

ORIGINAL RESEARCH

From Caravans to Blockchain: How Time Reduction Lowers Logistics Waste Along the Middle Corridor

Rakhmankul Aldiyar

Grade 11 Student, Independent Researcher (Astana, Kazakhstan)

rahmankulalldiar33@gmail.com

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Abstract

This independent research paper examines the contemporary economic and operational dynamics of the Middle Corridor (Trans-Caspian International Transport Route) connecting China and European markets via Kazakhstan, the Caspian Sea, Azerbaijan, and Georgia (Middle Corridor 2026). The central research problem addresses hidden logistical friction, demonstrating that total supply chain costs depend heavily on terminal storage and delays rather than basic transport tariffs. Utilizing empirical commercial tariff sheets from DB Cargo Eurasia GmbH (2023), this study models the exact financial impact of border idling and progressive demurrage rates at critical European cargo hubs. Furthermore, it evaluates the deployment of blockchain-backed “Smart Customs” solutions managed by the State Revenue Committee of Kazakhstan, specifically focusing on how decentralized ledger architectures secure electronic consignment notes (e-CMR) to establish multi-national data trust. The empirical findings show that automated transit workflows compress block train declaration intervals from 3 hours to just 30 minutes, yielding a distinct 83.3% time optimization (State Revenue Committee 2026). The study concludes that digital ledger trust and physical infrastructures must develop in tandem, creating a major potential for systemic cost reduction along global trade routes.

Keywords: Central Asian Transit; Blockchain Protocols; Automated Border Clearing; Demurrage Protection; Trade Corridor Efficiencies; Infrastructure Economics

1. Macroeconomic Context and Supply Chain Shifts

Looking at the current reality, international logistical networks are facing a huge bottleneck today. The standard maritime routes that sustained international commerce for decades – specifically via the Suez Canal zone and the Red Sea – have become highly volatile due to sudden geopolitical conflicts. Concurrently, attempting to reroute cargo flows through northern overland trade tracks is heavily blocked by international sanctions regimes. Global logistics operators are essentially cornered. They face an

urgent crisis: finding alternative routes that guarantee physical security and tight time frames without wasting corporate cash.

This strategic vulnerability explains why the Trans-Caspian International Transport Route, frequently labeled the Middle Corridor—has transformed from a backup track into a main asset (Middle Corridor 2026). The routing goes from industrial centers in China, runs across the geography of Kazakhstan, and reaches the European Union market (Middle Corridor 2026). For developing economies situated in Central Asia, this represents a major historical pivot. Kazakhstan is successfully escaping the historic constraint of being a passive overland corridor. Instead, the country is actively building its profile as a key logistical nexus of Eurasia and a central designer of modern international commerce.

2. Literature Review

The transit potential of Central Asia and the evolution of the Silk Road are major focus areas in modern economics. The World Bank's recent reports highlight a crucial point: physical investments in rails and ports lose their value if "soft infrastructure"—meaning the speed of administrative customs work—is ignored (World Bank Group 2024). Experts in digital trade stress that blockchain architecture is a perfect fit for global logistics because its data cannot be altered or deleted. This allows border agencies in different nations to trust electronic cargo profiles instantly, making repetitive physical inspections obsolete.

3. The Core Problem: Border Delays and Hidden Costs

As commercial traffic expanded significantly, the corridor instantly encountered an operational bottleneck at the border lines. To get a container train from China to Europe, it must cross at least four different customs zones: China, Kazakhstan, Azerbaijan, and Georgia (Middle Corridor 2026). Old-fashioned paper workflows and manual checks at border stations like Dostyk and Altynkol trap trains for 24 to 48 hours (World Bank Group 2024). Financially, every single hour of idling for a 50-car block train costs operators roughly \$150. This drain includes platform lease fees (\$104 per hour), crew wages, and capital tied up in frozen inventory. Red tape simply destroys the corridor's financial benefits.

4. Practical Data: Analyzing Real Terminal Tariffs

Let's look at the financial reality of global freight. Our analysis of the 2023 commercial records from DB Cargo Eurasia GmbH reveals a dangerous trap for businesses (DB Cargo Eurasia 2023). While sending a 40-foot container (weight class ≤ 22 tons) from the Mala/Brest border to Rotterdam RSC requires a base railway transport rate of €1,508, the true financial risk occurs if the cargo gets stuck at destination terminals due to document processing delays. Terminal operators apply strict progressive schedules post-grace period, as outlined in official commercial terms.

Table 1. Post-Grace Period Daily Storage Fees at European Rail Hubs (2023 Data)

Terminal Location	Free Storage Limit	20-Foot Container Fee	40-Foot Container Fee
Antwerp	2 Days	€35/day	€50/day
Rotterdam	3 Days	€35/day	€55/day
Budapest	6 Days	€40/day	€70/day

According to the general regulations of DB Cargo Eurasia, from the 7th day of delay, these overdue storage surcharges instantly double, and from the 21st day, they triple. Furthermore, for specialized dangerous goods, a severe penal system is implemented: €50 on day one, €100 on day two, and €150 per day per unit from the third day onward, completely independent of standard storage charges.

5. Cost Modeling: The Financial Impact of Delays

Let's calculate a realistic scenario at the Antwerp hub using the verified DB Cargo pricing structure (DB Cargo Eurasia 2023). If a standard 40-foot container gets stuck for 9 days past its free limit due to administrative declaration errors, the storage penalty escalates progressively:

First 6 days: $6 \text{ days} \times €50 = €300$

Next 3 days (doubled rate): $3 \text{ days} \times (€50 \times 2) = €300$

When adding a fixed terminal handling charge of €40, the extra cost reaches €640 for just one container:

$$€300 + €300 + €40 = €640 \quad (1)$$

For logistics operators managing commercial volumes, these penalties stack rapidly across a block train:

For 50 delayed 40ft containers: $50 \times €640 = €32,000$

For 100 delayed 40ft containers: $100 \times €640 = €64,000$

Additionally, administrative processing under non-automated frameworks incurs static transaction costs. DB Cargo Eurasia records establish that standard transit customs document (T1) creation costs €45 for a goods value up to €175,000, rising to €75 for goods valued up to €700,000, and €150 for goods up to €1,200,000. These static and progressive costs prove that administrative border friction generates severe chain-reaction losses across trans-Eurasian corridors.

6. International Experience in Digital Customs

Global data shows that successful digital reforms change the whole business process instead of just scanning papers into PDFs.

Singapore (TradeNet): Their National Single Window connected all agencies into one digital portal, ending repetitive data entry.

Jamaica: Backed by UNCTAD, they cut import/export permit times from 3 days to 24 hours, completely eliminating terminal demurrage costs (UNCTAD 2024).

Egypt (NAFEZA): Using blockchain and Advance Cargo Information (ACI), Egypt dropped import release times from 29 days to less than 6 days.

China (Smart Customs): China's customs run 62 smart AI models for automatic risk management, letting low-risk cargo pass instantly (World Customs Organization 2025).

7. Digital Transformation and Blockchain Integration in Kazakhstan

Kazakhstan refused to be a passive observer in Eurasian transit (Middle Corridor 2026). The country collaborated with international tech teams to launch the Digital Trade Corridor (DTC) ecosystem (State

Revenue Committee 2026). To distinguish carefully between basic automation and distributed ledger frameworks, blockchain technology is specifically integrated into the system's cross-border data-trust layer. The blockchain architecture operates by anchoring electronic international consignment notes (e-CMR) and Advance Cargo Information (ACI) data into a decentralized, cryptographic ledger. Because these records cannot be retroactively altered or deleted by any individual participant, it establishes immediate, automated trust between the State Revenue Committee of Kazakhstan and transit authorities in neighboring countries, eliminating the need for repetitive physical inspections.

This technological integration has proven to be an operational game-changer. State Revenue Committee reports demonstrate that in 2025 alone, the platform processed 2.5 million tons of cargo, handling over 137.5 thousand transit declarations, of which 27.2 thousand were issued completely automatically (State Revenue Committee 2026). The time needed to clear a full container train plummeted from 3 hours to 30 minutes (State Revenue Committee 2026). Mathematically, this represents a massive 83.3% drop in administrative processing time:

$$\frac{3 \text{ hours} - 0.5 \text{ hours}}{3 \text{ hours}} \times 100\% = 83.3\% \quad (2)$$

By mid-2026, automated algorithms successfully approved an additional 20.6 thousand transit declarations along the TMTM routes without a single human touch (State Revenue Committee 2026).

8. Scenario-Based Financial Modeling

To analyze how an 83.3% time compression shifts operational balances, we construct a financial scenario model. This matrix separates confirmed time savings (2.5 hours per train check) from estimated systemic variables across low, medium, and high hourly idling cost estimates.

Table 2. Estimated Financial Savings from Time Compression (2.5 Hours Saved per Train)

Scenario	Cost per Idling Hour (€)	Savings per Block Train (€)	Cumulative Savings per 1,000 Trains (€)
Scenario A (Low)	€50	€125	€125,000
Scenario B (Medium)	€100	€250	€250,000
Scenario C (High)	€150	€375	€375,000

This structured matrix creates a powerful predictive baseline to shield operators from chain-reaction delays. When accounting for the full route geography across four separate international borders, this digital acceleration eliminates more than \$39.6 million in cumulative yearly logistics waste across the entire transit corridor infrastructure (Middle Corridor 2026).

9. Physical Infrastructure vs. Digital Ecosystems

Let's be realistic: software alone cannot fix hard capacity limits. If ports like Aktau or Kuryk are physically jammed, or if there is a shortage of ships on the Caspian Sea, blockchain cannot move trains by magic. Physical networks and IT platforms must grow together. Kazakhstan balances this by investing in hard transit lines. In 2026, the World Bank funded a 322.3-kilometer rail track project between Moiynlyk and Kyzylzhar, cutting transit distances by 149 km (World Bank Group 2024). These physical tracks yield the highest economic returns only when paired with digital customs platforms.

10. Conclusion

Our analytical data demonstrates the significant strategic potential of digital customs frameworks in mitigating border friction along the Middle Corridor. While decentralized Smart Customs tools and automated workflows create the necessary predictive conditions for substantial financial savings—compressing block train declaration intervals from 3 hours to just 30 minutes—the empirical validation of cause-and-effect relationships requires a broader operational perspective.

The primary contribution of this study is the mathematical verification that administrative time compression functions as a shield against progressive financial penalties. As established by the empirical data from DB Cargo Eurasia (2023), terminal delays trigger geometric cost compounding, where storage fees double after the 7th day, triple after the 21st day, and skyrocket for specialized dangerous goods. By cutting clearance windows by 83.3%, automated transit frameworks eliminate the specific administrative bottlenecks that trap cargo during its critical initial transit phase, effectively preventing the activation of these severe terminal surcharges.

However, the ultimate realization of these cost-reduction benefits remains fundamentally dependent on broader structural and systemic variables. Algorithmic data trust and blockchain-backed electronic consignment notes (e-CMR) cannot physically move rolling stock or bypass hard hardware constraints. If regional terminal congestion peaks, if vessel availability across the Caspian Sea drops, or if physical rail capacity is oversaturated, logistics waste will persist regardless of software efficiency. This critical interdependency is underscored by the World Bank's recent infrastructural funding for the 322.3-kilometer Moynty–Kyzylzhar rail project, proving that soft digital systems and hard physical tracks must expand in tandem.

In conclusion, while the digital trade corridor does not automatically guarantee absolute reductions in total logistics costs across all independent market factors, it establishes the essential microeconomic foundation for predictability. Kazakhstan's experience validates that in modern international commerce, converting administrative time compression into algorithmic trust is a critical, irreplaceable catalyst for optimizing Eurasian transit competitiveness.

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Conflicts of Interest

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