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The Impact of Coal Quality and Availability on the Efficiency of Distribution Strategies: A Perspective from the Polish Mining Sector*

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Abstract

This study investigates how coal quality and availability influence the efficiency of distribution strategies in the Polish mining sector—an issue that gained urgency following the energy crisis triggered by the war in Ukraine. Despite extensive literature on supply chain management, research on declining markets and the impact of raw material characteristics on distribution remains scarce. The study addresses this gap through qualitative research based on semi-structured, in-depth interviews with senior managers from all eight operational Polish coal mining companies. Thematic and emergent coding techniques were applied to analyze the data using Creswell's methodology.

The findings reveal that coal quality directly affects customer satisfaction and the perceived efficiency of distribution strategies, while availability constraints shape inventory practices and the resilience of supply chains. Mining firms demonstrate limited flexibility in adjusting production volumes, which is constrained by geological, regulatory, and labor-related factors. Four distinct surplus stock management strategies were identified, ranging from speculative storage to external warehousing. Moreover, the role of intermediaries proved vital in customizing coal products to meet end-user requirements, thus enhancing adaptability and market fit.

This research contributes to strategic management in resource-based and declining industries, offering practical implications for production planning, inventory optimization, and stakeholder coordination. It recommends improving product alignment with market needs, leveraging intermediaries' capabilities, and developing adaptive strategies to cope with resource constraints and market volatility. The study enhances our understanding of supply chain efficiency under structural limitations and provides a foundation for further research in energy and distribution economics.

Keywords: Coal distribution strategies, Resource availability, Customer satisfaction, Supply chain management

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Introduction

The war in Ukraine has had a significant impact on the European Union's economy, including Poland (Boichenko i in., 2023; Darmayadi and Megits, 2023). One of the key areas affected is the energy sector, particularly the coal market (Sumirat i in., 2023). In terms of the coal market, the war has disrupted regional trade flows and patterns leading to supply shortages and price spikes (Sumirat i in., 2023). What led to windfall gains (Siciński, 2024).

In 2020, the EU imported 53% of its coal from Russia, covering 30% of its total demand. In Poland, Russian coal made up over 13% of solid fossil fuel consumption (Chrząszcz i in., 2022). The war in Ukraine showed that despite rich resources, Polish mines couldn't meet domestic demand, turning Poland from a leading coal producer into an importer (Bednorz, 2024). Hard coal quality and availability are crucial for energy security and economic development, forming the foundation of Poland's energy system (Olkuski i in., 2016; Strzałkowski and Maruszczyk, 2024). On the other hand, fluctuations in hard coal use, driven by government policies, renewable energy growth, and alternative fuels, may affect demand and supply dynamics (Gajdzik i in., 2023; Kaszyński and Kamiński, 2020).

The article presents research findings from semi-structured interviews with management from all Polish mining companies. Conducted between September and November 2022 amid a domestic coal shortage caused by the war in Ukraine, Poland still faces market instability.

Distribution is a key part of a company's marketing strategy. Along with product, price, and promotion, it forms the core of the marketing mix, helping align activities with market demands and customer expectations. Integrating these tools creates a cohesive and efficient marketing mix (Garbarski i in., 2001). Decisions regarding distribution channels are inherently strategic (Odlanicka-Poczobutt and Brodnicka, 2015), as the efficiency of these channels is determined by the balance between the outcomes they deliver and the associated operational costs (Altkorn and Kramer, 1998). Following Baran (2006) the effect broadly means any results compared to costs. Narrowly, it refers to company benefits without considering the costs incurred to achieve them.

The research aimed to understand how product quality and availability affect distribution efficiency in the coal market. Given changing conditions and mining challenges, it was crucial to examine how companies adapt strategies to customer demands and resource issues. The objectives were:

Analyze management strategies on coal production and distribution.

Assess the impact of coal quality on customer satisfaction and distribution.

Identify challenges related to coal availability and their business impact.

Evaluate the role of intermediaries in distribution.

Develop management recommendations for mining companies.

These objectives helped to address the following research questions:

1. What factors influence management's strategic decisions?
2. How does the quality of mined coal affect customer satisfaction?
3. What are the resource availability challenges faced by mining companies?
4. What is the role of intermediaries in the supply chain?
5. What recommendations may be made to management?

Literature Review

Theoretical foundations of distribution strategies in the mining sector

Maintaining a sufficient supply of hard coal is of great importance for ensuring the energy security of the country (Gawlik i in., 2016). Optimization of the mining sequence is also crucial for maximizing the net present value (NPV) of the coal mine (Liu i in., 2023). The effectiveness of the distribution strategy is crucially influenced by the quality and availability of raw materials (Gürsoy and Soner Kara, 2021; Wilson, 2011). Sustainable coal supply chain management is essential to minimize costs while meeting environmental standards. It requires considering both economic costs and environmental impacts of mining, transportation, and power generation (Naderi i in., 2020).

A common issue in coal supply chains is the “Bullwhip effect,” where demand distortions amplify upstream. Tackling causes like demand signal processing, batch ordering, price changes, and rationing can improve efficiency (Yun and Zhang, 2016). In particular accurately forecasting availability dates is crucial for the efficient execution of logistics operations, as it helps to reduce overall transportation and inventory expenses (Camur i in., 2024). The storage location problem in coal supply chains is complex due to diverse coal grades, zones, and balancing risk with return on capital. Advances in supply chain design can help optimize storage and distribution (Benalcazar i in., 2017).

Relationship between raw material quality, availability, and supply chain management

Research highlights that the profitability of distribution channels depends directly on customer satisfaction (Stern i in., 2002). The quality of coal sold plays a significant role in this satisfaction, especially when it meets contractual agreements. The research conducted by Widianti and Sabary (2019) confirmed that coal quality, aligned with agreement terms, improves customer satisfaction. Offering coal that meets customer expectations and maintains quality is crucial. However, hard coal’s unique characteristics depend on the deposit, with quality varying even within the same deposit. Mining enterprises may work several seams with different parameters, limiting but not eliminating the ability to influence product attributes. Research by Baica, Blaschke, and Gaja (2019) indicates that 90% of extracted coal undergoes processing or enrichment. Nycz (2000) highlights that the highest-quality product does not always attract buyers in the market. He emphasizes the importance of conducting the coal enrichment process in a way that maximizes the yield of concentrate with quality tailored to meet market demands. Cebo (2017) underlines that, ultimately, achieving optimal economic outcomes requires the product to be aligned with market requirements.

Literature studies have shown that product availability, alongside price and the quality of coal products, has a positive and significant impact on customer satisfaction (Widianti and Sabar, 2019). At the same time, it influences the size and distribution of stockpiles, thereby affecting the total logistics costs of distribution (Li i in., 2010). Widianti and Sabar (2019) also argue that ensuring the reliability of coal supply is a key concern for coal companies.

To effectively manage the relationship between raw material quality, availability, and supply chain performance, several strategies have been proposed. Putra et al. (2020) suggest that increasing the intensity of competition in the business environment forces organizations to optimize the performance of efficient supply chains to meet service levels and increase customer satisfaction. Badr and Ahmed (2023) recommend integrating sales forecasting, supply chain management, and inventory management technologies to make informed decisions on raw material needs and product manufacturing.

Risk management in the supply chain is another area where the quality and availability of raw materials play a key role. Maulidah (2020) points out that risk management in this context is related to supplier failure to deliver which may result in unmet demand from consumers.

From the customer's point of view, the total cost for the coal purchasing enterprise was calculated as the aggregate of expenses related to coal procurement (including purchase and transport), environmental protection measures, and the acquisition of CO2 emission allowances (Malec, 2024). Customer satisfaction also influences sales volume (Babakus i in., 2004; Mursalim i in., 2017). Research confirms that it depends on the quality of the product (Da i in., 2023; Kusuma i in., 2023; Taufik i in., 2022) as well as its availability (AL-Noorachi, 2013).

Materials and Methods

The research sample was purposive, based on holding an active coal mining license. All nine operational Polish mining enterprises were invited. Semi-structured interviews were conducted with management representatives, including senior leaders like company presidents and managers such as key account managers. Participants came from the following mining enterprises: Jastrzębska Spółka Węglowa S.A., Lubelski Węgiel Bogdanka S.A., POLSKA GRUPA GÓRNICZA S.A., Przedsiębiorstwo Górnicze "SILESIA" Sp. z o.o., TAURON Wydobycie S.A., WĘGLOKOKS KRAJ S.A. (in 2021, WĘGLOKOKS KRAJ Sp. z o.o.), Zakład Górniczy EKO-PLUS Sp. z o.o., Zakład Górniczy SILTECH Sp. z o.o.

The empirical research was conducted between September and November 2022 using a semi-structured in-depth interview, tested in a pilot study. Respondents were management staff, and the study aimed to characterize mining enterprises’ distribution strategies in 2021 and address key research questions. Due to the coal shortage caused by the war in Ukraine and government measures, the study period was extended to 2022. Respondents were asked about changes in coal distribution strategies during this time.

The recorded interviews were analyzed following the procedure described by Creswell (2013). The coding process involved a combination of thematic codes (established based on a literature review) and emergent codes identified during the analysis of the collected data. Coding was conducted manually.

Results

Production And Distribution Management Strategies

The shortest planning period for tailings plant production is one year, with monthly detailing cycles to meet current distribution and sales needs. (Rogala and Hochuł, 2018). Respondents emphasized that production plans are continuously adjusted, though this is difficult due to the mine's need for uninterrupted operation.

Respondents noted that inventory is both necessary and costly. It ensures supply reliability, provides a competitive advantage, and helps meet contract deadlines, avoiding penalties.

CM5: Of course, everyone builds this stock depending on their experience, needs and their own discretion, but this rhythm, ensuring these supplies is the most important thing in this whole chain. This effectiveness of these supplies is most often assessed during negotiations with a given contractor.

CM8: If there is no stock, there is no liquidity, regularity of shipments. Which is very important in regulating contract schedules, not to mention spots and maintaining quality in coal issuance and avoiding penalties, etc. (…) So everything has to run like clockwork. And for it to run like clockwork, there has to be a stock, a buffer regulating the continuity of shipments.

Inventory represents costs from product degradation (requiring re-screening or price reduction) and stockpile management, including handling, transport, space allocation, and infrastructure maintenance. Thus, companies aim to keep an optimal, technical inventory at the level of weekly sales.

The best quality coal does not always find customers due to physical and chemical limitations, which often determine the final buyers. However, customer loyalty can develop because of the product's specificity. Company profitability relies on demand from price-insensitive buyers or those with low bargaining power caused by high switching costs. According to Porter (1996), such demand enclaves are typical in declining markets. The decline of Poland's hard coal market was confirmed by Przedworska (2003), offering opportunities to sell via direct channels and influence final prices.

The impact of coal quality on distribution efficiency

The relationship between distribution channel profitability and customer satisfaction, as highlighted in the previously cited studies, remains a key factor in evaluating distribution efficiency. The quality of coal sold significantly and positively influences this satisfaction, especially when aligned with contractual terms. Providing coal that meets customer specifications and maintains high quality is therefore crucial. However, hard coal is a specific product, shaped by the deposit from which it is extracted, and its quality can vary even within a single deposit with multiple seams. Thus, controlling and adjusting product parameters is limited but not impossible.

In surveyed companies, some producers adjust coal quality by mixing pure coal with stone, a by-product of excavation, while others focus on achieving appropriate physical parameters like granulation. This highlights that coal enrichment should aim to maximize the output of market-suitable concentrate.

CM1: The product results only from the quality that is created. We have no influence on that; it is created underground. Sometimes it is better, sometimes it is worse. End. This coal itself, this black coal, is a very good product because that is how fate has decreed that there is good coal here. However, we sometimes pollute it, not really, because sometimes we drive over a stone, it all mixes and then we have a worse product, a better product and then the price is lower, the price is higher. There are no other criteria.

CM4: we created such a mixture... it currently has the X brand [author change], we created it with the participation of (…) coal produced by the Y company [author change], with a small addition. And it has such properties reducing dust and benzoalphapyrene emissions.

Another way to influence coal quality is through controlled mining in owned longwalls, though limited by geology. To meet customer needs, companies create blends using their own coal or combining it with coal from other mines. One firm produces a premium product with improved environmental properties tailored to specific users. This customization enables them to achieve higher unit prices.

Problems related to the availability of raw materials

Product availability depends on effective stock management, which is crucial in mining due to its operational specifics. Companies develop annual production plans based on capacity and expected sales, while considering factors like longwall continuity (to prevent rock mass tightening) and storage limits. Respondents noted that stockpiling is both necessary—for supply reliability—and costly. To balance this, they aim to maintain optimal, so-called technical or operational stock, typically at the level of weekly sales.

The research conducted has identified 4 strategies for dealing with excess stock which shows table 1.

Table 1: Strategies for dealing with excess stock

Strategy	**Coal Mine's example**
1. **waiting/speculation** - safely stockpiling coal and waiting for demand to rise to sell at higher prices.	CM8: There are months when we don't sell at all, because it's not profitable for us. We'll keep this coal in heaps, and if the price increases, we'll sell it for more. But it depends on the year, on the whole situation, on the macro, micro situation on the market.
2. **selling at any price** - when storage is full, offering coal at lower prices and leveraging contractor relationships.	CM1: I have to manage. They're just lying around, so we'll convince someone to pick them up. (...) so we look for them, call them, drive around, encourage them to buy from us. We encourage them with price, quality - that's good coal.
3. **renting external storage facilities** - using external facilities when internal yards reach capacity.	CM5: First of all, as I said, each mine has so-called mine dumps, where it is able to operationally store reserves, and secondly, some surplus, and if not – we rent external storage facilities.
4. **deposit** - storing coal purchased by contractors on mine heaps, with rotation to prevent degradation or spontaneous combustion.	CM8: Because now, yes, it is worth getting into something like deposits. (…) Because low-energy coal can be stored in reserve for a long time and it will not heat up, which means it is cheap to store. And you have to maintain such a fast warehouse rotation. That is, first use the oldest material, you know, FIFO, LIFO, etc. On the other hand, you can do anything with low-energy coal. You can even store it for 5 years and it will not change much there, and you can use it constantly and rely on it.

Source: Own research

Respondents were also asked whether they would be able to increase coal production if they saw an increase in demand. The majority of respondents admitted that this was virtually impossible. Reasons shows table 2:

Table 2: Reasons why coal production cannot be increased

Reason	**Coal Mine's example**
Bureaucracy, not allowing for a rapid increase in output	CM1: Yes, I can, but the bureaucracy is holding me back – sick bureaucracy, because tomorrow I can mine twice as much coal, and they're flying somewhere in New Zealand or Australia and they don't want to give me the papers.
Not enough workers willing to work at the bottom of the mine	CM2: But first of all, to mine more coal, that's the first basic thing, you need to have people to do it, and today there are no people to work in mining
The need to secure production with signed long-term contracts, the risk of spot sales (ad hoc, without a contract)	CM4: Well, I'll say no. No, to a very small extent, because none of us will risk selling spot coal. Looking at 2022, we should not have concluded contracts last year. And simply sell spot coal. Then the price would be the most efficient as with imports. However, no one can predict this, and leaving a mine that can store 300 thousand tons and extracts one and a half million without securing contracts is a quick end.

Lack of investment funding	CM7: No, not because you can't simply decrease/increase production with a button, because it is clearly defined in long-term time frames for infrastructure and investment reasons.

Source: Own research

Some respondents indicated that it was possible to adjust production volumes in a positive way. This was possible by:

- increasing the production of selected grades through changes in coal processing, allowing for a higher yield of grades desired at a given time, such as eco-pea;

- speeding up extraction on currently owned longwalls which carries the risk of depleting them more quickly and therefore carries the risk of shortages at a later date;

- planning in advance for additional 'emergency' longwalls that may be quickly brought into production.

CM6: We can change the type of coal we produce faster, due to some processing issues, or just crushing large lumps of cubes and nuts into peas, if necessary. It's more of a change in production parameters, but we can't quickly change the production volume.

CM8: We are able, we are able, because we can start an additional wall with better quality coal, an emergency one, which is always prepared somewhere, if there is a greater demand, that's one, and two, if it turns out that there is a risk that this wall will have a breakdown, that something will happen.

The role of intermediaries in the supply chain

In shaping the quality of the product, the role of intermediaries was highlighted in the interviews:

CM3: And that's why we need [intermediaries], because they are definitely more mobile - our sales network, yes. Because their activity is not only about redistributing coal, but also creating mixtures, producing eco-pea coal, which is currently causing sleepless nights for everyone.

CM8: Apart from that, intermediaries also do it, they buy coal from us as a semi-finished product and enrich it with various other things.

Often, contracts require accepting coal grades defined by producers or limited to the mine's available quality, which may not meet end-user needs. Intermediaries, equipped with yards and tools (e.g. crushers, loaders, bagging machines), adapt the product to boost sales. They act as a crucial link, tailoring coal to final customer requirements.

However, more often than not, it was emphasized that the product from a physical and chemical point of view must already be adapted by the mining company to the final buyer:

CM5: The quality, as I said, may not be the best, it is good, it is high, but it meets the current requirements of coking plants, it is tested in mixtures.

CM7: Coal is a product that can only be slightly enriched, but there is no possibility of changing its so-called parameter. In a sense, these are parameters, such as sulfur, that are unmodifiable, so we have no influence on the sulfur parameter. Therefore, coal with high sulfur can only be burned by recipients with desulfurization installations.

Coking coal, or coal with a high sulfur content, cannot be burned in standard installations. It is necessary to use appropriate filters or suitably adapted boilers.

Discussion

The conducted research allowed for an in-depth analysis of distribution strategies in the Polish hard coal mining sector and the identification of challenges arising from resource availability and quality. These findings align with existing literature, confirming the critical role of coal quality in shaping customer satisfaction and the efficiency of distribution channels (see Widianti and Sabar, 2019; Nycz, 2000). Simultaneously, the results underscore the importance of optimizing inventory management which supports the conclusions of Gawlik et al. (2016) regarding the role of energy security in Poland.

Resource constraints and the need to adapt to dynamic market changes, driven in part by the war in Ukraine, compelled companies to seek new solutions. Respondents identified four strategies for managing excess stock, each with its limitations and requiring further research into their effectiveness under varying market conditions.

The analysis of coal quality and its impact on distribution efficiency highlights the limited ability to modify resource parameters due to their specific geological characteristics. However, creating blends with improved quality parameters proved to be a significant way to tailor products to customer needs, enabling higher profit margins. These findings complement earlier studies by Cebo (2017) and Widianti and Sabar (2019), emphasizing the growing importance of coal enrichment processes in enhancing its market value.

The discussion on the role of intermediaries in the supply chain reveals their importance as a link between producers and end customers. Intermediaries, with their ability to adapt resource parameters, play a crucial role in ensuring flexibility and competitiveness across the entire supply chain. This underscores the need for further research into how their activities impact the overall efficiency of the logistics system.

Despite the obtained results, the study has its limitations. Its static nature did not allow for capturing the dynamics of changes over a longer period, and the limited number of respondents precluded the use of more advanced analytical methods. Nevertheless, the findings provide a solid foundation for further analyses of the efficiency of distribution strategies in sectors facing specific market challenges.

Conclusion

The study met its objectives by analyzing factors influencing distribution efficiency in the Polish coal mining sector. Key elements included coal quality, availability, and strategic management. High-quality coal was crucial for customer satisfaction and effective distribution, while sound inventory practices ensured continuity and cost control.

The research identified four stock management strategies and emphasized the role of intermediaries in enhancing product adaptability and supply chain flexibility. These insights inform efforts to improve efficiency in declining markets like the Polish coal industry.

Recommendations for managers include regularly updating production and distribution strategies, investing in technologies to improve coal quality, and tailoring products to customer preferences. Creating coal blends and conducting satisfaction surveys may enhance competitiveness and loyalty.

Effective inventory systems are essential to reduce costs and maintain supply. Firms should apply diverse strategies for surplus management and prepare long-term plans responsive to market demand. Building ties with intermediaries can further support product customization and adaptability. Direct sales may also help reduce costs and increase margins.

In summary, applying these recommendations may improve the operational efficiency and market position of Polish coal companies. Ongoing market monitoring and strategic adaptation remain critical.

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