*” (I3). China's early-2020 lockdowns further curtailed API output, causing downstream shortfalls and export restrictions elsewhere. MGJ's network of 69 sites across 32 countries could redirect some production, but shortages of critical single-use biologics inputs bioreactor bags and sterilization filters led to the creation of a cross-functional “*control tower*” to allocate scarce materials to priority medicines and emerging vaccines (I2). To bolster resilience, MGJ invested in a regional hub-and-spoke model enhancing North American and European hubs with upgraded fill–finish and formulation capabilities, supported by local spokes for packaging and distribution (I7) and increased safety stocks from four to over seven months, qualified multiple vendors per key input, standardized non-proprietary components for swift supplier switches and implemented real-time vendor-performance monitoring.

Crucially, MGJ engaged EU and U.S. policymakers to align its regional manufacturing expansion with emerging health-sovereignty efforts. This convergence of corporate planning and public policy underscores a new paradigm: reconciling international sourcing efficiencies

with the geopolitical necessity of regional diversification. “*EU open strategic autonomy and U.S. onshoring have redefined regional hubs as ‘must-have’ rather than ‘nice-to-have’*” (I9). Early-2020s export bans and tariffs thus exposed deep vulnerabilities in an over-concentrated pharmaceutical supply chain. MGJ’s European API spin-off, hub-and-spoke strategy, and proactive supplier diversification provide a blueprint for converting weakness into strength—ensuring uninterrupted patient access even amid severe geopolitical and public-health disruptions.

4.6 A Holistic Framework for Supply-Chain Resilience

While ad hoc reactions to emergencies cannot be avoided, prolonged resilience must be managed in an orderly fashion. MGJ Group adopted a four pillar approach which involves: end to end visibility, routine stress testing, mitigation of risk exposures, and governance for resilience (Foster et al., 2021). First, visibility is gained from an integrated digital backbone linking internal sites, CDMOs, and logistics partners so that lead times, temperature excursions, and inventory levels appear in real-time. Second, stress testing applies scenario planning simulation (digital twins) to gauge the impact of interruptions, ranging from natural disasters to cyber-attacks (Bain & Company, 2020). Third, risk reduction from exposure is gained by diversification across the network: multi sourced APIs by geography, just in time balanced with just in case inventory, and building key partners with capability in contingencies. Fourth, it is codified by means of chartered Risk and Resilience Committee, reviewing key metrics monthly and approving mitigation measures. “*We moved from reactive firefighting to proactive drill-and-practice.*” (I8).

These pillars have been supplemented by MGJ Group's examination of other forms of drivers for resilience like joint warehousing agreements, buying clearinghouses, and notification systems for regulators to achieve maximum risk-return without incurring the highest cost for end-to-end localization (Stark et al., 2022). By integrating all these strategies in one system, the company aims to ensure constant patient access, maintain cost discipline, and remain dedicated to the environment making their supply chains resilient to future shocks.

4.7 Tariffs and Import Bans - Navigating a New Protectionist Era

U.S. Section 301 tariffs of 7.5–25 percent were levied on Chinese chemical intermediates during 2018 and 2019 that go into antibiotic and antiviral manufacturing. On Europe’s

purchasers of APIs whose cost of these intermediates was US \$40 kg in 2018 15 percent cost pass-through represented additional \$6 kg, which is about \$300 million of increased input costs on a medium-sized 50-tonne capacity API plant (Kaltenbach, 2021). While the finished-dose forms were exempted on paper, ambiguity concerning excipient and reagent coverage caused manufacturers to include a 10–15 percent risk premium on all inbound inputs (I10). India's sudden export prohibition in March 2020 of 26 priority APIs and generic drugs such as paracetamol that represented 20 percent of global volumes nearly wiped out some 10 percent of global generic API exports in one night (The Guardian, 2020). The effects were seen with almost instant impact in Europe: pharmacies in Spain and Italy ran out of paracetamol syrup in just two weeks' time, and ciprofloxacin inventory in hospitals dropped more than 40 percent by April 2020.

By late 2022, Beijing's retaliatory threat against EU tariffs on electric-vehicle imports, potentially on lipid excipients to be used in mRNA vaccines, triggered another price shock. Though never put into practice, estimates based on hypothetical 10 percent tariffs on EU-originating biologics in markets in the United States projected that it would cost American health care systems \$3.7 billion annually (since 17.9 percent of EU pharma exports, or €366 billion in 2019, were to the United States) and put at risk \$2.8 billion of return exports from the United States to Europe. *“Each tariff point was a direct hit to our margin, so we ran ‘what-if’ simulations daily.”* (I7).

Aggregated together, these measures increased European API and excipient costs by an average of 12 percent (Bain & Company, 2022), lengthened lead times from 50 days to record peaks of more than 110 days in times of acute export bans and imposed delays of 0.5–1.0 month in vaccine fill–finish timetables vital where rapid deployment of mRNA boosters is called upon. Each percentage point of cost-of-input inflation eats into margins in low-margin generics (as often less than 10 percent net) and can equate to €2–3 billion of increased annual expenditure through EU health systems in the case of life-critical medicines (I10). It is against such measured context that European policymakers and industry CEOs have come to adopt selective onshoring and multi-sourcing strategies which were bolstered by stringent vulnerability analyses (Roades, Colvill, & McClellan, 2025) and WTO exception frameworks (Mitchell, 2025) to turn volatility of tariffs from a threat to life into a tolerable cost of doing business.

4.7.1 Vulnerability Assessments

Tariff-caused cost shocks propagate down production chains, destabilize prices, and depress R&D incentives. More importantly, tariffs focus risk: because one country dominates supply of a key API, often to historical cost arbitrage, any export stop in that country is a systemic risk (13). Roades, Colvill, and McClellan (2025) contend that policymakers need to conduct granular vulnerability analyses, tracing dependencies at the level of APIs and finished-dose products and estimating source-country shares and assessing alternative-supplier viability. They caution that blanket tariffs may increase shortages without enhancing resilience.

4.7.2 International-Legal Flexibilities

Under the WTO's General Agreement on Tariffs and Trade, two exception clauses allow trade-law compliance and support onshoring. GATT Article XX(b) the "*public health*" exception permits measures "*necessary to protect human ... life or health*" that do not operate as disguised trade barriers. Mitchell (2025) shows that production incentives specifically tailored to critical APIs may trigger Article XX(b) if they target proven shortage risks and remain proportional. GATT Article XXI(b)(iii), the "*security*" exception, allows measures "*taken in time of war or other emergency in international relations.*" "*GATT's public-health clause is now corporate playbook fodder, not legal footnote.*" (19). Mitchell (2025) writes that pandemics and acute geopolitical confrontations may be thought to be covered by the exception, supporting import-diversification mandates without WTO breach, subject to a visible nexus with the emergency and reasonableness in their national-security justification.

4.8 Europe's Strategic Countermoves and the Corporate Playbook

Europe's policy reaction converged in the Critical Medicines Act (put forward in March 2025) that infuses supply-security standards into public purchasing, provides strategic-project funding of onshore facilities to manufacture APIs, and requires joint Member-State tendering of critical medicines (European Commission, 2025). Capacity expansions in France, Germany, and Italy have been co-funded in state-aid waivers in anticipation of expected tariff spillovers in national recovery funds.

MGJ Group's July 2022 spin-off of its six European API facilities into a standalone entity Europe's largest small-molecule API manufacturer demonstrates the corporate playbook (MGJ

Group, 2022). The proceeds of the IPO supported capacity investments that reduced the lead times on most intermediates from more than 50 days to less than a week, shielded the business from extraterritorial taxes, and narrowed customs processing to a green lane preferred treatment (I5). In parallel, MGJ broadened its supplier coverage to ten geographies, ramped up safety-stock policies to seven months' cover, and synchronized risk-assessment tools with the vulnerability-mapping paradigm of Roades et al. (2025).

4.9 Outlook

Autonomy through divers with tariffs and trade bans setting the agenda in the political life of Europe, its pursuit of supply-chain resilience and strategic autonomy will be determined by bringing macro-policy design and nimble corporate implementation together. “*Digital twins, regional ‘friend-shoring,’ and ESG metrics will be table stakes by 2026.*” (I8). Using GATT exceptions, the performance of carefully designed vulnerability analyses, and investment in local capacity, Europe can turn trade-policy unpredictability into a de facto operational parameter thus ensuring unbroken patient access, strengthening its bargaining power, and setting an example of a resilient model of global health security in the face of accelerating global protectionism.

5 Teaching Notes

The next chapter is intended to provide instruction to teaching faculty on utilizing the case study in their courses.

Starting with a summary of the case study, including challenges and protagonists, this is followed by pedagogical intentions, related theory concepts such as a list of literature and ideas on how the case study can be integrated in a particular course. Furthermore, the process of analysis is proposed – including an outlined teaching approach as well as suggested time allocations for every segment. Lastly, an explanation of proposed case questions is presented as is an offer for case analysis with viable solutions. Please note that various methods exist for analysing the case study. The approach followed by this paper's author is limited to one potential way that teaching educators might employ this case study in class.

5.1 Synopses

MGJ Group, an biopharmaceutical multinational, gains competitive edge from a vertically integrated value chain, strong innovation capabilities, and tight relationships with major customers. Over 2020 to 2023, it weathered three concomitant industry-wide disruptions: the COVID-19 pandemic, which dramatically boosted demand for critically needed medicines and vaccines just as air-cargo space was cut, ports were logjammed, and manufacturing sites were working under social-distancing limitations; unexpected export regulations on active pharmaceutical ingredients in India and China, which challenged its just-in-time supply philosophy; and an emerging wave of ESG and decarbonization requirements that forced MGJ to revisit energy-intensive syntheses and long-distance cold-chain logistics.

As part of efforts to ensure business continuity and support its long-term strategy, MGJ Group deployed cross-functional coordination, operational agility, and selective strategic investments in R&D, manufacturing, and procurement. This is an instructive case for students to study in which an intricate pharma supply chain can leverage underlying capabilities, overcome nascent rigidities, and modify its strategic stance in response to multiple, simultaneous external shocks.

Students are encouraged to use Resource-Based View, Dynamic Capabilities, SWOT and PESTEL analysis, as well as crisis-response models, to analyse MGJ Group's approach and to extract wider lessons in strategic adjustment.

5.2 Pedagogical objectives

This case study is ideal for Bachelor's and master's students studying management, business, and economics. It is advised to be used as an in-class discussion case that allows students to showcase their knowledge about real-life situations along concepts of strategic management.

This case is structured to prepare students to apply analytical tools to connect theory to practice. The students will learn to use basic strategic management models like Resource-Based View and Dynamic Capabilities to real-life business situations, getting hands-on practice at diagnosing and solving real-world challenges. The students will study how companies develop and implement their strategies under stress, analysing the measures companies adopt in response to external shocks and crises.

Throughout their work on the case, students will also refine their skill in determining an organization's value drivers and identifying the capabilities and assets behind sustainable competitive advantage. Above all, they will realize that in fast-changing industries, adaptive agility, constant innovation, and conscious strategic renewal cannot be nice-to-haves but must become ingrained habits for sustaining and securing a company's competitive status in the marketplace.

5.3 Teaching Approach

It is anticipated that students will be introduced to the frameworks discussed in the Research Note in class before discussion on the case study. Students should read the case study before class and have noted down bulleted answers to questions to prepare for class activities to the best of their abilities. The lesson is structured on case study discussion mode involving group work as well as role play. The following guide is recommended:

1. Step: Introduction (10 minutes)

The lecture will start by providing an overview of the case study of MGJ Group, explaining the company's historical context, challenges in the present day, and strategic adaptation in response to industry broad change.

2. Step: Overview of Frameworks (10 minutes)

Although the structures were previously covered in class, the instructor should offer a Brief overview with slides emphasizing the most crucial features in relation to the relevant models.

3. Group Discussions: MGJ Group Board Meeting (30 minutes)

The students must be grouped in sets of 4-5 students because each set is to represent the board of MGJ Group. Each group is presented with a set of questions for the case (A, B, C and D – see table below). The questions below are based on the learned frameworks and ought to assist in making students better understand the application in relation to an actual case. Students should not just reflect on the details from the case but attempt to think about additional strategies, risks etc. that might be relevant to MGJ Group.

During class, all students will take on the role of an MGJ Group senior executive e.g. CEO, CFO, Supply Chain Heads, R&D Director or Sustainability Lead and address one of discussion questions from that role. In groups, they will discuss their allocated question from that role's point of view and make strategic recommendations within their function's priorities based on concepts they've learned

Recommended questions to teaching faculty:

Table 2: Recommended questions to teaching faculty (Own Figure)

<p>A. VRIN Analysis</p>	<p>Which resources can you identify that provide sustainable competitive advantage for MGJ Group according to Barney’s VRIN criteria? Imagine that a rival is eager to reproduce one of MGJ’s VRIN resources. Which three would they go after first and why is it so difficult to replicate or substitute each of them? Explain how MGJ can make these assets even more resilient.</p>
<p>B. Dynamic Capabilities:</p>	<p>What dynamic capabilities has MGJ Group built, and how have these processes influenced its response to recent disruptions? Using the Dynamic Capabilities framework, identify examples of how MGJ Group has sensed, seized, reconfigured, and transformed its resources and propose one strategic initiative to strengthen each of these four capabilities for future adaptation.</p>
<p>C. SWOT:</p>	<p>What are MGJ Group’s core strengths and weaknesses, and how do these internal factors influence its strategic approach to recent disruptions? Using a SWOT analysis, pinpoint the most significant external opportunities and threats, and propose one targeted strategic action for each quadrant to address weaknesses and threats and to leverage strengths and opportunities.</p>

<p>D. PESTEL Analysis:</p>	<p>For each of the PESTEL dimensions, list the two most significant macro-drivers, describe these drivers' strategic implications under both "business-as-usual" and crisis conditions, and outline concrete actions that the MGJ Group must undertake in order to handle risks, leverage opportunities, and enhance its competitive edge in the pharmaceutical sector.</p> <p>Drawing from your work on PESTEL, create a “Crises Addendum” that situates each of the three big disturbances COVID-19 pandemic, India API ban, and US–China trade tensions within the appropriate PESTEL drivers, summarizes their direct effect on MGJ operations, and provides an overview of the firm’s fast-response actions.</p>
<p>E. Supply Chain Management</p>	<p>Describe how MGJ Group's separation of its European API segment as a standalone entity, its increase in dual-sourcing and safety stocks, and its implementation of a digital control tower are manifestations of the network reconfiguration, redundancy and visibility enhancement strategies. In each of the tactics, give a tangible example and discuss why such moves maintained the operations of MGJ through the COVID-era API bans and resultant tariff shocks.</p>

4. Step: Case Debate (25 minutes)

The entire class needs to restart, and all groups need to present their board's strategy recommendations. The instructor is to promote a debate style where other students can challenge the approach outlined. This fosters higher-level thinking and reflection on more than one strategic angle.

5. Step: Application to Current Industry Development (10 minutes)

The instructor can update the class on some of the most recent trends in the pharma industry like nascent “health-sovereignty” regulations, AI-based demand forecasting, new onshoring

efforts for APIs by regions, or hardening ESG rules and challenge students to revisit their previous strategic suggestions considering these trends.

6. Step: Wrap-Up and Homework Assignment (5 minutes)

The educator summarizes important learning points and relates discussion to course objectives. The lecturer also thanks students for their participation and offers additional resources or readings for follow-up. The students can be asked to write as homework Paper on how they would apply as an MGJ Group's Board Member with respect to the discussions and current industry trends that they have learned about

Because the case allows for multiple teaching approaches, one alternative could be an immersive Crisis Simulation Workshop: students step into C-suite roles and react in real-time to successive “breaking news” shocks export prohibitions, cyber-attacks, ESG audits employing VRIN, Dynamic Capabilities, SWOT, and PESTEL tools. Students quickly write down early remedies, iterate in response to mounting tensions, and pivot to medium-term strategies for resilience in one session. This experiential modality anchors theoretical models in hands-on practice and sharpens quick, adaptive decision-making in uncertainty.

5.4 Analysis and Discussion

Question A - VRIN Analysis:

Which resources can you identify that provide sustainable competitive advantage for MGJ Group according to Barney’s VRIN criteria? Imagine that a rival is eager to reproduce one of MGJ’s VRIN resources. Which three would they go after first and why is it so difficult to replicate or substitute each of them? Explain how MGJ can make these assets even more resilient.

This question requires students to apply Barney’s Resource-Based View to analyse MGJ Group’s internal resources in relation to the VRIN criteria. Students should determine which resources support the company’s long-term competitiveness, examine the difficulty a competitor would have in duplicating or substituting each of the three assets selected, and suggest specific steps MGJ might take to increase the resilience of the selected resources. Through the exercise, students better understand the ways in which firms capitalize on unique resources, foresee threats from the competition, and reinforce their strategic position.

Analysis of question A:

Using Barney's VRIN lens across MGJ Group, three of its most powerful and hard-to-imitate assets come into focus. First, the newly spun-out European API production arm, grouping six legacy sites into a single governing structure. This asset is of great value in that it reduces lead times from months to days and shields MGJ from politically motivated export bans. It's uncommon: not many competitors have a network of modernized, regional API sites with hinged public-private investment and streamlined regs like it. Its inimitability lies in the huge capital outlay, decades of process know-how, and ingrained vendor relationships underpinning each facility. To reinforce this advantage, MGJ should codify a continuous improvement masterplan incorporating digital process twins and next-generation analytics while extending preferred-supplier co-investment deals to lock in capability and capacity over the next decade.

Second comes MGJ's real-time "control-tower" digital platform that tracks inventory levels, shipment status, regulatory batch release, and demand signals end to end across its network. The system is useful in crisis management, a rarity among its peers, and impossible to replicate due to its proprietary data algorithms, the depth of MGJ's historic supply-chain data, and its incorporation in corporation-wide decision forums. To make it more robust, MGJ needs to follow a tiered-access approach onboarding major contract-manufacturing partners to enhance the data feed and create a formal "data governance council" continuously refining its predictive models.

Third is the deep Specialty Care biologics franchise, anchored by a portfolio of first-in-class monoclonal therapies with potential to become blockbusters. Its strength lies in the high margin and premium positioning it provides; its rarity in terms of breadth of indications and worldwide launch rhythm; and its inimitability with the company's proven Phase III conversion history, extensive real-world evidence platforms, and embedded launch-excellence machine. MGJ can support this strength by forging long-term licensing and co-develop partnerships in high-growth markets (China, Brazil, for example) and by incorporating sustainability considerations into molecule design thus challenging any competitor to replicate the clinical and ESG aspects of MGJ's portfolio of biologics.

Question B - Dynamic Capabilities:

Referring to Barreto's framework, discuss how MGJ Group has exemplified (1) ability to sense opportunities and threats, (2) ability to make good decisions in a timely manner, (3) market-driven discipline in decision-making, and (4) ability to modify its resource base to respond to recent shocks. For each ability, state one tangible example of MGJ's response to the COVID period and a prospective strategic action which would reinforce the related capability.

This question requires students to map MGJ's crisis response mechanisms on to Barreto's framework. They first mark the places in which the firm's sensing radar detected repeated supply-chain shocks or nascent market opportunities; secondly map how it converted those signals into fast-moving and timely decisions; thirdly how it deployed market intelligence to discipline its resource redeployments; and lastly how it fundamentally reshaped its asset base. To conclude the exercise, students will suggest a forward-looking action that maximizes each propensity. In doing so, they learn to track the exact levers by which firms remain adaptable under uncertainty and craft strategic routines to effect ongoing renewal.

Analysis of question B:**Tendency to perceive opportunities and threats:**

When global API supply chains were first broken by COVID-19, MGJ Group's newly developed control-tower briefings and interindustry executive calls were instrumental: they picked up early warning signs of export bans, port shutdowns and raw-material constraints days ahead of peers scrambling to react. This was built on a rigorously maintained information-sharing cadence and the promotion of even small-scale anomalies to the C-suite radar. To add muscle to this sensing ability, MGJ will deploy an AI-based geopolitical horizon scanner constantly consuming trade-flow data, policy monitors and multilingual news feeds automatically marking up incipient supply-chain threats or opening market windows well ahead of normal intelligence loops.

Ability to make timely decisions:

MGJ's war-time response six months of API stockpiles redirected quickly on chartered ships, Tier-1 supplier contracts renegotiated in days, and a standby list of contract manufacturers mobilized jettisoned firefighting on a reactive footing to proactive supply-chain arbitrage. That

velocity was fuelled by pre-defined escalation procedures and cross-functional decision authority to eliminate any legal or commercial barrier to execution. To capture that advantage on paper, the firm ought to standardize "option-based" supply contracts conferring the right (not the obligation) to scale volumes against agreed terms, tying up surge capacity without ballooning fixed costs or committing MGJ to unnecessary take-or-pay obligations.

Discipline of Market-Driven Decision-Making:

Confronted by unpredictable patterns of demand in the pandemic era, MGJ modularized its fill–finish capabilities in both North America and Asia and cross-trained plant teams to redeploy capacity on a moment’s notice. By connecting real-time order data to production-line configurations, the company converted volatility into a margin lever. To make this market discipline stick, MGJ needs to construct a unified market-insights dashboard to combine customer analytics, competitor movement and inventory flows so planners can redeploy capacity with surgical accuracy and assure capacity is aligned dynamically to actual demand instead of fixed forecasts.

Ability to change the resource base:

The most fundamental makeover of MGJ was the spin-out of its European API business as a standalone unit, a maneuverer that realigned governance, freed up more than €500 million of strategic capital through an IPO and injected entrepreneurial adaptability into a previously centred operation. This visionary makeover rebooted the firm’s architectural DNA and emancipated it from legacy burdens. To maintain momentum on this engine of revitalization, MGJ ought to set up an internal Innovation Incubator tasked with testing containerized mobile API modules, next-generation single-use bioreactors and other revolutionary supply-chain prototypes--establishing a constant stream of fresh asset innovations competitors cannot anticipate or readily duplicate.

Question C - SWOT:

What are MGJ Group’s core strengths and weaknesses, and how do these internal factors influence its strategic approach to recent disruptions? Using a SWOT analysis, pinpoint the most significant external opportunities and threats, and propose one targeted strategic action for each quadrant to address weaknesses and threats and to leverage strengths and opportunities.

This question challenges students to perform a holistic SWOT analysis of MGJ Group by first analysing its internal strengths and weaknesses and then analysing the external world of opportunities and threats. Students should describe the way MGJ's inherent capabilities and constraints have determined its responses to current crises, then select the single most significant external opportunity and threat and suggest one tangible action for each of the four quadrants (strength, weakness, opportunity, threat) to reinforce or counterbalance them. By doing so, students learn to link internal evaluation with environmental scanning, rank-order strategic decisions, and develop workable initiatives that map organizational resources to changing market realities.

Analysis of question C:

Strength:

MGJ Group's globally integrated network backed by its newly spun-off European API business provides end-to-end control over raw material procurement, synthesis, fill-finish and distribution. This integration enhances speed and cost control and is supported by rich process know-how built over decades. Its Specialty Care business provides best-in-class biologics with blockbusters at stake, underpinned by a world-class R&D prowess (Phase III success rates in the top quartile) and a best-in-class capability for market-share capture post-launch in 50+ markets. Its in-house "control-tower" digital platform integrates real-time data across procurement, manufacturing, quality, and commercial teams to deliver razor-sharp decision-making in emergency situations. Lastly, MGJ's financial firepower (revenues over €40 billion, Specialty Care's 30%+ operating margins) provides the runway and appetite for taking significant risks to invest in capacity growth, green chemistries, and bolt-on buys.

Weaknesses:

That same worldwide scope brings organizational complexity and high fixed-cost architectures: more than 70 sites of manufacturing globally and legacy IT/ERP footprints can stifle transformation and escalate overhead. The spinoff of the API business last year, while strategically prudent, adds the risk of integration as it refocuses the organization and requires new routines of coordination. MGJ's revenue streams remain concentrated in a few blockbusters in the world of biologics, leaving it vulnerable to patent cliffs and biosimilar competition. While its digital platform ranks best-in-class, sections of the network most notably

legacy CMO partners remain blind to seamless connectivity to data, and blind spots in some geographies result. Finally, MGJ's significant focus on batch-scale chemistries means it needs to accelerate investment in continuous-flow and single-use technologies to remain in the forefront of regulation and sustainability requirements.

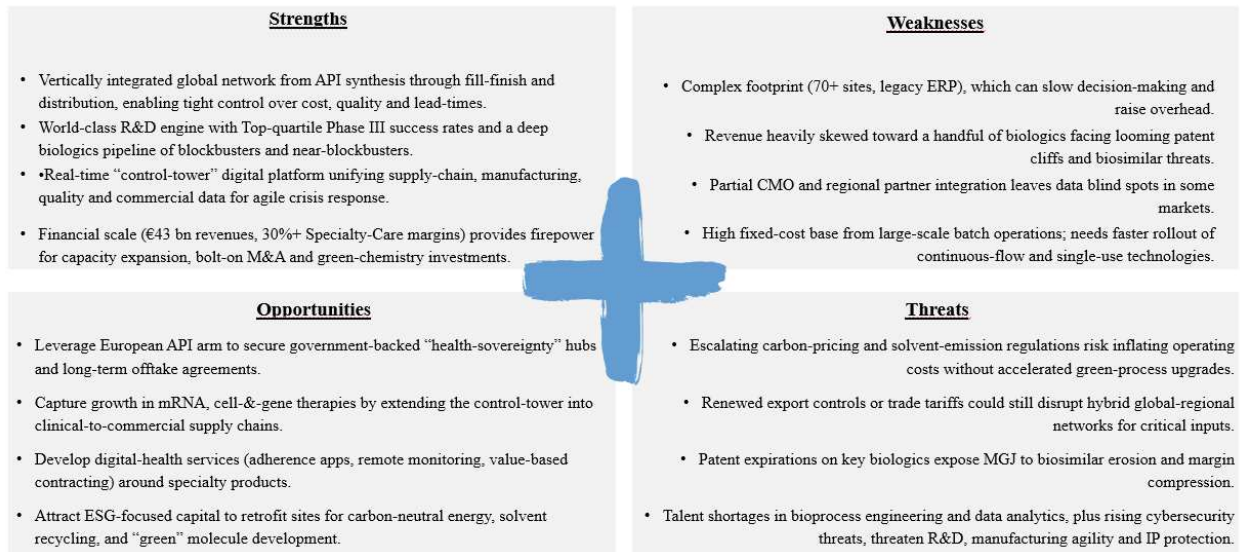
Opportunities:

Growing "health-sovereign" programs in Europe and North America create the opportunity for government-backed, co-invested manufacturing parks where MGJ's European API business can secure long-life offtake agreements. Demand growth for mRNA and cell-gene therapies provides a white space in which MGJ's control-tower can bring together clinical-to-commercial supply chains. Population aging in developed markets and burgeoning access in emerging markets create a two-way chance for digital-health services remote monitoring and patient compliance applications, as well as value-based contracting linked to MGJ's specialty treatments. ESG-fund money is pouring into green chemistry and carbon-zero process upgrades; MGJ can use it to retool energy-intensive facilities and lock in premium prices for "sustainably produced" APIs.

Threats:

Exponentially rising carbon-pricing and solvent-emission requirements could balloon costs of operation unless MGJ moves faster in implementing its roadmap of low-carbon processes. Geopolitical trade tensions new export restrictions or cross-border tariffs remain a threat to its network of hybrid global-regional routes, particularly for single-source special-intermediate chemistries. Patent loss of key biologics leaves MGJ vulnerable to biosimilar erosion and margin compression. Talent shortages in the areas of bioprocess engineering and digital-analytics present a strategic threat to R&D and control-tower growth. And escalating cyber threats to supply-chain systems call for ongoing investment in IT security to protect real-time data streams and IP.

Figure 1: SWOT analysis (own figure)



Question D - PESTEL Analysis:

For each of the PESTEL dimensions, list the two most significant macro-drivers, describe these drivers' strategic implications under both "business-as-usual" and crisis conditions, and outline concrete actions that the MGJ Group must undertake in order to handle risks, leverage opportunities, and enhance its competitive edge in the pharmaceutical sector. Drawing from your work on PESTEL, create a Crises Addendum that situates each of the three big disturbances COVID-19 pandemic, India API ban, and US–China trade tensions within the appropriate PESTEL drivers, summarizes their direct effect on MGJ operations, and provides an overview of the firm’s fast-response actions.

This question requires students to analyse the macro-environment influencing MGJ Group’s strategy using a PESTEL framework. Students need to identify the most significant political, economic, social, technological, environmental, and legal drivers affecting the pharmaceutical industry, and then select one or two key factors per dimension and identify strategic responses that MGJ Group might employ to manage risks, capitalize on opportunities, and enhance its market position. By working through this task, students enhance the skill of connecting external drivers to actionable strategies and of predicting how policy, market, technological, societal, environmental, and regulation changes will inform business choices in the future.

Analysis of question D:

Table 3: Crises Addendum table (own figure)

Crisis Scenario	Date	Primary Impact	MGJ's Response to Date
COVID-19 API & logistics shock	2020	Indian export ban on 26 APIs; China lockdown; global air-cargo drop by 90%	<ul style="list-style-type: none"> • Built 6–12 months' API safety stock • Dual-sourced Tier 1/2 suppliers across Europe/India • Real-time “control-tower” reallocation of critical inputs
Indian API export prohibition	Mar 2020	10 % of global generics supply cut; paracetamol & antibiotics scarce	<ul style="list-style-type: none"> • Spun off European API arm as standalone IPO (six sites) • Regional on-shoring of high-value intermediates
U.S.–China Section 301 chemical tariffs	2018–2019	7.5–25 % tariffs on Chinese intermediates: ~12 % input-cost inflation	<ul style="list-style-type: none"> • “Green-lane” customs for EU API exports • Expanded supplier base to 10+ geographies • Increased safety-stock to 7+ months

Table 4: Implications of PESTEL dimensions and MGJ's responses (own figure)

Dimension	Key Factor	MGJ's Response (to Date)	Next-Step Strategic Initiative
Political	Health-sovereignty & local-content mandates	<ul style="list-style-type: none"> • European Critical Medicines Act co-development • Spin-off EU API arm to secure regional supply under new procurement rules 	Strategic Public-Private Consortium: Form a multi-stakeholder EU API coalition (industry, regulators, sovereign funds) to co-fund next-generation oncology APIs, gaining preferential market access and shared R&D risk.
	Export-control regimes	<ul style="list-style-type: none"> • Daily CEO-level industry lobbying to pre-empt bans • Dual-sourcing across India, Europe, North America 	Crisis-Trigger Agreements: Negotiate “hard-trigger” MoUs with non-hostile governments guaranteeing API exports during emergencies, backed by predefined legal/financial penalties.
Economic	Pricing pressure & payer budget squeezes	<ul style="list-style-type: none"> • Value-based contracting pilots in Specialty Care • Tiered launch sequencing (West → emerging markets) 	Outcome-Linked Bundles: Expand RWE partnerships with major payers to roll out indication-based pricing—e.g. 100 % rebate if outcomes targets not met—preserving ASP while deepening payer relationships.
	FX volatility & rising input costs	<ul style="list-style-type: none"> • Natural hedging via multi-region footprint • 5-year off-take contracts for key reagents 	Strategic Commodity Swap Desk: Establish an in-house trading desk to hedge energy and key raw materials (solvents, lipids) using financial swaps and indexed long-term agreements, locking costs at favorable forward rates.
Social	Decentralized care & digital-health adoption	<ul style="list-style-type: none"> • Rapid tele-medicine deployment for clinical trials (retained 98 % enrollment) • Home-delivery partnerships for injectables in specialty markets 	“Care as a Service” Platform: Launch an integrated digital therapeutics + remote monitoring app tied to MGJ biologics, charging subscription fees and boosting adherence while creating a stickier patient ecosystem.
	Public/NGO scrutiny on drug access & pricing	<ul style="list-style-type: none"> • Expanded patient-assistance & tiered-access programs in lower-income countries • Transparent cost-plus disclosures on key vaccines 	Global Access Accelerator: Partner with Gavi/GFATM to co-invest in local fill-finish facilities in Africa/Asia, sharing cost & risk to secure bulk tender wins and bolster MGJ's social license.
Technological	mRNA & cell-therapy modular platforms	<ul style="list-style-type: none"> • Modular mRNA suites installed in EU/NA sites • Single-use bioreactor halls deployed via €500 m capex 	mRNA CDMO JV: Form a joint-venture CDMO with a pure-play mRNA pioneer to co-develop and manufacture third-party mRNA vaccines/therapies, maximizing asset utilization and revenue diversification.
	AI-driven supply-chain & quality analytics	<ul style="list-style-type: none"> • Deployed IoT-powered control tower for real-time inventory & shipment tracking • Predictive maintenance pilots on fill-finish lines 	Next-Gen Digital Twin: Build a full “digital twin” of MGJ's global network—integrating external data (pandemics, geopolitical news)—to run stress-test simulations and auto-trigger contingency plans days before disruptions materialize.
Environmental	VOC/solvent limits & carbon-pricing (EU, NA)	<ul style="list-style-type: none"> • “Green by design” R&D filters in Sustainable Futures 2030 • EU heat-recovery retrofit & on-site renewables at flagship plant 	Carbon-Neutral API Roadmap: Commit to 100 % green hydrogen & electrified CHP across all API sites by 2030, funded via green bonds—and partner with leading carbon offset registries to retire unavoidable emissions.
	Circular bioprocessing & plastic packaging	<ul style="list-style-type: none"> • Single-use bioreactor recycling pilot with specialty recycler • 20 % reduction target in process-waste solvents 	Closed-Loop Bioprocess Network: Create a blockchain-enabled take-back system for single-use components (bags, tubing) with certified recyclers, targeting 80 % circularity by 2028—and extend to secondary/tertiary packaging via compostable innovations.
Legal	Biosimilar & compulsory-licensing regimes	<ul style="list-style-type: none"> • Patent-thicketing & line-extension strategy around core biologics • AI-powered patent-monitoring to preempt challenges 	Global IP Safeguard Fund: Establish a cross-border legal defense pool to rapidly litigate and negotiate in compulsory-license cases—leveraging Article XX(b) & XXI exceptions—to protect MGJ's critical assets in emerging markets.
	Evolving data-privacy (GDPR, HIPAA) for digital solutions	<ul style="list-style-type: none"> • Privacy-by-design compliance frameworks in new tele-health apps • Cross-functional regulatory task force for digital health standards 	Interoperability Consortium: Lead an industry consortium to define unified global standards for digital-therapeutic data exchange, ensuring MGJ's platforms are both compliant and “plug-and-play” with major EHR systems—raising barriers to new entrants.

Question E - Supply Chain Management

Describe how MGJ Group's separation of its European API segment as a standalone entity, its increase in dual-sourcing and safety stocks, and its implementation of a digital control tower are manifestations of the network reconfiguration, redundancy and visibility enhancement strategies. In each of the tactics, give a tangible example and discuss why such moves maintained the operations of MGJ through the COVID-era API bans and resultant tariff shocks.

This question requires students to break down MGJ Group's responses to crisis and match each to fundamental supply-chain resilience and agility tactics. By connecting actual actions to academic models, students will learn how such levers work together to safeguard continuity and competitive standing against extreme external shocks.

Analysis of question E:

MGJ's carve-out of its six European API sites into an IPO-backed subsidiary is a masterstroke of network realignment. By on-shoring high-margin production in a dedicated governance framework aligned to incentives and compressing decision-making times, MGJ collapsed lead times to less than seven from a multiple of over 100 days and reframed those plants as a strategic hub to internal and external customers. The tailored structure opens fresh investment capital to targeted capacity augmentation, increases regulatory and commercial "lock-in" and turns the API business into a permanent fortress against prospective export controls or tariff fluctuations. Progress is tracked through lead-time-to-market, fill-rate enhancements and incremental IRR on the carve-out investment to make certain the fresh entity provides both operational robustness and financial accretion.

The outward expansion of dual-sourcing arrangements to ten geos coupled with a leap in safety-stock cover from two to more than seven months reifies redundancy as a sharp instrument and not a blunt shield. By vetting several Tier-1 and Tier-2 vendors and using dynamic reordering algorithms, MGJ turned a potential cascading shortage into a choreographed supply-realign exercise. As India's 2020 API export ban came into force, MGJ seamlessly reallocated volumes to alternate locations to maintain unbroken production without the need to resort to airfreight at a high price.

MGJ's real-time "control-tower" platform combines in-hand inventory, shipment telemetry, batch-release status and tariff-scenario modelling on a single pane of glass and turns raw data into actionable foresight. Throughout the pandemic, the nerve centre uncovered impending bottlenecks days ahead of legacy reports would have allowed, supporting pre-emptive rerouting, renegotiation of contracts and dynamic capacity reallocations. Forward-looking metrics (forecast accuracy, anomaly-detection lead time and decision-cycle frequency) are now baked into weekly operations reviews. This data-enabled cadence does more than shelter MGJ from disruption; it builds a continuous ability to smell out nascent shocks, mobilize stakeholders around a common truth and turn its global network on a dime.

6 Limitations

Although this dissertation provides rich insights regarding how a global pharma giant can lever its resource-based assets and dynamic capabilities to navigate the unparalleled volatility of the COVID-19 pandemic, its limitations must be recognized. First, the focus of the study on a single multi-national corporation, namely MGJ Group, necessarily limits the extent of its conclusions' applicability. The scale, mix of assets, and access to financial resources of MGJ Group may be significantly different from that of smaller companies, pure-generics producers, or businesses in nearby industrial sectors. Second, while in-depth interviews with members of the MGJ strategy team as well as with two external commentators provided rich strategic insights, they did not elicit the voices of frontline operators, contract-manufacturing partners, or regulation authorities. These stakeholders inevitably faced other different operational issues, bottlenecks in terms of available information, as well as decision-making trade-offs beyond the scope of the current analysis.

Additionally, the retrospective nature of the data collection opens the door for recall and self-presentation biases. Carried out several months later than the peak of the crisis and through virtual interviews, our discussions may contain post-hoc rationalizations or miss key real-time fine-tuning that only on-the-ground observation or diary studies could have captured. Although we alleviated these risks through member checking and triangulation with internal MGJ documents and industry reports, the lack of contemporaneous field observation confines the temporal specificity of our results.

Simultaneously, the reproducibility of the results over several interviews as well as sources of information is an indicator of the reliability of the method of investigation as well as its central

implications regarding the integration of MGJ's resource pool with its dynamic routines. These constraints imply several future areas of investigation. Follow-up studies could use a multi-firm, cross-industry design for examining whether the adaptation strategies documented here generalize to smaller firms or in other sectors with other types of regulation demands. Following these avenues, subsequent research can leverage the foundation of the current investigation toward creating a generally applicable, empirically rigorous supply chain resilience roadmap for high-stakes businesses.

7 Conclusion

This thesis has explored the complex odyssey of strategic adaptation in the pharma industry in the form of an in-depth examination of MGJ Group. Against the backdrop of record-breaking disruptions from a global pandemic that disrupted air and sea supply routes to abrupt imposed export controls on key APIs as well as boom-like spikes in demand for lifesaving medicines, the transformation of MGJ Group serves as a testament that the ability to foresee change as well as make quick turns is no longer desirable but a condition for survival for an organization. With investments in scenario-based digital twins, modular single-use lines for biological medicines, as well as in real-time "control-tower" data platforming, the firm equipped itself not only to ride out disruptions but transmute them into competitive strengths. Its rapid redirection of six months' worth of raw materials, its eleventh-hour chartering of backup supply routes, as well as the spin-out of an independent European API business all provide the hallmarks of an anticipatory, opportunity-driven mindset.

The MGJ example showcases how concrete assets like physical capacity, buffer stocks, and specialized facilities must be choreographed with intangible capabilities like cross-functional coordination processes, analytics capabilities, and governance dexterity. This mutual interdependence of resource investments and dynamic capabilities helped MGJ Group detect nascent threats, capture latent opportunities, reorganize operations with breakneck velocity, and even change its corporate setup to secure newly found resilience. While doing so, it ensured supply chain continuity in markets where lives literally depended on continued access to medicines. To summarize, the saga of MGJ Group confirms that long-lasting resilience in the pharma industry comes not from resisting turmoil but from embracing it capitalizing on every crisis as an opportunity for rebirth. Through the integration of strategy, technology, and business agility, companies can turn turmoil into a launching pad for expansion.

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9 Appendix

9.1 Appendix A – Extended Foundations of the Resource-Based View

A.1 Evolution from I/O to the RBV

The evolution of strategic management theory indicates a significant paradigm shift. Traditional industrial organization (I/O) paradigms like Bain (1959) and Porter (1980) assume that the structure of the industry and external competitive forces are the primary drivers of firm performance. The RBV counters this by asserting that differences in performance even between firms operating in the same industry are largely accounted for by the unique, heterogeneous, and often immobile resources and capabilities they possess (Rumelt, 1991; Lippman & Rumelt, 1982). The intellectual foundations of the RBV are in the initial economic thought of Ricardo, Schumpeter, and Penrose, who all stressed the internal determinants of firm success and growth. Wernerfelt (1984) laid the ground with the hypothesis that a firm's resource base may be a source of competitive advantage with Barney (1991) codifying it with the introduction of the VRIN framework.

A.2 Prescriptive & Integrative Nature of the RBV

RBV is prescriptive in nature and guides managers to develop, defend, and exploit such assets that are valuable, rare, inimitable, and non-substitutable in nature. Although initial research on RBV focused on intangible assets as the major source of competitive advantage (Ambrosini & Bowman, 2009; Kor & Mesko, 2013), modern studies have encouraged an all-encompassing view including both tangible and intangible assets (Foss, 1997; Andersen & Kheam, 1998). It is through the holistic analysis including both tangible and intangible assets, according to Foss (1997) and Andersen and Kheam (1998), that we have better understanding of the determinants of competitive advantage. It considers the fact that firms are bundles of complex assets and the competitive advantage emanates from the dynamic interaction between the internal assets and the external market environment (McGahan & Porter, 1997; Short et al., 2009).

9.2 Appendix B – Organizational Capabilities & Capability Lifecycle

B.1 Organizational Capabilities

Organizational capabilities represent a firm's ability to deploy and coordinate its resources effectively to create value. They are the dynamic routines, processes, and skills that convert static resource stocks into competitive action. These capabilities are the subject of the RBV because they explain not only what a firm possesses, but also how it uses the assets to create superior performance. Researchers recognize several types of organizational capabilities. Functional capabilities are a firm's proficiency in conducting core operations, such as production management, logistics, and marketing. Amit and Schoemaker (1993) suggest that these capabilities arise within specific functional areas, and Stalk et al. (1992) describe them as business processes that are managed strategically. These capabilities form the operational backbone for achieving efficiency and ensuring quality.

Dynamic improvement capabilities, on the other hand, represent the capacity of a firm to innovate and continuously optimize procedures. Teece et al. (1994) state that dynamic capabilities are the processes whereby a firm is capable of learning, adapting, and renewing itself amid rapid changes in the market. Hayes and Pisano (1994) demonstrate the fact that such capabilities enable firms to switch quickly between strategies, i.e. from rapid development to the minimization of costs with the minimum use of resources. Such capabilities are necessary in technology-disrupted and shifting consumer demand-based businesses. Finally, meta-capabilities or strategic insight capabilities are higher-order functions through which a firm can develop new strategies and innovating in advance of rivals. Such capabilities enable a firm to conceptualize, choose, and enact strategies that leverage existing and future resources (Barney, 1992). Henderson and Cockburn (1994) underscore the fact that meta-capabilities are embedded in collective tacit knowledge and are capable of sustaining long-run differentiation.

B.2 The Capability Lifecycle: Dynamics and Heterogeneity

There needs to be an understanding of the dynamic evolution of capabilities and resources to be able to account for the heterogeneity among firms. The capability lifecycle is a conceptual framework for such an understanding through analogy with the lifecycle of a product. The fact that products have introduction, growth, maturity, and decline phases, organizational capabilities develop in the same way through the elapse of time. The capability lifecycle typically begins with the founding phase where a new capability is first created, most often in the context of start-ups and then progresses to a development phase where the capability is

developed and shaped step-by-step. The capability then reaches the maturity phase where the growth levels off and the competitive value is maximized.

But the lifecycle need not end with maturity. Capabilities can branch into transformational paths through such processes such as retirement, retrenchment, renewal, replication, redeployment, or recombination. Such branching processes, both driven by internal managerial decisions and external forces such as technological change, changes in market demand, or regulatory changes explain the fact that even firms with similarities may develop capabilities in different ways. The dynamic nature of the capability lifecycle emphasizes the fact that competitive advantage is not static but is reconfigured continuously through the firm's ability to renew and reconfigure its resource base (Helfat & Peteraf, 2003; Teece, 2007). The model not only explains the emergence of resource heterogeneity but also explains the fact that even valuable and inimitable capabilities may be lost or replaced with better substitutes in the long term. Briefly put, the RBV posits the success of a firm to be contingent on the specific mix of tangible and intangible assets it holds and, notably, on the ability to leverage these assets into dynamic value-creating competencies.

9.3 Appendix C – Deep Dive into Dynamic Capabilities Theory

C.1 Evolving Definitions: From Teece et al. to Barreto

The initial formulation of dynamic capabilities by Teece, Pisano, and Shuen (1997) introduced the idea that firms should “*integrate, build, and reconfigure*” (p. 516) internal and external competences with the purpose of coping with environmental change. As influential as this definition was, it was also general, and criticisms of vagueness and the ensuing problem of empirical measurability arose. In response, Barreto (2010) introduced a refined definition, defining dynamic capability as “*the firm’s ability to systematically resolve problems created by its tendency to sense opportunities and threats, make timely and market-driven decisions, and modify its resource base*” (p. 271). Not only does this multidimensional, collective approach capture the principal dimensions of sensing, seizing, reconfiguring, and transformation, but it also rejects the reductionism of a have it or not binary by recognizing that dynamic capabilities exist on a continuum. This evolution of definition has been vital for theory and practice development, with the construct remaining conceptually strong and empirically tractable (Winter, 2003).

C.2 The Role of Transformation in Dynamic Capabilities

The transformative character of dynamic capabilities is central to understanding how firms achieve long-term strategic renewal. Beyond the making of incremental improvements, transformation involves rethinking and rebuilding a firm's resource base and core capabilities. Those industries faced with disruptive technological innovations, for example, must substitute existing systems with entirely new capabilities. This is inherent in the dynamic capability framework, avoiding firms from being bogged down by core rigidities a scenario whereby existing routines become a source of impediment in a changing context (Leonard-Barton, 1992). By making the dimension of transformation explicit, scholars have made it apparent that dynamic capabilities involve not only the ability for adaptation but also for the ability to change profoundly, hence translating the strength of internal resources into superior market performance (Teece, 2007).

C.3 Cost Considerations, Matching, Inertia, and the Transformation Imperative

The investment and application of dynamic capabilities involve tremendous cost - financial, organizational, and cognitive. In relatively stable contexts, excessive investment in dynamic capabilities can compromise efficiency and water down the reward of reaping existing resources. Dynamic capabilities, on the other hand, can experience the matching problem (where experience is not a strong determinant of new circumstances) and the inertia problem (where existing routines resist revolutionary change) (Levinthal & Rerup, 2006; Sørensen & Stuart, 2000). The transformational element is critical here, avoiding the entrapment of firms on outmoded routines. Rather, by pro-actively employing transformation, firms can better overcome inertia and effectively match their responses with the unique requirements of crisis.

9.4 Appendix D – Crisis-Management Paradigms & Practices

D.1 Strategic Responses to Crisis

Global crises call not only for reconsideration of short-term operational solutions but for reconsideration as well of the underlying paradigms of strategy and crisis management, as well as supply chain resilience. Early seminal works in crisis management define resilience as an organization's ability to prepare for, react, and rebound from interruptions (Christopher & Peck, 2004; Ponomarov & Holcomb, 2009). Multiple essential frameworks enrich this conceptual approach to resilience.

The Resource-Based View asserts that a company's lasting competitive advantage emanates from building upon assets that are valuable, inimitable, rare, and non-substitutable (Barney, 1991). During crises, its internal assets are more vital to enable speedy adaptation and recovery. Supplemental to this assertion is dynamic capabilities, which focuses more on processes by which companies transform their resource base as a function of new threats and opportunities (Teece, 2007). Additionally, Transaction cost economics addresses why, with higher levels of uncertainty, there may be a wish to internalize important activities like by vertical integration to mitigate transaction cost and protect vital functions (Williamson, 1985).

Moreover, strategic adaptation and environmental scanning are critical in crisis management. Jennings (2004) emphasizes the need for adaptive capabilities to detect and act on new opportunities and threats. Andersen's (2015) model of centralized strategizing coupled with autonomous entrepreneurial action shows how organizations can actively define their capabilities in changing markets a necessity in markets with high-speed technological and market changes.

D.2 Vertical Integration as a Resilience Strategy

Vertical integration implies ownership or control of critical supply chain segments either by managing upstream suppliers or controlling downstream distribution channels (Gereffi, 2020). Organizations incorporated vertical integration in response to the COVID 19 pandemic to decrease reliance on external partners and lock down supplies of crucial inputs (Gereffi, 2020). Internalization of major operations helped protect organizations from universal disruption of external markets. Recent empirical work by Fazio, Silva, and Skrastins (2020) also supports the argument that vertical integration can strengthen economic resilience. The study identifies how integrated arrangements can create spillovers and take advantage of legal and institutional arrangements, hence reducing risks from external shocks.

Practically, vertical integration increases a company's internal control over its supply chain, allowing early identification of potential bottlenecks and facilitating better resource allocation. Internalization can also lower transaction costs and achieve economies of scale, with strict quality control maintained across various production processes. It has been empirically proved (Fazio, Silva, & Skrastins, 2020) that vertically integrated organizations are more resilient. For example, industrial manufacturers and large pharmaceutical corporations succeeded in keeping control over the whole supply chain from raw material acquisition to end production even in

difficult situations due to high demand. Still, increased internal control may limit internal flexibility because internal organizations may become trapped in fixed processes (Gereffi, 2020). Furthermore, administration of a larger internal supply chain amplifies program complexity and needs high initial capital outlays. Consequently, many organizations adopt a selective vertical integration approach, securing only those internal nodes that prove to be fundamentally important and maintaining overall flexibility.

D.3 Sustainability Considerations in Pandemic-Era Operations

The crisis highlighted more recently how sustainability and resilience are inter-dependent goals. Instead of suspending sustainability activity when times get tough, most businesses instead ramped up their activities because sustainable behaviour by promoting transparency and building longer-term relationships with suppliers adds to overall supply chain resilience (Linton et al., 2007; Seuring & Müller, 2008).

With regard to proactive production and procurement based on sustainability, establishing trust-based relationships with suppliers is of prime importance. Businesses who actively observe and are familiar with their suppliers' practices and capacities are in a better position to detect vulnerabilities and modify their operations in times of disruption. Furthermore, adoption of green and sustainable logistics practices, such as the usage of alternative fuels, transport optimization, and adoption of circular economy practices (recycling and remanufacturing), can decrease environmental footprint as well as increase operational performance in times of resource scarcity (Seuring & Müller, 2008). All these contribute not only to operational resilience in the short run but also to stakeholder trust building as well as corporate public image enhancement, both of which are essential prerequisites to long-run business advantage.

D.4 Alternative Strategic Responses to Crisis

Academic scholarship has identified four fundamental approaches - retrenchment, persevering, innovating, and exit - that are viable (Wenzel et al., 2020). Retrenchment entails cutting costs, assets, product offerings, and overhead, hence enhancing concentration and eliminating complexity (Pearce & Robbins, 1993, 1994). Although this approach may increase transparency, it risks destroying synergy effects and inhibiting long-term economies of scale (De Figueiredo et al., 2019). Persevering emphasizes keeping things as they are to counteract negative effects, a strategy whose applicability becomes evident when changing strategy too

often may compromise renewal; however, it is only viable if enough internal and external resources are available over long periods (Wenzel, 2020; Stieglitz et al., 2016). Innovating, on its end, entails expanding the scope of the organization by investigating new business activities and reshaping business models, hence facilitating a faster adaptation to changing market conditions. The success of innovative approaches, however, relies on high-quality decision-making and resource allocation in conditions of contingency (Reymen et al., 2015; Wenzel, 2020). Lastly, exit constitutes the withdrawal from some operations when other responses become unsustainable. Although exit may liberate resources for renewal strategy, it may also invoke stigma of failure, and with this come potential longer-term reputational effects (Carnahan, 2017).

D.5 Demand Forecasting and Collaborative Supply-Chain Strategies

Traditionally, industry demand signals used to be extremely transactional, based on short lead times and instant purchase orders. But with the COVID 19 pandemic, everything has changed fundamentally. More and more, businesses are realising that demand forecasting needs to become a collective activity, leveraging inputs from throughout the supply chain to create long-term business plans. Collaborative planning, forecasting, and replenishment (CPFR) methods have proven to increase supply chain performance by improving demand forecasting accuracy and facilitating more intimate partnering between supply chain participants (Min & Yu, 2008; McCarthy & Golicic, 2002).

Today, companies are planning customer demand plan by as much as three to five years. While flawless forecasting isn't possible, building a solid forecast starts with gaining a holistic picture of supplier capacity. Due to the COVID 19 pandemic, organizations rearranged their planning methodology by setting up centralized "crisis control towers" with a focus on vertical organization. For instance, companies brought together a broad network of internal production sites with external contract manufacturing organizations, thus building an end-to-end supply chain with more accurate demand signals and greater interaction with important partners in the life sciences space.

To gain accurate projections, companies make quarterly routine business reviews to revise short-, medium-, and long-range planning horizons (Min & Yu, 2008). Instead of depending on advanced electronic data interfaces, however, most organizations have come to realize that regular coordinated checks among major stakeholders who comprehend the process of

globalization enable a stable platform to standardize communication. For those with partially integrated ERP/MRP arrangements, high-level business discussions among counterparties are crucial to align business trajectories and planning major product launches. In coping with inherent uncertainties of long-range planning, especially with multiple new product launches, strong partnerships and a system perspective in terms of supply constraints are crucial. Moreover, extending worldwide manufacturer networks as well as ensuring quality and redundancy in sourcing also enhance on-time, in full shipment performance and lessened lead times, thereby extending total supply chain robustness.

D.6 Supply-Chain Optimization and Crisis Management in the Pharmaceutical Industry

The highly regulated and margin-constrained pharmaceutical industry presents challenges in planning supply chains to withstand crisis situations and meet future demand against available capacity. State-of-the-art operations research has concentrated on optimizing supply chain components like facility location, materials management, capacity planning, and accurate scheduling. The challenge in this industry is dealing with high-level uncertainty due to competitor actions and uncontrollable clinical trial results (Haijema & van der Sluis, 2009). With increasingly tightened regulation and diminishing profit margins, efficient utilization of capacity and prudent infrastructure investments becomes more paramount.

Innovative supply chain design practices today involve determining strategic nodes in worldwide networks and optimizing trading and transfer prices, which add more degrees of freedom. Organizations need to prioritize pipeline and testing planning, i.e., select products to build and when to launch them, prior to carrying out capacity planning to balance risk and reward. Coordinated inventory management, debottlenecking, as well as decoupling strategy, are crucial to responding rapidly to external changing situations and internal inefficiencies in processes (Pishchulov, Ivanov, & Dolgui, 2020). Furthermore, crisis management in pharmaceutical supply chains also depends significantly on collaborative practices. Recent conceptual frameworks elucidate how inter-sectoral cooperation, made possible by institutions and government-imposed committees, can increase resource pooling and information sharing among stakeholders.

Traditionally, pharmaceutical supply chains focused mainly on supply security to effectively deliver products to the marketplace. Today, as changing operating conditions challenge supply chains, businesses are rethinking their supply chain infrastructures to gain more strategic

leverage (Schweitzer, Cachon, & Hausman, 2016). The pharmaceutical value chain now incorporates innovation, product development, planning of capacity, and production scheduling, in addition to material distribution (Ivanov & Dolgui, 2020). Through optimization techniques coupled with crisis management methodologies shared by multiple stakeholders, the industry can more effectively continue its operations and deliver high performance even in times of extreme disruption.

9.5 Appendix E – Extended Supply-Chain Theory

E.1 Supply Chains as Complex Adaptive Systems

The concept of the supply chain as a system of systems has gained traction in recent years. This view regards the supply chain as an extended, complex adaptive system where individual sub-systems work together to deliver performance that is greater than the sum of their parts. Key characteristics of such systems include autonomy, belonging, connectivity, diversity, and emergence the ABCDE framework (Boardman & Sauser, 2006; Jamshidi, 2008; Giachetti, 2011). In the pharmaceutical sector, for example, supply chains involve multiple autonomous yet interconnected entities from suppliers and manufacturers to distributors and regulatory agencies that must work together under stringent quality and regulatory conditions (Kaylor, 2023). Describing the pharmaceutical supply chain as an SoS has significant risk reduction management implications. Engineered pharmaceutical supply chains, like other complicated systems, can exhibit emergent behaviour when exposed to uncertain events. As such, they must be able to react in both scale and scope by quickly identifying and removing objectionable behaviour, particularly during local and global catastrophic crises. Vaccine supply chains (VSCs) that support mass vaccination during pandemics are one such highly interconnected system. Their vulnerability to disruption is due to their sheer size, number of interactions, dependencies, global scope, and the products involved (Chaabane & Trentesaux, 2019; Linkov et al., 2019; La Porte, 2006).

E.2 Risk Classifications

Risk events can be categorized in several ways. One common distinction is between operational risks those that arise from internal processes such as quality deviations or equipment breakdowns and disruptive risks, which are rare external events like natural disasters or pandemics (Kleindorfer & Saad, 2005; Tang, 2006; Macdonald et al., 2018; Son et al., 2021).

Another approach classifies risks as known-known, known-unknown, or unknown-unknown, with the latter category including unpredictable events such as volcanic eruptions or global pandemics (Madni & Jackson, 2009; Bailey et al., 2019; Ashcroft, 2022). Additionally, risks can be viewed as cumulative, additive, or singular in magnitude, where cumulative risks may snowball throughout the supply chain (Heckmann et al., 2015). Traditional risk management approaches can address some of these categories, yet unknown and disruptive risks require radically different strategies. To manage such risks, resilience emerges as a critical complement to traditional risk management approaches (Pettit et al., 2019).

E.3 Supply Chain Resilience

Supply chain resilience is the dynamic capacity of a supply chain to anticipate, prepare for, respond to, recover from, and ultimately adapt to disruptions that may range from day-to-day operations issues to extreme events such as pandemics, geopolitical unrest, or dramatic market shifts (Hohenstein et al., 2015). It is a multi-step process that begins with preparedness and readiness where the organization proactively scans for potential threats and vulnerabilities through contingency planning, risk analysis, and strategic buffer creation such as inventory buffers or dual source agreements. This phase centres on the construction of a resilient supply chain risk management culture using innovative technologies for increased supply chain transparency (Christopher & Peck, 2004; Hohenstein et al., 2015).

E.4 Key Attributes and Strategies for Resilience

Key attributes that underlie supply chain resilience are flexibility and agility to quickly shift production, logistics, and sourcing strategies. Additionally, redundancy in the form of buffer stock, dual sourcing, and diversification of suppliers to ensure continuity should failures occur. Collaboration through the creation of strong trust-based relationships that facilitate effective information exchange, collaborative planning, and coordinated action (Sodhi & Tang, 2012). Increased visibility enforced through advanced digital technologies allows for increased transparency across the supply chain, with superior tracking of supplies, better demand forecasting, and early warning systems for potential disruptions. An essential element of resilience also lies in managing dependencies on resources, which requires understanding and strategically managing internal and external dependencies through mechanisms like buffering and bridging (Sodhi & Tang, 2012; Pfeffer & Salancik, 1978).

E.5 Evolving and Universal Definitions

Despite a great deal of effort spent on researching the term, a definition of supply chain resilience acceptable to all remains elusive. In the earlier literature (Christopher & Peck, 2004; Sheffi & Rice, 2005), resilience had been defined as the ability to recover from disruptions only to be broadened in later work (Ponomarov & Holcomb, 2009; Tukamuhabwa et al., 2015) to cover recovery and growth through adaptation. Recent work (Wieland & Durach, 2021) highlights its dynamic and multi-dimensional nature in the most extreme situations. Together, they suggest resilience involves the ability to anticipate, absorb and recover from disruptions, but no universal all-embracing definition yet exists.

E.6 Theoretical Foundations of Supply Chain Resilience

When disruption occurs, the supply chain must demonstrate speed, flexibility, and coordination in reaction. Through the response phase, the chain is capable of absorbing shocks through fast production adjustments, tactical allocation of resources, and greater cooperation among supply chain actors. Proactive and reactive strategies are adopted to maintain operations and safeguard critical services, especially in such critical sectors as health care (Sheffi & Rice, 2005; Ponomarov & Holcomb, 2009).

The subsequent recovery stage is not only about reverting to normal but also about restructuring and reorganizing operations to establish a “new normal” that is stronger and more resilient. It involves learning from the disruption, incorporating lessons and feedback, and making processes better and better through continuous improvement to prevent future threats. Organizations that learn from disruptions are better positioned to design their supply chains and are more likely to make structure and strategy transformational changes (Tukamuhabwa et al., 2015).

Above recovery itself, resilience also involves being able to develop and emerge stronger from disruption. This stage of adaptation and growth may include capturing new market opportunity, creating new products or services, and expanding strategic partnerships. The end target is not simply to recover supply chain performance but to achieve higher customer service levels, higher market share, and superior financial performance even in the context of uncertainty (Fiksel, 2006; Ivanov, 2020).

E.7 Resilience under Extreme Conditions

In extraordinary circumstances i.e., concurrent, multi-dimensional shocks such as the COVID-19 pandemic traditional supply chain risk management practices may prove to be insufficient. Extreme supply chain management hence requires dramatic transformation of practices to deal with not only individual events but sustained, widespread disruptions that cut across societies and economies. This includes the adoption of innovative technologies (e.g., blockchain for traceability and IoT for data collection in real-time), new governance mechanisms, and the fostering of public–private partnerships for risk and resource sharing at increased scale (Sodhi & Tang, 2012). Relevant are also divergent perspectives on the idea of resilience as the ability to come back to an equilibrium point (closed-system approach), as compared to the idea of resilience as a continuous process of adaptation and development in an open, complex adaptive system (Gunderson & Holling, 2001; Wieland & Durach, 2021). These perspectives further highlight the need for the recovery of supply chains as well as transformation and development to achieve optimal functioning despite adverse conditions.

E.8 Agile Supply Chain Management

Agile supply chain management has emerged essential in the complex and dynamic global environment today. At the basic level, supply chain management has been characterized as the systems approach towards managing the entire process of information flow, materials, and services from the raw material providers all the way down to the factories and warehouses and ultimately the customer at the consuming point (Leenders & Fearon, 1997).

Primarily, the main function is the optimization of operational effectiveness, cost minimization, profitability maximization, and customer satisfaction by process simplification, inventory minimization, and effective cooperation among the supply chain stakeholders (Cooper et al., 1997). In today's industrial settings, Tang and Qian (2008) claim that the supply chain extends from the manufacturers of raw materials all the way up to the companies that manufacture sophisticated electrical and computing technologies, explaining the complex and interconnected nature of the supply networks today.

Increasing complexity in supply chains coupled by challenges such as globalization, technological transformation, and evolving customer requirements demands that there be a focus on agility. As sectors such as the automotive and pharmaceutical sectors are faced by

turbulent markets and speeding change, companies have learned that supply chain risk management and operational resilience are not solely the function of efficiency but also the ability to respond rapidly to uncertainty (Lambert & Cooper, 2000; Mizgier et al., 2013). Agility in this regard is the capacity of the supply chain and stakeholders thereof to align operations rapidly to dynamic customer demand and proactively reconfigure to changing market conditions (Christopher, 2000). Agile supply chains also focus on customer responsiveness, effective use of people and information, and robust cooperation among firm's characteristics that are essential for survival and prosperity in turbulent times (Tang & Qian, 2008).

At the heart of the conceptual underpinnings of agility lies the realization that firms can overcome threats, seize new opportunities, and react more speedily to demand changes by efficiently managing material and information flows (Hugo et al., 2004). This managerial ability is supported by emerging digital technologies. By way of illustration, the utilization of the Internet of Things (IoT) puts executives in control of a steady stream of real-time big data regarding the location of products and the condition of shipments so that aberrations (e.g., products shipped in the wrong direction) are immediately detected. Real-time monitoring improves inventory control, reduces the cost of transactions, and simplifies the workflow along the supply chain a tendency that is revolutionizing warehouse and distribution centre operations (as considered in the literature on IoT-enabled agile-lean logistics). Convergence among IoT, blockchain, and artificial intelligence is regarded as the revolutionary impetus for improved agility of pharmaceutical and other vital supply chains since it renders improved information sharing and streamlined processes achievable.

With the dynamism in today's supply chains, agility has become the essential characteristic. Christopher (2000) contends that agility does not only mean responding to change but also developing supply chain capabilities that enable fast reconfiguring and proactiveness. Tang and Qian (2008) claim that highly agile supply chains possess certain characteristics that include being sensitive to the marketplace, process integration, and strong networking capabilities. These characteristics not only enable companies' fast reaction to unforeseen disruptions but also the capacity for sensing and capitalizing on opportunities in the marketplace, thereby achieving sustainable competitive advantage in turbulent environments.

E.9 Strategic Significance in Crisis Environments

The strategic relevance of agile supply chains is most severely felt in times of crises, when disruptions ranging from natural disasters and geopolitical shocks to global pandemics can interfere with regular operations. Literature indicates that static risk-reduction measures such as maintaining buffers in stock or relying exclusively on dual-sourcing prove inadequate in the case of crises. Agile practices characterized by real-time decision-making, decentralized coordination, and quick reconfiguration enable companies to provide operational resilience and mitigate the impacts of disruptions.

For example, in the pharmaceutical industry a sector where the punctual supply of goods has life-and-death implications for public health the ability to adapt is paramount. Chandrasekaran and Kumar (2003) illustrate that even minor improvement in production or lead time can lead to substantial cost savings and enhanced market share. In addition, the pharmaceutical industry is also highly regulated and subjected to supply and demand pressures (Garattini et al., 2007). Governments and the stakeholders within the industry itself therefore emphasize the importance of flexible supply chains that possess the ability to change production, reorganize resources, and rapidly respond to demand changes while ensuring compliance with strict regulatory controls (Hakonsen et al., 2009).

Agile supply chain operations in the event of crises usually involve the speedy re-arranging of networks. As such, for instance, in the case of unforeseen shortages or transport congestion, firms have effectively implemented measures that include qualifying alternate suppliers, re-purposing production lines, and decentralising distribution networks. Having the ability to re-assign production and source materials from diversified locations not only mitigates the immediate impact of a crisis but also promotes long-term resilience by reducing dependence on single-source suppliers (Brown & Zhang, 1999). Underlying this proactive and dynamic risk management approach is the presumption that the agile supply chain has the capacity to absorb shock and quickly return to normal.

Moreover, research on the development of agile supply chains concentrates on the integration of long-term collaborative relationships with agile suppliers as the most significant improvement driver (Preiss et al., 1996). While others have argued that very close relationships with a single supplier could limit adaptability (Rich & Hines, 1997; Jordan & Michel, 2000), others have contended that the best approach would be the balance between extended and virtual enterprise strategies that would grant the network the capability of rotating and re-linking

resources quickly in the face of unfolding disruptions (Brown & Zhang, 1999). Supply chain management's trade-off theory also suggests that the improvement of agility could sometimes come at the expense of efficiency; thus, businesses must balance such competing priorities very cautiously to gain sustainable competitive advantages (Carvalho & Azevedo, 2014).

In today's rapidly evolving marketplace environment, the measurement of performance against certain criteria and embedding digital enablers are critical in ensuring competitiveness and operational resilience (Preiss et al., 1996).

Performance measurement in agile supply chains has been the subject of significant academic interest. Academic researchers have presented numerous performance indicators that cater to the complexity of agility. Some of the indicators include reaction rate, which measures the pace at which the system adapts in reaction to external stimuli; response time, which measures the period between the customer request and fulfilment thereof; and overall supply chain agility level, which measures the capacity of the system to reconfigure operations rapidly (Carvalho & Azevedo, 2014). Other measures such as common planning effectiveness, cooperation among members, and information-sharing efficiency are also essential (Hugo et al., 2004). Literature indicates that improvement in one area of performance, such as responsiveness, may at times occur at the expense of another area such as efficiency a concept that has been explained by trade-off theory (Carvalho & Azevedo, 2014). Through the measurement of these indicators, the organization has better capacity to identify operational blockages and design interventions that optimize agility without undermining cost competitiveness.

Digital transformation plays an important role in supporting and tracking agile performance. Convergence of digital technologies such as the Internet of Things (IoT), blockchain, and artificial intelligence (AI) has revolutionized supply chain operations by providing real-time information and advanced analytics. IoT, for instance, enables the tracking of inventory in real-time, shipment status, and environmental conditions, thereby reducing transactional cost and inventory management (Hugo et al., 2004). Real-time feeds from sensors and location tracking enable decision-making authorities to foresee disruptions and proactively adjust logistics plans (Chandrasekaran & Kumar, 2003). Blockchain technologies also ensure transparency and trust among supply chain partners by creating unalterable records of transactions, while analytics based on AI offer predictive modelling and fast turnaround times (Chandrasekaran & Kumar, 2003).

Strategic supply chain integration also encourages agility by developing long-term alliances between suppliers and other stakeholders. Academic theory proposes two mutually supporting strategies for strategic integration. The extended enterprise approach and the virtual enterprise approach. Both approaches emphasize the importance of flexible supplier networks that have the capacity to reorganize rapidly in the case of changes in the marketplace (Preiss et al., 1996). Some research cautions that very tight bonds between single suppliers will suppress adaptability (Rich & Hines, 1997; Jordan & Michel, 2000). Brown & Zhang (1999) argue that there must be balance between fixed alliances and dynamic re-allocation of assets. Strategic integration is critical in ensuring that measures for performance truly reflect not only the internal efficiencies within one company but also the overall responsiveness and resilience within the overall supply chain network. As Tang and Qian (2008) note, the ability for the supply chain to stretch from the raw material suppliers all the way down the final assembly at the point-of-use underscores the importance of processes that are well-integrated, where smooth communication and coordination between the partners are essential to gain marketplace sensitivity and operational superiority.

Moreover, the convergence between digital transformation and strategic integration supports the development of agile supply chain transformation matrices that provide companies with a systematic approach to assess, monitor, and enhance performance. These matrices combine key performance indicators with qualitative measures of supplier coordination and network integration into one complete picture of supply chain agility. Digital technologies' dynamic capabilities allow firms to adapt performance measures in real-time and implement corrective measures rapidly, bridging the gap between strategic intent and operational implementation.

E.10 Lean Versus Agile Supply Chain Models: A Comparative Analysis

Within the recent literature on supply chains, the lean versus agile paradigms have been the focus for explaining the most effective means by which organizations can manage an environment that is growing more volatile globally. Lean supply chain management has at its core the focus on efficiency, waste elimination, and cost minimization. Lean focuses on steady, predictable environments where production systems are streamlined to minimize excess inventory and unnecessary processes (Cooper et al., 1997; Lambert & Cooper, 2000). Agile supply chain management focuses on the importance of being flexible, responding quickly, and

being adaptable in the presence of turbulence in the marketplace and unstable demand (Christopher, 2000; Tang & Qian, 2008).

Lean systems operate on the principle that by reducing waste and keeping processes simple, companies can achieve increased operational effectiveness. Lean systems function effectively where demand patterns are predictable and consistent so that companies can focus on process optimization, just-in-time production, and tight cost controls. Lean strategies in these circumstances reduce duplication and rely on highly standardized processes to ensure quality and reduce the cost of operations. Lean supply chains become less flexible where there are sudden changes in demand or supply disruptions because the very emphasis on efficiency makes them less flexible (Van Hoek et al., 2001).

Agile supply chains, on the other hand, are designed to thrive in the uncertainty environment by being capable of reconfiguring operations rapidly, incorporating real-time information, and being highly responsive to changes in the conditions in the marketplace. Agile supply chains are not cost-minimization-driven like the lean systems; rather, they spend money on flexibility and digital enablers IoT, blockchain, and AI so that they are capable of sensing and responding to the signals in the marketplace in real-time (Hugo et al., 2004; Chandrasekaran & Kumar, 2003). Dynamic capability in such form proves essential in sectors where there is fast innovation or high demand variability, such as in the car and drug industries (Tang & Qian, 2008).

Several researchers have posited that the real strength in supply chain competitiveness lies in the synthesis between the agile and the lean paradigms to form the so-called “leagile” strategy. It tries to balance the two paradigms' strengths by being effective in the steady parts of the supply chain while also being flexible enough to manage the unexpected disruptions (Naylor et al., 1999). For instance, the steady flow of materials and process standardization might be controlled by the practices of the lean. Agile approaches are utilized in the variability parts where responsiveness is critical (Christopher & Towill, 2002; Naylor et al., 1999).

Whether one adopts agile or lean strategies or goes for the hybrid approach typically depends on the nature of the industry and the specific competitive dynamics. Those industries that experience high product variety, product life cycles that are brief, and rapidly changing markets would likely adopt agile practices. Sectors that benefit from economies of scale and predictability would likely adopt the practices of lean. Empirical research on supply chain

performance suggests that cost benefits are likely to arise from the use of lean systems where the environment does not change frequently, while agile systems offer superior customer responsiveness and the ability to capitalize on emerging opportunities in the marketplace (Peck & Jüttner, 2000; Rich & Hines, 1997)