The Impact of Rail Transport on Transport and Logistics Efficiency in Zimbabwe: A Network Theory Perspective

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Abstract: *This study examined the extent to which rail transport influences the efficiency of transport and logistics in Zimbabwe. Grounded in network theory, the research adopted a pragmatic philosophy combining positivist and interpretivist approaches. A quantitative explanatory design was used to test the relationship between rail transport operations as the independent variable and transport /logistics efficiency as the dependent variable. Primary data were collected from 180 valid questionnaire respondents and 8 key informant interviews, supplemented by secondary document analysis. Quantitative data were analysed using SPSSv21, including descriptive statistics, exploratory factor analysis (EFA), and hypothesis testing, while interview data were thematically analysed. The study found that rail transport positively and significantly impacts transport and logistics efficiency. Key findings include deteriorating rail infrastructure, critical modernisation needs such as signaling, rolling stock, track rehabilitation, operational challenges such as regulatory bottlenecks, poor service reliability, comparative cost and energy advantages of rail over road, and positive socio-economic implications for local communities and businesses. The study concludes and recommends that strategic investment in rail transport, supported by enabling policies, is essential for improving Zimbabwe's logistics performance.*

Keywords: *rail transport, rail infrastructure, transport logics, network theory*

1. Introduction

Efficient transport and logistics systems are fundamental drivers of economic growth, regional integration and social development (Zheng, 2024) particularly for landlocked countries such as Zimbabwe. Positioned in Southern Sahara, Zimbabwe relies heavily on its transport corridors, road, rail and intermodal connections to facilitate domestic trade, access regional markets through the ports of Durban, Beira and Dares Salaam and support key economic sectors including mining, agriculture and manufacturing. Colonial rule across much of Africa left a legacy of primary commodity export economies and associated railway networks that were explicitly configured to sustain that pattern of production (Mhlanga, 2020).

The SADC region possesses an extensive but uneven rail network linking landlocked countries to seaports and regional markets (Bouraima et al., 2023). Much of this infrastructure was historically developed to support extractive industries, resulting in export-oriented corridors rather than integrated regional systems (Bagwandeen, 2023). Although the network has strong potential to support sustainable and efficient transport, it currently operates below capacity and lacks integration across national systems (Mulke et al., 2024). This fragmentation significantly affects logistics efficiency.

Historically, Zimbabwe possessed one of the most developed rail networks in sub-Saharan Africa, operated primarily by the National Railways of Zimbabwe (NRZ). The rail system served as a cost-effective bulk carrier for goods such as chrome, coal, grain, and fuel, while also relieving congestion on road networks. However, decades of economic challenges, underinvestment, policy inconsistency, and ageing infrastructure have severely eroded the operational capacity and reliability of rail transport. Concomitantly, road transport has increasingly dominated the logistics landscape, leading to higher vehicle operating costs, accelerated road deterioration, carbon emissions and safety concerns (ADB, 2022). The collapse of alternative low-emission modes, such as the national rail system, coupled with systemic underinvestment and fragmented regulation, has severely constrained the development of a sustainable logistics system in Zimbabwe (Kanyepe & Manyanga, 2026).

Despite the theoretical advantages of rail transport, including higher energy efficiency, lower costs for bulk commodities, and lower environmental impact, the actual contribution of rail transport to transport and logistics efficiency in Zimbabwe remains underexplored. Stakeholders continue to debate whether rail still offers a viable efficiency advantage over road given its state of despair, or whether modernization could reverse declining performance. This knowledge gap necessitates a systematic investigation, hence this research study.

2. Statement of the Problem

Despite the growing recognition of rail transport as a strategic driver of economic transformation, empirical research focusing specifically on Zimbabwe remains limited and fragmented. Existing studies tend to examine isolated aspects of rail transport such as infrastructure conditions or economic contributions without providing an integrated analysis of how multiple factors like infrastructure quality, regulatory efficiency, investment levels, and operational performance, collectively influence transport and logistics efficiency. This lack of a holistic analytical framework limits the ability of policymakers and stakeholders to design effective interventions for revitalising the rail sector. Despite its importance, the rail sector is hindered by systemic inefficiencies, outdated infrastructure, and high operational costs that undermine Zimbabwe's competitiveness in both regional and global markets.

Despite being a critical conduit for regional trade and domestic economic recovery, Zimbabwe's transport and logistics sector remains constrained by fragmented technological adoption, underdeveloped sustainability frameworks, and fragile resilience mechanisms. This disjuncture between operational demands and infrastructural reality perpetuates inefficiencies, supply chain vulnerabilities, and an inability to adapt to climate-induced disruptions or post-pandemic economic shocks. Consequently, there is an urgent scholarly and practical need to systematically examine how the impact of rail transport on transport and logistics in Zimbabwe in a bid to fundamentally reshape the sector's trajectory.

3. Research questions

1.To what extent do rail transport operations (infrastructure quality, service reliability and frequency) predict the overall efficiency of transport and logistics in Zimbabwe?

2.How do operational challenges mediate the comparative advantages of rail transport over road transport in improving logistics network performance in Zimbabwe?

4. Theoretical Frameworks

This study was grounded in the Network theory which conceptualises transport systems as interconnected nodes and links. The Network Theory models complex systems as a web of interconnected entities, focusing on the relationships between them rather than the isolated properties of the parts (Rashid & Kim, 2023). Efficiency depends on connectivity, flow capacity, redundancy and coordination. Rail transport, as a fixed network, benefits from economies of scale and density, but its efficiency is contingent on infrastructure quality, scheduling integration and intermodal connections. Logistics efficiency encompasses cost, time, reliability, safety and environmental impact. Logistics efficiency refers to the ability to deliver goods at minimum cost, shortest time, highest reliability (consistency of transit time and condition), lowest accident risk, and least environmental damage per unit of freight moved (Beresford, 2014). Rail transport offers high volume-carrying capacity, lower energy consumption per ton-kilometre and reduced congestion compared to road (Rodrgue, 2020). However, these advantages are realised only when infrastructure is well maintained and operations are predictable.

5. Literature

Recent studies have further demonstrated that railway infrastructure can reshape economic activity by influencing the spatial distribution of industries and urban development. Ivanov & Dolgui, (2020); Notteboom & Rodrigue, (2021), and Christopher (2022) found that improvements in rail infrastructure significantly affect industrial location decisions, land values, and economic clustering patterns, particularly in inland regions. This suggests that rail infrastructure not only supports existing economic activities but also actively shapes the structure and geography of economic development. However, Kowalski et al. (2024) argues that infrastructure investment alone does not guarantee economic growth unless accompanied by effective institutional frameworks, operational efficiency, and complementary policies. This highlights the importance of considering rail infrastructure within a broader systemic context.

Although the National Railways of Zimbabwe has made notable progress in refurbishing wagons and locomotives through its ongoing public-private partnership with Zimasco, improving operational efficiency and reinforcing rail as a preferred mode of bulk cargo transport (Tshuma, 2026), this has remained a dream. Zimbabwe's crumbling railway system, once the backbone of the economy, has become a major obstacle to growth, inflating transport costs, stifling exports, and threatening emerging sectors such as lithium and tobacco. The inefficiency is forcing companies to rely on costly road haulage (Business Times, 2025). Lithium producers, whose output is forecast to reach 10 million tons in three years, are particularly hard-hit. Transporting lithium from mines to ports can cost up to US$1,500 per ton, eroding Zimbabwe's competitiveness in the global market. Tobacco exporters are also losing out. "It costs US$6,000 to move a container from Harare to Durban, while the Chinese pay US$2,000 to move a container from China to Chicago. This shows the structural drag on the economy.

Agamez-Arias & Moyano-Fuentes (2017) conducted research in the field of intermodal transport systems and the efficiency gains over single mode transport. The basic modelling objectives were to reduce transportation costs and delivery times. However, these parameters cannot be considered in isolation. They identified that a relationship exists between the elements in the logistic chain, being the products, infrastructure locations, transport modes and various other criteria. In addition, infrastructure location influences distance, freight flows and volumes. The loading unit itself also has its own set of characteristics, that are addressed by planning models.

As the cost of transport of their goods to market becomes more significant, companies must consider alternative modes and combinations of modes of transport to stay competitive, (Racunica & Wynter, 2005). Railways have enjoyed an advantage over road in movement of bulk commodities. Railways can no longer rely on this type of business where they could operate without significant competition from other modes. The rail mode has specific advantages over road depending on distance, weight, parcel size and flexibility requirements. The same holds true for road regarding its specific advantages as a mode. Economic benefits accrue to the rail mode as distance and volume increase, whereas road gains an advantage where flexibility is more valued. Flexibility could be origin-destination flexibility or time flexibility, therefore perpetuating the intermodal hub and spoke model (Reddy, 2025).

6. Research Methodology

The study adopted a pragmatic research philosophy where both quantitative and qualitative elements were combined. Pragmatists value both the objective quantitative worldview and the subjective experience of stakeholders. They situate the research problem within its specific context (Foster, 2024). The suitability of pragmatism as a guiding philosophical research paradigm in this case is significant as it "places high regard for the reality of and influence of inner world of human experience in action (and where) knowledge is viewed as being both constructed and based on the reality of the world we experience and live in" (Johnson & Onwighbuzie, 2004:18). A quantitative explanatory design was used to explain the relationship between independent variable, rail transport operations and dependant variable, efficiency of transport and logistics (Tenkir, 2021). For data collection, primary data was collected using questionnaires and semi-structured interviews. Secondary data was collected using document analysis (NRZ performance reports, Ministry of Transport policy papers, World Bank logistics indicators). Bowen affirms that:

The rationale for document analysis lies in its role in methodological and data triangulation, the immense value of documents in case study research, and its usefulness as a stand-alone method for specialised forms of qualitative research. In other types of research, the investigator should guard against over-reliance on documents (Bowen, 2009:29).

Quantitative data analysis was done using SPSS v21 for descriptive statistics and reliability was tested using Cronbach's alpha. Validity was tested using pilot testing and hypothesis was tested using regression analysis.

7. Findings and discussion

Operational challenges faced by the rail transport sector

The mean scores and standard deviations for items that were used to analyze the operational challenges faced by the rail transport sector, including regulatory issues and service reliability, are presented in Table 1:

Table 1: Operational challenges faced by the rail transport sector

Item Code	Item description	Mean Score	Mean Response	Std. Deviation
D1	Poor maintenance- Lack of regular repairs and maintenance has resulted in the deterioration of track, signalling, and telecommunication systems	4.21	Agree	0.711
D2	Underfunding- Insufficient capital for improvements and rehabilitation means infrastructure remains old and needs extensive repair	4.35	Agree	0.660
D3	Equipment issues- Depreciation and a lack of spare parts for locomotives and wagons mean equipment is often unreliable. This has led to a reduced service capacity	4.31	Agree	0.744
D4	Single-track lines- Most rail lines are single-track, which limits the efficiency of operations	4.19	Agree	0.782

D5	Government interference- The National Railways of Zimbabwe (NRZ) has faced government interference in management, impacting its operational autonomy	4.12	Agree	0.723
	Overall	4.24	Agree	0.724

Source: Survey data (2025)

From Table 1 above, an overall mean score and standard deviation of (M=4.24; SD=0.724) was found, indicating that respondents agreed to a greater extent that there are operational challenges faced by the rail transport sector in Zimbabwe, which include regulatory issues and service reliability. In addition, the mean responses ranged between (M=4.12, SD = 0.723) and (M=4.35, SD=0.660). Additionally, the results from the questionnaire agree with those gathered from interviews, for instance, Respondent 3 said, "The National Railways of Zimbabwe (NRZ) has faced government interference in management, impacting its operational autonomy," Respondent 6 also said, "Most rail lines are single-track, which limits the efficiency of operations." Respondent 8 went further to say, "Insufficient capital for improvements and rehabilitation means infrastructure remains old and needs extensive repair." Findings from the primary data agree with literature, according to United Nations, (2018) problems of under-investment or no investment in railway infrastructure, and of misconceived, inappropriate or poor-quality railway infrastructure, are often influenced by geopolitics, national and local politics, and economic and financial interests (United Nations, 2018). Moyo & Chitiga (2022) labelled regulatory inefficiencies and maintenance backlogs as inhibiting service delivery and investment.

Comparative advantages of rail transportation over other modes of transport regarding cost and efficiency

The results on items that were used to explore the comparative advantages of rail transportation over other modes of transport regarding cost and efficiency are presented in Table 2.

Table 2: Comparative advantages of rail transportation over other modes of transport regarding cost and efficiency

Item Code	Item description	Mean Score	Mean Response	Std. Deviation
E1	Cost-effective for bulk goods- Rail is significantly cheaper than trucking for moving large quantities of heavy or voluminous cargo like minerals, grain, or construction materials over long distances	4.55	Agree	0.783
E2	Lower per-unit cost- Transporting goods by rail lowers the cost per unit of cargo for large shipments	3.16	Agree	0.799
E3	More stable operating costs- The costs of rail freight are often more stable and predictable than air freight, which can be heavily influenced by fuel prices and airport fees	3.82	Agree	0.832
E4	Fuel efficiency- Rail is more fuel-efficient than road transport, with a single train able to move a ton of freight much farther on the same amount of fuel	3.45	Agree	0.807
E5	Reduced congestion- Shifting freight from roads to rail reduces traffic congestion, which can improve overall road network efficiency.	3.77	Agree	0.899
	Overall	3.75	Agree	0.824

Source: Survey data (2025)

As can be seen in Table 2, an overall mean score and standard deviation of (M=3.75; SD =0.824) were found. In addition, the mean responses and standard deviation for all items ranged between (M=3.16, SD = 0.779) and (M=4.55, SD = 0.783) imply that respondents agreed that there are comparative advantages of rail transportation over other modes of transport regarding cost and efficiency. This is in line with the 10 interviews that were conducted, for example Respondent 4 said, "Rail is significantly cheaper than trucking for moving large quantities of heavy or voluminous cargo like minerals, grain, or construction materials over long

distances", Respondent 7 said, "Rail is more fuel-efficient than road transport, with a single train able to move a ton of freight much farther on the same amount of fuel." and Respondent 8 also said, "The costs of rail freight are often more stable and predictable than air freight, which can be heavily influenced by fuel prices and airport fees." The primary data also agree with secondary data gathered in this research, according to World Bank, (2020), the railways in Zimbabwe are a critical transportation mode for the mining, agricultural and manufacturing industries in the country. The main mining products are coal, chromium ore, asbestos, gold, nickel, copper, iron ore, vanadium, lithium, clay, tin, platinum group metals and numerous metallic and non-metallic ores; the main agricultural products are maize, cotton, tobacco, wheat, coffee, sugar cane, peanuts, sheep, goats and pigs; and the main production industry products are steel, wood products, cement, chemicals, fertiliser, clothing and footwear, foodstuffs and beverages. It has been estimated that rail transport reduces logistics costs by up to 30% and lowers carbon emissions relative to road transport while offering the possibility of social-economic benefits such as creating jobs and boosting local economies (ADB, 2022).

Reliability Analysis

Cronbach's (α) measures of research constructs are shown in Table 3.

Table 3: Reliability Analysis

Construct		ScaleMeanif Item Deleted	ScaleVarianceifItemmmmDeleted	CorrectedItem-Total Correlation	Cronbach'sAlphaif ItemDeleted
Current state of rail transportation infrastructure in Zimbabwe	0.911				
Outdated locomotives, wagons, and other infrastructure		12.38	5.010	.527	.984
About 10% of the 2,760km rail network has speed restrictions, and many branch lines have expired steel sleepers and low-capacity rails		12.45	4.958	.828	.825
The fleet is aging, with 60 out of 168 locomotives operational but unreliable, and 175 of 283 passenger coaches out of service		12.41	5.003	.837	.829
Dilapidated tracks, signalling systems, and depots		12.41	5.541	.775	.846
Lack of functional rolling stock and low freight capacity		12.22	5.400	.677	.833
Key areas for modernization and investment	0.871				
Infrastructure Upgrade- Rehabilitate 2,760km of rail network, focusing on the Mvuma-Dabuka stretch (78km). Replace outdated tracks, sleepers, and signaling systems		16.1	10.161	.724	.838
Rolling Stock- Acquire new locomotives (21 planned) and wagons (2,650 needed). Refurbish existing fleets (60 operational locomotives, 108 passenger coaches)		16.16	10.232	.772	.851
Technology & Efficiency-Implement automated signalling, real-time tracking, and predictive maintenance. Improve digital logistics and management systems.		16.03	11.177	.680	.870
Capacity Building-Train local staff and foster knowledge transfer from international partners		16.45	9.782	.698	.871

Regional Connectivity- Develop new links (e.g., Zimbabwe-Mozambique) to enhance trade		16.41	9.980	.702	.860
Operational challenges faced by the rail transport sector	0.849				
Poor maintenance- Lack of regular repairs and maintenance has resulted in the deterioration of track, signalling, and telecommunication systems		11.11	7.260	.721	.779
Underfunding- Insufficient capital for improvements and rehabilitation means infrastructure remains old and needs extensive repair		10.86	7.432	.730	.774
Equipment issues- Depreciation and a lack of spare parts for locomotives and wagons mean equipment is often unreliable. This has led to a reduced service capacity		10.64	7.821	.724	.780
Single-track lines- Most rail lines are single-track, which limits the efficiency of operations		10.99	7.013	.744	.785
Government interference- The National Railways of Zimbabwe (NRZ) has faced government interference in management, impacting its operational autonomy		10.80	7.769	.789	.799
Comparative advantages of rail transportation over other modes of transport regarding cost and efficiency	0.801				
Cost-effective for bulk goods- Rail is significantly cheaper than trucking for moving large quantities of heavy or voluminous cargo like minerals, grain, or construction materials over long distances		12.18	5.363	.525	.792
Lower per-unit cost- Transporting goods by rail lowers the cost per unit of cargo for large shipments		12.30	4.274	.735	.694
More stable operating costs- The costs of rail freight are often more stable and predictable than air freight, which can be heavily influenced by fuel prices and airport fees		12.21	4.678	.677	.723
Fuel efficiency- Rail is more fuel-efficient than road transport, with a single train able to move a ton of freight much farther on the same amount of fuel		12.04	5.915	.532	.800
Reduced congestion- Shifting freight from roads to rail reduces traffic congestion, which can improve overall road network efficiency.		12.44	5.766	.522	.688
Socio-economic implications of improved rail transportation on local communities and businesses	0.791				
Job creation- Rail improvements directly create jobs in construction, maintenance, and operation, while indirectly generating employment in related sectors like logistics, trade, and hospitality		12.11	5.367	.522	.711
Economic growth-Lower costs for moving raw materials and finished goods boost business competitiveness. Improved connectivity facilitates access to new markets, expanding the customer base for local businesses. Investment is attracted to rural and urban areas, potentially fostering new industries, real estate projects, and tourism		12.10	4.2112	.7122	.699
Enhanced mobility and accessibility-Reduced travel times and costs benefit residents, especially those with lower incomes. Rural areas gain better access to urban centers, which can help reduce regional disparities. Lower transportation costs also benefit consumers through a wider range of available goods		10.09	4.676	.676	.710

Urban development-Improved rail can lead to urban regeneration, with areas around stations becoming high-density commercial and residential zones. It can also foster transit-oriented development (TOD) and promote the growth of public transport networks		11.04	5.593	.520	.829
Environmental Benefits-Reduced Carbon Footprint: Rail is more fuel-efficient than road transport, cutting emissions and traffic pollution. Sustainability, less wear on roads, lowering maintenance costs		11.44	5.677	.527	.867

Source: Survey data (2025)

As shown in Table 3, the Cronbach's Alpha statistic for current state of rail transportation infrastructure in Zimbabwe was 0.911 and the corrected item-total correlation recorded a minimum of 0.527. For key areas for modernization and investment, the Cronbach's alpha statistic was 0.871 and the corrected item-total correlation ranged between 0.680 and 0.772. The Cronbach's alpha for operational challenges faced by the rail transport sector was 0.849 and the corrected item total correlation recorded a minimum observed of 0.721. Table 4.10 also shows that the Cronbach's alpha for comparative advantages of rail transportation over other modes of transport regarding cost and efficiency was 0.801; while the corrected item-total correlation ranged from 0.522 to 0.735. The Cronbach's alpha for socio-economic implications of improved rail transportation on local communities and businesses was 0.791 and the corrected item-total correlation ranged from 0.520 to 0.7122. According to Bryman and Bell (2017), the optimal minimum alpha statistic is 0.7. However, other scholars, Saunders et al., (2019), argue that even alpha statistics of 0.6 are still reliable. With respect to corrected item-total correlation, Creswell (2020) recommends that the coefficient must be greater than 0.3. In line with these recommendations, the data collected for the study was therefore reliable, hence, all the items extracted were reliable.

Table 4: Hypotheses Testing

Hypotheses	Hypothesised Relationship	SRW	CR	Remark
H1	Current state of rail transportation infrastructure → efficiency of transport and logistics in Zimbabwe	.268	11.995***	Supported
H2	Key areas require modernization and investment → efficiency of transport and logistics in Zimbabwe	.413	19.334***	Supported
H3	Operational challenges the rail transport sector face → efficiency of transport and logistics in Zimbabwe	1.226	21.943***	Supported
H4	Comparative advantages of rail transportation over other modes of transport → efficiency of transport and logistics in Zimbabwe	1.269	18.567***	Supported
H5	Socio-economic implications of improved rail transportation → efficiency of transport and logistics in Zimbabwe	0.344	21.1516***	Not Supported

Source: Survey data (2025)

Table 4 shows that: H1, H2, H3, H4 and H5 were statistically supported. The implication of these findings is that there is sufficient statistical support for direct relationships between the five independent variables (the current state of rail transportation infrastructure in Zimbabwe (B); key areas for modernization and investment (C); operational challenges faced by the rail transport sector, including regulatory issues and service reliability (D); comparative advantages of rail transportation over other modes of transport regarding cost and efficiency (E) and socio-economic implications of improved rail transportation on local communities and businesses (F)) and dependent variable (efficiency of transport and logistics in Zimbabwe). This suggests that independent variables significantly impact the efficiency of rail transport and logistics in Zimbabwe.

8. Conclusions

The study concludes that rail transport positively impacts the efficiency of transport and logistics in Zimbabwe.

Findings confirm that rail transport significantly influences logistics efficiency, consistent with network theory, a well-functioning rail node enhances overall network flow. However, current underinvestment and regulatory fragmentation undermine this potential. However, the current system operates far below potential. Infrastructure decay, regulatory incoherence and unreliable service are the main constraints.

9. Recommendations

In the light of above conclusions, the following recommendations are proffered.

9.1 Policy and investment: Policymakers should enact legislation that attracts private and public investment in rail operations (e.g., tax incentives for rolling stock leasing, PPP frameworks for signaling upgrades).

9.2 Regulatory reforms: the Government of Zimbabwe should establish a single rail regulator with mandate over tariffs, safety, and performance standards.

9.3 Infrastructure modernisation: there is need by the government of Zimbabwe to prioritise track rehabilitation on the Harare-Mutare and Bulawayo-Beitbridge corridors, plus installation of GPS-based train tracking.

9.4 Intermodal integration: the government of Zimbabwe should develop dry ports at key railheads to connect with road and warehousing.

Community engagement programs: To reduce vandalism, the Zimbabwean government should enhance local ownership.

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