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Progressive Management of Hydroelectricity Interruptions in Zambian Manufacturing Businesses

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ABSTRACT
Interruptions in hydroelectric energy damage equipment and reduce worker productivity. Manufacturing leaders in Zambia who fail to implement strategies to manage hydroelectricity interruptions risk financial losses. Grounded in the contingency theory (CT), the purpose of this qualitative multiple-case study was to explore strategies that some manufacturing leaders use to manage hydroelectricity interruptions. The participants were six managers from different manufacturing industries based in Lusaka, Zambia, who implemented strategies to manage hydropower interruptions. Data collection involved semi-structured interviews and reviews of company documents, company websites, and publications from the Zambia Association of Manufacturers related to managing hydroelectricity power interruptions. Thematic analysis was used to understand and discern the data. The important emergent theme was the importance of investment in stabilizers and storage facilities. A key recommendation from the findings, is to ensure an appropriate level of investment in alternative power-generating equipment and upgrading of plant transformers. The investment and the strategic outcomes from substantive investments in preventing energy disruptions are in the impetus for job creation, and the consequent positive social change with arising from fueling the local economy and subsequent tax base.

Introduction

Africa is experiencing unprecedented growth and change. The stumbling block however is the frequent interruptions of hydroelectricity-generated power in Zambia. The disruptions adversely and severely exact manufacturing and business operations. The losses attributed to these disruptions are well documented and lead to financial losses in the manufacturing sector (NamPower, 2018).

A study of 12,452 small-scale enterprises in Zambia revealed that the average revenue loss per firm resulting from hydroelectric interruptions was K 19,251, with 22.8% of firms reporting cases of idle labor, 29.9% reporting equipment damage, and 7.6% reporting reduced working hours (Mwila et al., 2017).

The major business problem found, was that the interruptions of the hydroelectric power supply caused operational interference and financial loss in the Zambian manufacturing sector. Narrowing down the problem to understand the challenges at a local level, we found there to be potential for some manufacturing leaders to improve strategies to manage hydroelectricity interruptions.

The research questions are elaborated as follows:

Central Research Question

The key research question for this endeavor was to explore and understand: What strategies do manufacturing leaders use to manage hydroelectricity interruptions?

Interview Question

The important Interview Question congruent with the central research question was:

1. What, if any, were the key barriers to implementing strategies to manage hydroelectricity interruptions, and how were the ensuing challenges addressed?

Review of Diversity in Scholarly and Practitioner Thoughts

The CT of locational entails an explicit understanding of the organization's structure and the environment, which provides the essential framework for organizational design (Donaldson, 2008). The theory postulations indicates that effective organizational structures are those that meet the adaptiveness imperatives of the business environment (Fiedler, 1964). Successful organizations evaluate their external environment in line with the entities; conditions, events, and factors surrounding the organization (Donaldson, 2008; Ha & Pasch, 2019).

Organizations relate to numerous environments regarding a peculiar setting in terms of uncertainty and the rate of change is in response to their markets and technological advancements in the industry regarding internal and external structures of the organization (Ha & Pasch, 2019). However, some ignore factors like government influence, market dynamics, and human resources by characterizing them in terms of certainty and the nature of their complexity. The result is having environments clustered into two bands of either being standardized/mixed or unwavering/fluctuating (Ha & Pasch, 2019). Organizational interactions with its environment demand a balance between set objectives and the setting of its internal and external structures.

A fundamental principle of locational understanding is that a specific environmental feature disturbs all businesses in a comparable mode of operations (Ha & Pasch, 2019). A leadership style that disregards the tactical choice element neglects essential factors, vital to achieve the optimum results being sought after by the business. Therefore, emphasizing the importance of analyzing two factors in decision-making of internal and external environmental influence on business operations. It is, therefore, critical to establish and understand the connection of the organization to the environment in detailed and accurate ways. Because the organization's environment changes over a period and needs to adapt (Ayoko & Ashkanasy, 2019). The organizational environment influences how businesses are conducted, and it is often best to understand how the business may be shaped and used to achieve an optimum desired result(s).

The CT of locational understanding informs how leaders prioritize the purpose of the organization and stay focused and on course. Essential to the theory is to understand factors that influence the location of the business in line with technology, political conditions, legal conditions, cultural, demographic, ecological, and economic standing (Commendatore et al., 2020). Businesses that create stable environmental conditions usually are known to optimize productivity and utilization of resources such as hydropower which is essential to minimize costs and maximize profits in the manufacturing industry. However, when faced with rigid structures and the organizational environment starts to change, it may necessitate the need to change, adapt, and optimize activities, to minimize costs and maximize profits.

The idea of locational understanding supports organizational innovation and adaptation as an early CT of managing environmental factors (Harrison, 2020). The importance of perception to understand the environment provides information for decision-making (Donaldson, 2013). Donaldson (2013) stated that business leaders are uncertain when they do not have the information, they need to make good organizational decisions, while the certainty of information points to opportunities. A system must therefore embrace the array of environmental segments with which a business network.

Emerging Trends in Hydropower Interruptions and Influence on Manufacturing Sectors

Current measures being considered to address hydroelectric power interruptions are not independent but dependent on other drivers. An optimum solution may resolve the aspects considered above, i.e., environmental impact, and business needs of manufacturers. To administer the demands intensifying in the manufacturing industry, suitable rationing may be reallocated proportionately to all the occupied time windows grounded on the typical hydropower consumption (Bharathi et al., 2017). Such interferences may therefore be done accommodatingly by influencing the loads using what Bharathi et al. (2017) identifies as the demand side management (DSM) technique.

The goal for manufacturing leaders is logically to minimize hydropower consumption throughout the hydroelectric power rush hour by commendably allocating the available hydropower when demand is low. Any maximization or minimization challenges may be addressed proficiently using a situational CT of the evolutionary system. However, the challenge is that the manufacturing sector needs a solution before the industry collapses due to the shortfall and lack of constant and stable hydroelectric power supply. In 2015 and 2016 alone, Zambia's hydroelectric power generation and distribution company ZESCO (Zambia Electricity and Supply Cooperation) introduced a countrywide load shedding for a duration of 8.00 hours a day (Ahmed et al., 2019).

In the same period, the sector's poor performance was attributed to the high cost of production due to hydropower interruptions (Ahmed et al., 2019). Machado and Bhagwat (2020) introduced a concept of cost-sharing using the insurance call option obligation (ICO). The ICO is a strategy to transfer risks associated with hydropower generation to consumers. The result is that it may drive significant wealth from manufacturers to hydropower generators impacting the margins of the manufacturing sector negatively.

The willingness of manufacturers to pay for reduced load shedding corresponds to a tariff increase of 16% (Carlsson et al., 2020). Moreover, the willingness to pay for the average length of load shedding by one hour corresponds to an increase of 33% (Ahmed et al., 2019; Carlsson et al., 2020). This means that the cost to the manufacturer would instantly increase by 33% i.e., before accounting for other variable costs of production. The manufacturing sector besides lost 15% of productivity due to hydropower interruptions in 2012, and small and medium manufacturing businesses lost between 4.2% and 4.7% (Ahmed et al., 2019; Cissokho, 2019). To improve the margins, manufacturing leaders may consider the use of CT of task structure for clear directions and approach to task completion. Task structure may improve the productivity levels of the business sector by scheduling production lines with a focus on achieving the desired daily production and avoiding unplanned downtimes due to load shedding.

Managing hydroelectric power supply due to challenges in generation and distribution affects business productivity. Bharathi et al. (2017) assessed businesses in line with their usage of hydroelectric power and its bearing on productivity and the community. To strike an equilibrium and satisfy both the manufacturing sector and domestic demand, it is essential to consider the concept of evolutionary or situational contingency theory. Bharathi et al. (2017) recommend the notion of the evolutionary system to be amended to difficulties where optimization is the fundamental yardstick.

To optimize and address, most of the challenges of load shedding, hydropower utility companies need to invest in technology to manage Load Redistribution (RL) to consumers (Bharathi et al. 2017; Ge, 2019). However, the investment in technology not only escalates the cost of providing and dispensing hydropower but also conveys risks such as cyber-attacks and false data injection (Ge, 2019; Xiang et al., 2017). Addressing these challenges may provide indicators on how manufacturing leaders may add toward economic consumption and elimination of wastage may be managed in times of high load shedding experienced by the industry.

Increased load shedding may have a negative influence on the profit margins of the manufacturing sector. Wang et al. (2018) considered the influence of hydropower interruptions on manufacturing industries profit ratios using arithmetical simulations of hydroelectric power constraints, green scientific advancement, and production profit ratios. The result is that there is a non-linear correlation concerning energy restrictions and business profit ratios (Wang et al., 2018). However, for highly computerized organizations the connection is U-shaped; while for those that are heavy on

mechanical or less teach the connection is N-shaped (Wang et al., 2018). Arguably, if good hydropower policies are in place, it may improve the profits of the manufacturing sector and champion environmental initiatives that are eco-friendly. Although most African government hydropower strategies have not comprehended the important practical consequences, good hydropower strategies should be implemented to fit into the qualities of different areas and industries (Wang et al., 2018). These strategies may result in contributions to good environmentally friendly business policies and support industry technological development such as those of the manufacturing sector to improve productivity. Besides, hydroelectric power tariffs differ by the nature of the consumer, i.e., domestic, commercial, and manufacturing connections, and currently the cost to supply hydroelectricity fluctuates minute by minute, (Akil, 2019). The differentiation of tariffs by industry sector is essential and provides good policy guidelines in terms of client segmentation.

Energy Constraints and Manufacturing Business Decisions

Energy constraints such as hydroelectric power interruptions have an impact on business decisions such as scheduling production times and workforce shifts. Wang et al. (2018) examine how energy constraints affect business decisions and stated that there is a general nonlinear relationship between energy constraints and business rations. Therefore, it is essential to appreciate that some entities can be related to each other concerning production downtime due to power shortages. On the other hand, the cost of electricity is one significant input to product costing in the manufacturing sector (Hoare, 2017). However, the ever-increasing costs of hydropower may also be associated with many factors at both regional and national levels regarding government policies. Saadi et al. (2015) introduced the opportunity for comparison of regional cooperation's promoting trade and renewable energy deployment. This would create favorable market conditions for solar and wind technologies, however, the question that is not addressed is the extra costs associated with such investments and its impact on the manufacturer if countries decide to deploy more fossil-based power-generated solutions while using hydroelectric power resources to mainly meet domestic demand.

It is essential to analyze the effect of wind and hydropower on wholesale electricity prices because of the high penetration of renewable energy, and the availability of data on water stored in dams. The aspects of consistency about hydroelectric power plants behaving strategically and, giving zero marginal cost may be the future and address the concerns of the consumers (Pereira et al., 2017). Therefore, complementing other intermittent renewables, are not only operationally, but also on an economic level. Consideration of renewable energy as a solution to most businesses in southern Africa may be an alternative for manufacturing businesses. Eales et al. (2017) elaborate on business challenges concerning limited resources and lack of local capacity to implement alternative renewable energy sources, highlighting the indirect cost of renewable energy that would need to be controlled by businesses before switching from hydropower.

Alternative renewable energy may be an option for most companies as far as load shedding is concerned in southern Africa. It is therefore essential to consider indirect costs which cannot be overlooked and may need to be prioritized just as direct costs, primarily associated with enhancing the supply of hydroelectric power (Eales et al., 2017). Essential to alternative energy is the consideration of policy regarding the supply of hydroelectric power to the grid. Shu et al. (2017) demonstrated that essential tools are critical for simulating the impact of public policy on the adoption of smart grid technology for electric utilities to determine utility pricing and manage the costs to consumers. It is evident that investment in energy infrastructure comes at a high price and may need engaging different valuation models for both costing and pricing, an essential consideration for the manufacturing industry.

Principal Theme: Investment in Stabilizers and Storage Facilities to Manage Power Fluctuations Critical

The principal theme that emerged from the analysis of the interview data was that investment in stabilizers and storage facilities to manage power fluctuations is critical.

Four participants out of six representing 67% of the target population responded to the Interview Question: If any, what key barriers to implementing strategies and how were any key barriers addressed? And what additional information, if any, can you share regarding your strategies to manage hydroelectricity interruption? Sixty-seven percent of the participants agreed that investment in stabilizers and storage facilities to manage hydropower interruptions was a strategy they used. The participants were assigned codes of Pax01 to 06 respectively.

Pax01 stated

Investing in additional equipment to stabilize power fluctuations and protect plants and equipment is essential. Investments in capacitors to stabilize power or create false leverage when starting equipment so as not to cause harm or interrupt the distribution of energy during production.

Pax02 mentioned

That part of product input is through the suppliers. It needs to consider the equipment designs that influenced investment in plant facilities to manage power interruptions and boost production.

Pax04 further stated

Mastering the power availability timetable was not easy and working around it was ineffective. To this end, it was critical to invest in stabilizers and storage facilities. To maximize production, we store power on different power storage devices for use when we experience load shedding.

Pax06 mentioned

Investment in a solar project was opted for, but we shelved it due to the unavailability of funds. At the time, we faced challenges of getting the power utility to agree to sign us up for a 1MV on-grid solar plant that would have almost halved the cost of the projects due to the elimination of storage batteries.

Pax03 stated that

We opted for a diesel generator due to its stable and reliable power output as compared to other power sources like solar power, which may not give a reliable power output due to factors like changes in the weather pattern.

Pax05

Did not cite the theme but cited that "from inception, we used only one strategy we thought was effective (diesel generator).

Correlation to the Literature and Conceptual Framework

To continue being relevant and authentic in all business undertakings, organizations or individuals may need to understand and analyze their internal environment or inner-self and act according to the demands of the internal

arrangements (Bhattacharyya, 2020). Internal practices relate to total productivity, continuous flow, maintenance, and process controls (Csaszar & Ostler, 2020; Negrão, 2019) within the organization's management.

The principal emergent theme aligned with many views expressed and uncovered in the literature review on decision making, leadership, team management, authenticity, innovation, and information technology. When faced with no uniform view on the innovative design, leaders may be forced to prioritize change in terms of three crucial elements (Kwadade-Cudjoe, 2020; Zhao & Sheng, 2019): purposes of the innovation, the political environment for the sought innovation, and the processes.

Innovation brings about transformation, and adaptation. For innovative ideas to be implemented, there must be visibly striking encouragement from leaders and proper use of information management technology. Every manufacturer has a model for its operations based on a specific need of the model (Micieta et al., 2020). Modern-day manufacturers must be open to changes and consider locational understanding (fit for purpose) decisions (Csaszar & Ostler, 2020). When investing in storage facilities to manage power interruptions and safeguard equipment, understanding the cost of investment becomes essential (Hoare, 2017); therefore, leaders in the manufacturing sector may need to decide based on the returns on investment because the initial cost of investment eventually ends up in the final output. To summarize the manufacturing sector may overcome barriers by investing in equipment that stabilize power fluctuations and consider equipment designs influencing the investment in line with production demand and facilities.

Applications to Professional Practice

The application of the study to professional practice could be beneficial for managers in the manufacturing industry in charge of strategy to manage hydropower interruptions. Additionally, the study may provide information to the business environment, address issues of managing production downtime, increase productivity through managing stock gaps, control costs, investment decision-making, job creation, and satisfaction, and improve the livelihoods of communities employed in the manufacturing sector. My study findings apply to the manufacturing industry's professional practice because it provides in-depth analysis and understanding that there is no universal or one best way to manage a business. Organizations' systems should fit within the business environment. Businesses should be concerned with accomplishing goals and objectives by aligning their strategies, practices, techniques, technologies, and adequately designing systems to meet the current needs (Woodward, 1981). Thus, it is essential for managers in the manufacturing sector to carefully consider systems integration and the immediate need for alternative power sources that operate using solar energy or generators. The strategies may be aligned in response to market demands for products to address stock gaps while focusing on quality and meeting customer requirements.

Implications for Social Change

The qualitative multiple case study findings on strategies to manage hydroelectricity interruptions in Zambian manufacturing businesses may contributes to social change by stimulating and appreciating essential leadership strategies within the manufacturing sector. Okta et al. (2021) reviewed the connection concerning current arrangements of operational transformation in a country's economy 101 and poverty reduction. Managing supply chain relationships may reduce youth unemployment levels and reduce poverty and inequality while diversifying the small-medium enterprises (SMEs); the result may contribute to the well-being of the communities, more job openings, and boost economic activities at both community and national level.

Recommendations for Further Research

In this qualitative multiple case study, the aim was to explore strategies to manage hydroelectricity interruptions in the Zambian manufacturing sector. The target population was six senior managers who have proven success in managing hydropower interruptions. For further research and knowledge to be added to the manufacturing industry, I recommend increasing the target population sample and a different research design and methodology. A mixed-method study approach may be valuable to address the quantitative aspects of the study. I would recommend considering other operational staff eliminating the restraints of data collection. I focused on manufacturers based in Lusaka, Zambia, and consideration of other cities would broaden the results. I would further recommend future research to consider different industries beyond the manufacturing sector that are challenged with power interruptions and non-strategic staff to examine the impact of power interruptions on businesses (i.e., small to medium enterprises (SMEs). Finally, I would also recommend research to include the influence of climate change and the use of alternative renewable energy to manage hydropower interruptions for business sustainability purposes.

Conclusion

Hydro energy demand is increasing significantly from 590 TWh to 3,100 TWh, whereas the installed capacity is expected to grow from 120 GW to 700 GW (Programme for Infrastructure Development in Africa, 2019). This implied that significant investment in hydropower and other renewable energy supply initiatives is required to meet future demand. There is no single best way of managing a business. Organizations should align themselves to the evolutionary decision-making attributed to the challenges faced. The use of leadership style, decision-making, and locational understanding proved to be efficient management styles to achieve the organizational targets and objectives of the manufacturer. In addition, having an environment that aligns well with the demands of the organization and is task-oriented to motivate employees and enhance job satisfaction.

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