Unpacking Quality Deficiency Costs:

A Framework for Mapping and Managing Quality Deficiency Costs at Company X, a large Swedish transportation company

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Abstract

This thesis explores the internal structure and propagation of Quality Deficiency Costs (QDCs) within Company X, Sweden's national train operator. While several cost components—such as quality deficiency fees, EVF compensation, and replacement traffic—are well documented and easily quantified, others like productivity loss, staff strain, and brand reputation are harder to measure but integral to the broader cost landscape. Despite their significance, the internal interconnections, escalation dynamics, and organizational distribution of these QDCs remain poorly understood. Without a clear picture of how quality-related costs emerge, propagate, and interact across functions, Company X struggles to distinguish between unavoidable losses and inefficiencies that could be proactively addressed.

To address this discrepancy, the study develops and applies a two-layered analytical framework. The first layer of the analysis categorizes and quantifies the Quality Deficiency Costs (QDCs) within Company X operations between the years of 2019 and 2024. The second layer offers supplementary, illustrative context for selected cost propagation patterns within the organization, supported by continuous meetings and a limited set of interviews. The framework integrates ripple effect theory, systems thinking, cost of quality models, and root cause analysis to trace how costs move and accumulate internally. By revealing quantitative cost patterns and propagation dynamics, complemented by perspectives from Company X stakeholders and employees, the study offers scope for prioritizing and improving QDC governance.

Keywords: cost of quality, cost propagation, Onion Model, public transport governance,, quality deficiency costs, QDC, QDCs, ripple effect theory, systems thinking

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1. Introduction and Background

Rail transport is central to Sweden's climate strategy, which has set out explicit goals to shift freight and passenger volumes from carbon-intensive modes. (Regeringskansliet, 2022). Although passenger volumes are rising, public confidence in the rail system has been declining due to service failures and poor disruption management, and recovery failures fuel growing dissatisfaction, according to surveys. (Trafikanalys, 2025; SKI, 2024) Company X, a large Swedish operator, stands at the center of this system, together with Trafikverket, which is the governmental body that manages the rail system in Sweden. One should also note that railway companies in Swden score poorly in passenger satisfaction, according to Swedish surveys (SKI, 2024). Such issues are not isolated technical faults; they stem from persistent structural weaknesses, including aging infrastructure, deferred maintenance, and limited capacity buffers (Riksrevisionen, 2022; Trafikverket, 2024). Disruption risks are further amplified by shared tracks, external dependencies, and limited redundancy. This leads to the escalation of minor events into large-scale service failures, which have ripple effects on a large scale. (Dekker et al., 2022; SVT, 2024) However, not all cost drivers are external; internal inefficiencies within Company X also contribute to QDCs These internal inefficiencies generate visible costs, such as emergency buses or compensation payouts, and generate indirect burdens, including staff fatigue, reputational damage, and reduced operational resilience. This thesis investigates these quality-related costs—Quality Deficiency Costs (QDCs)—which prove to be a significant burden when contrasted against revenue, and it encompasses both formal penalties, such as quality fees and payouts for delays, and informal, often untracked consequences (e.g., operational inefficiencies, loss of customer trust). It does so by analyzing their origins of how they spread, how they escalate and their systemic enablers. While some disruption-related costs such as penalty fees from Trafikverket (TRV), or emergency service expenditures are formally tracked many indirect and compounded costs remain overlooked. Among other factors rarely captured systematically are reduced staff productivity, increased sick leave, and passenger attrition due to eroded trust. Quality Deficiency Costs (QDCs) often surface through reactive spending: emergency rebookings, hotel arrangements, or manual customer recovery. These "secondary" costs often exceed the direct financial impact of the event and fall outside of formal penalty structures (Johnston & Clark, 2008; Senge, 1990). This gap between the source of the disruption and the entire cost chain maintains reactive management cycles and impedes systemic learning.

1.1 Defining Quality Deficiency Costs vs. Quality Deficiency Fees

A core conceptual distinction in this thesis lies between quality deficiency fees and quality deficiency costs (QDCs): Quality Deficiency Fees are penalties issued by Trafikverket for disruptions in services where Company X is deemed to be the causing party. Quality Deficiency Fees are easily traceable costs, but they represent only a limited subset of Company X total Quality Deficiency Costs (QDCs), which account for the full spectrum of financial consequences originating from disruptions to services regardless of who is the causing party (Heinzmann, A. (2018). These costs include mandated compensation for delays (EVF), emergency logistics, staff overtime, rolling stock adjustments, and long-term impacts such as loss of goodwill and ridership. Unlike standardized fees, most QDCs undergo cross-functional absorption, often resulting in a fragmented perception that hinders effective governance and cost control. This fragmentation impairs Company X ability to distinguish between preventable costs and those that must be absorbed.

1.2. Purpose, Problem Statement, and Research Objectives

1.2.1 Purpose

The purpose of this study is to aid Company Xin better QDC management by formulating and applying a structured multi-layered approach. This approach will help in better categorization and analysis of QDCs by showing how they generate, propagate, and escalate; thus, it offers an explanation of patterns that existing cost systems do not fully capture. While some QDCs are clearly visible and tracked to distinct root causes, many others remain poorly defined and diffusely interpreted. The framework integrates principles from Ripple Effect Theory, Systems Thinking, and the Cost of Quality (CoQ) model to support a shift from reactive cost tracking to more proactive cost governance.

1.2.2 Problem Statement

Company X incurs substantial QDCs annually, yet it lacks a comprehensive framework that will aid in understanding where QDCs originate, how they propagate and interact, and ultimately how they escalate across boundaries within the organization. Given that such costs are dispersed across multiple departments without being tied to the root causes from which they stem, this leads to a fractured organizational perspective that does not fully capture the extent of QDCs. Without integrated tracking of how QDCs are distributed across departments, accountability may become scattered and lead to inefficient management that focuses on interventions for external symptoms rather than underlying reasons. As Riksrevisionen (2022) noted, this lack of integrated cost attribution is a structural weakness Overlooking propagation and ripple dynamics may further complicate cost management.

This study addresses that gap by introducing a cross-functional framework for quantitatively mapping QDC propagation and escalation. This framework can help Company X identify areas for further investigation into root cause mitigation.

1.2.3 Research Question and Objectives

How can Company X quality deficiency costs be systematically identified, categorized, mapped, and managed to optimize operational performance and reduce inefficiencies?

This question guides the study's investigation into the origins, escalation pathways, and interdepartmental impacts of quality-related costs. The goal is to develop a structured framework that enhances cost traceability, supports strategic decision-making, and enables more proactive governance.

- Develop a framework to identify and classify QDCs across Company X operations.
- Distinguish between direct, indirect, and systemic costs using internal financial data and qualitative insights.
- Map cost propagation pathways across functions, revealing organizational escalation mechanisms and blind spots.
- Identify leverage points for preventive action and improved cross-functional cost governance.
- This study will contribute to research on cost escalation and governance in regulated railway systems through an applied, data-driven case study.

2. Literature Review

2.1 Introduction and Purpose

Quality Deficiency Costs (QDCs) in railway operations represent a complex, multi-dimensional challenge with increasing operational and strategic importance. Operators such as Company X face both formal penalties and informal costs related to service degradation. However, existing literature lacks comprehensive frameworks that integrate the origins, escalation mechanisms and persistence of these costs. Current models tend to focus narrowly on performance-based penalties or overlook the organizational and systemic drivers behind cost propagation.

This literature review lays the conceptual foundation for a two-layered empirical investigation into QDCs at Company X. Layer 1 quantifies and categorizes visible and hidden costs. Layer 2 interrogates organizational and structural factors that influence cost persistence. To support this dual-layered design, this review integrates insights from three analytical lenses:

1.Quality management and Cost of Quality (CoQ) frameworks
2.Systems dynamics and ripple-effect theory
3. Governance and organizational learning literature

Despite their contributions, these perspectives share a critical limitation: insufficient conceptual integration for effective diagnostic use in railway contexts. To address this, the thesis introduces the Onion Model- a layered classification framework elaborated in Chapter 3- that operationalizes QDCs across four layers, enabling analysis of both cost visibility and systemic fragility.

2.2 Conceptualizing QDCs: Definitions, Typologies, and Systemic Limitations

Quality Deficiency Costs (QDCs) refer to the full range of financial and non-financial consequences that arise when railway operations deviate from intended service standards or trainplan. In practice, these include formal penalties or customer compensation. It also includes a wider range of issues such as reactive resource allocation, reduced resilience, damaged reputation and lost chances for organizational learning. As Juran (1988) framed it, these are costs that "would disappear if everything were done right the first time".

The traditional Cost of Quality (CoQ) framework -segmenting costs into prevention, appraisal, internal failure and external failure - offers a foundational taxonomy (Juran, 1989; ASQ, n.d.). In complex service systems like railways, its application often remains incomplete. For example, Sweden's quality fees and the UK's Schedule 8 system compensate for visible disruptions but fail to address the underlying structural or behavioral factors that allow these disruptions to continue (Riksrevisionen, 2022; Smith & Ojeda Cabral, 2022).

In the context of QDCs, these systems are likely to enable cascading disruptions due to coupled dependencies between vehicles, crews, passengers, and infrastructure. Even localized failures, such as late crew arrival or platform mismanagement can ripple through the network. Amplifying costs across both financial and organizational domains (Homer et al., 1999; Meadows, 2008; De Regt et al., 2022). Most cost reporting systems isolate incidents, neglecting the broader propagation logic underlying systemic escalation.

2.3 Escalation Dynamics and System Behavior in Railway Operations

Quality Deficiency Costs (QDCs) do not arise from simple, isolated mistakes but from the deeper, connected structure of railway systems. Rail operations are closely linked, depend on each other and have little spare capacity, which makes small problems likely to escalate. This section brings together research and theory on how misaligned incentives, spreading delays, unclear costs and system-wide solutions explain how small disruptions can lead to much larger costs.

Across Europe performance-based penalties are commonly used to promote punctuality. Yet their effectiveness varies. In Sweden, the redistribution of quality fees from Trafikverket to operators unintentionally weakened the infrastructure maintenance budget. Reducing long-term system resilience (Riksrevisionen, 2022). The UK's Schedule 8 system has been criticized for its complexity and limited effect on behavior, whereas the Dutch bonus–malus model better aligns incentives by rewarding teamwork in managing disruptions (van Hagen &

van Oort, 2015). These examples show that simple, linear incentive systems often fail to effectively handle the complexities of non-linear service environments.

These cases reveal that linear incentive systems struggle to address non-linear service environments. Empirical research confirms that railway delays propagate in structures across organizations, affecting vastly different domains such as crew cycles, rolling stock availability, and platform access (De Regt et al., 2022; Daniotti et al., 2023). Similarly, studies on extensive international railway networks have modeled how ripple effects contribute to failure risk propagation and influence across the system (Lyu et al., 2023). These patterns reflect underlying system dynamics: non-linearity, time delays, and reinforcing feedback loops (Senge, 1990; Meadows, 2008). Minor incidents can generate network-wide effects, often disproportionately larger than the initiating event. These dynamics are central to the thesis's propagation logic, elaborated in Chapter 3.

Despite this, most cost-tracking systems are still limited, capturing only immediate disruptions while ignoring delayed or shifted effects. Impacts that occur later in time (such as overtime or reduced future capacity) and those that spread to other areas (such as delays affecting regions not originally impacted) are often undermeasured. Accounting frameworks also ignore behavioral consequences such as reduced trust, staff disengagement and reputational erosion; such hidden costs often remain overlooked. (Schlake etl., 2011). These gaps in visibility hide the underlying causes and encourage reactive, rather than proactive, management. Some operators have moved toward system-oriented mitigation. ProRail and Deutsche Bahn focus on high-risk railway lines using predictive analytics and buffered capacity to prevent problems from escalating (ProRail, 2023; DB, 2025). Life Cycle Costing (LCC) models support these strategies by helping to quantify the long-term savings from investments in reliability, as highlighted by Nissen (2009) and Smith & Ojeda Cabral (2022).

2.4 Governance, Accountability, and Organizational Capacity

While cost escalation in rail operations is often framed as an operational problem, its persistence is deeply shaped by governance structures, institutional interfaces and the organization's ability to interpret and act on signals of systemic degradation. This section synthesizes literature on fragmented accountability, organizational learning theory and incentive misalignment to examine how structural and behavioral factors shape the lifecycle of Quality Deficiency Costs (QDCs).

2.4.1 Fragmented Interfaces and Institutional Constraints

Railway systems involve multiple stakeholders: operators, infrastructure managers and regulators. All governed through performance contracts and layered responsibilities. In Sweden, Company X operates on infrastructure owned and maintained by Trafikverket. This structural split undermines cost attribution, as delays and their financial consequences can arise from causes that the operator cannot control (Infrastructure related failures) . Riksrevisionen (2022) critiques this arrangement for reducing transparency and decoupling penalties from reinvestment priorities.

Similar accountability gaps are evident in other jurisdictions. The UK's Schedule 8 system monetizes performance shortfalls, but its complexity obscures who is truly responsible for systemic improvements (Smith & Ojeda Cabral, 2022).

2.4.2 Organizational Learning and Normalized Failure

Beyond institutional interfaces, internal organizational dynamics are central to understanding why Quality Deficiency Costs (QDCs) persist. Drawing from Organizational Learning Theory, Argyris and Schön (1978) distinguish between single-loop learning (correcting errors without altering underlying norms) and double-loop learning (challenging root assumptions and processes). Rail operators often engage in the former—addressing symptoms (e.g., compensating passengers or adding bus replacements) without revisiting the deeper routines and assumptions that enable recurrence.

High-Reliability Organization (HRO) literature reinforces this concern. Weick and Sutcliffe (2001) emphasize the need for error sensitivity, decentralized response and post-incident learning. Traits that are often underdeveloped in large infrastructure organizations. These dynamics have concrete effects, influencing the financial structure of QDCs. Behavioral costs like staff disengagement, poor customer communication and organizational resistance to change are rarely recorded, yet they reinforce cost recurrence. Recognizing these patterns is essential for interpreting Layer 2 findings later in this thesis.

2.4.3 Toward Integrated Control and Strategic Alignment

Effective QDC mitigation requires alignment between information flows, cost attribution and decision-making authority. Agency Theory and Transaction Cost Economics (Williamson, 1985) explain that when incentives do not match and accountability is unclear, it leads to moral hazard and poor coordination. These problems allow Quality Deficiency Costs (QDCs) to continue even when they are recognized.

Some rail systems have attempted to integrate visibility and responsibility. ProRail embeds cost control into performance-based maintenance contracts, aligning supplier incentives with network resilience (ProRail, 2023). Tools such as Life Cycle Costing, internal audit loops and behavioral risk metrics offer practical pathways—yet only when embedded in routines and supported by data infrastructure.

For Company X, these insights frame the analytical need for a dual-layered approach. While Layer 1 reveals where costs occur, Layer 2 seeks to understand why they persist and what structural reforms might prevent recurrence. The literature reviewed here offers both the analytical terminology and the theoretical framework necessary for the thesis's organizational analysis.

2.5 Synthesis of Research Gaps and Theoretical Contribution

Despite increasing recognition of Quality Deficiency Costs (QDCs) as a strategic challenge in railway operations. The literature remains fragmented across performance metrics, cost typologies and governance models. While existing frameworks provide partial visibility, they fail to integrate financial, systemic and organizational dimensions into a coherent analytical approach. This fragmentation limits the ability of operators such as Company Xto trace cost origins, design preventive interventions or assign strategic accountability.

This thesis identifies seven critical gaps and responds through a structured, dual-layered research design supported by a conceptual model.

Gap 1: Absence of Railway-Specific QDC Taxonomies

While the Cost of Quality (CoQ) framework offers useful distinctions, it lacks operational fit for the structural interdependencies of rail systems (Sörqvist, 2001). This thesis introduces the Onion Model: a layered taxonomy that maps QDCs from direct accounting entries to hidden systemic issues. The model enables structured classification, escalation analysis and strategic targeting of cost drivers.

Gap 2: Underdeveloped Frameworks for Cost Propagation

Although delay spread and feedback loops are well-documented (De Regt et al., 2022; Daniotti et al., 2023; Schlake et al 2011), few studies link these to cascading cost outcomes, especially so in a Swedish Railway context. This thesis uses systems thinking and ripple-effect theory to analyze how disruptions evolve into multi-layered financial burdens, providing a logic that connects operational events to indirect and hidden costs.

Gap 3: Invisibility of Cross-Stakeholder Accountability

Current governance models frequently blur the boundary that infrastructure management and operations create. Swedish arrangements between Trafikverket and Company X, for instance, create structural gaps in feedback and reinvestment (Riksrevisionen, 2022; Andersson, 2007). This study maps internal QDC flows at Company X to identify how responsibility diffusion may reinforce system fragility.

Gap 4: Neglect of Organizational and Behavioral Cost Drivers

Organizational routines, isolated departmental learning, and the acceptance of failure as normal have been largely ignored in Quality Deficiency Cost (QDC) research. Building on these insights, this thesis investigates how the persistence of costs reflects structural fragmentation as well as the organization's internal capacity for absorbing knowledge and facilitating learning.

Gap 5: Lack of Connection Between Preventive Investment and Avoiding QDCs

While Life Cycle Costing models indicate that preventive strategies can yield significant savings, they are rarely applied to measure the Quality Deficiency Costs (QDCs) that could be avoided (Nissen, 2009; Smith & Ojeda Cabral, 2022). This thesis examines Company X internal cost patterns to identify key areas where investment could effectively reduce future costs.

Gap 6: Lack of Tools for Real-Time Monitoring and Governance

Most QDC analyses retrospectively evaluate data and do not connect with operational decision-making.While this thesis does not develop a real-time tool, it specifies prerequisites for enabling such capabilities in the future. Grounded in Company X reporting architecture and internal processes.

Gap 7: Limited Relevance Beyond Domestic Passenger Contexts
Most QDC studies focus on domestic passenger rail, neglecting freight, international corridors or transfer interfaces. Although this thesis focuses on Company X national passenger services, the Onion Model and propagation framework are developed to be adaptable for wider use, including freight, cross-border operations and multiple-operator settings. With appropriate adjustments for each context.

3. Theoretical Framework

3.1 Introduction to the Conceptual Framework

The Theoretical Framework analyzes QDCs within Company X, diagnosing how they emerge, propagate and persist beyond isolated disruptions. The theoretical model consists of two layers: Layer 1 categorizes and quantifies QDCs, while Layer 2 adds qualitative depth by identifying the structural and systemic drivers of cost escalation. The core framework for categorizing QDCs is the Onion Model, developed specifically for this thesis in collaboration with Company XBusiness Controllers and Strategists. It showcases costs across four nested visibility layers—*Direct Costs, Operational Inefficiencies, Indirect Costs, and Systemic Effects*, thereby providing a diagnostic lens to interpret escalating costs considered to have originated in quality deficiencies. To interpret why these costs emerge and persist. This thesis integrates four complementary models:

- **Ripple Effect Theory** (Dolgui et al., 2017): to model how initial disruptions propagate through interdependent operational systems and amplify over time;
- **Systems Thinking** (Senge, 1990; Meadows, 2008): to identify feedback loops, structural inertia, and governance blind spots that sustain QDC patterns;

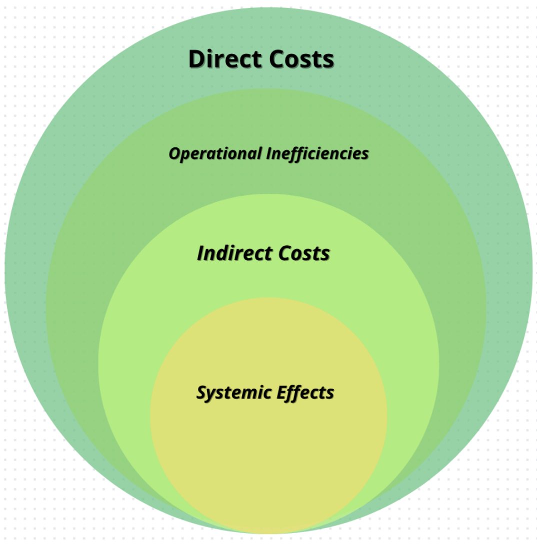
- **Fishbone Diagram** (Ishikawa, 1990): applied conceptually to structure categories of root causes that may underlie recurring deficiencies;
- **Cost of Quality (CoQ)** (Juran, 1989): to distinguish between preventive, appraisal, internal failure, and external failure costs—supporting strategic prioritization of upstream investment.

These models are not applied in isolation but jointly as a diagnostic framework. The Onion Model anchors the classification logic, while the other models add interpretive depth by tracing cost propagation (Ripple Effect), understanding systemic behavior (Systems Thinking), structuring root causes (Fishbone), and prioritizing investment logic (CoQ). This integration allows the thesis to transform from the descriptive mapping in Layer 1 to casual and structural interpretation in Layer 2. It aids in identifying leverage points for upstream prevention while also reframing QDCs as an outcome of the organizational structure and not only anomalies. Together, the models ensure theoretical coherence and empirical flexibility—enabling the thesis to interpret cost data not only in financial terms but as indicators of deeper structural vulnerabilities and governance logic.

Analytical Function	***Framework***	***Contribution***
Cost Categorization	Onion Model	Structures QDCs into four escalating layers
Root Cause Identification	Fishbone Diagram	Maps potential technical, human, and managerial causes
Escalation Logic	Ripple Effect Theory	Traces disruption propagation across cost categories
Structural Persistence	Systems Thinking	Reveals organizational feedback failures and blind spots
Strategic Prioritization	Cost of Quality (CoQ)	Assesses investment logic and reactive cost bias

Table 1 above summarizes how each framework contributes to cost management and governance improvements at Company X.

3.2. The Core Framework: The Onion Model for Categorizing QDCs



To structure QDC analysis, this study introduces the **Onion Model**, developed with Company X Business Control team. It organizes costs into four nested layers based on visibility and systemic complexity: **Direct Costs**: Immediately traceable expenditures (e.g., EVF payouts, taxi services). **Operational Inefficiencies**: Internal frictions and coordination gaps (e.g., overtime, reactive rescheduling). **Indirect Costs**: Latent impacts such as customer dissatisfaction, staff fatigue, and reputational erosion. **Systemic Effects**: Deep-rooted structural enablers including siloed governance, poor feedback mechanisms and reactive cultures. Each layer is therefore ordered by increasing invisibility, complexity and resistance to interventions.

Layer	*Description*	*Typical Examples*	*Ease of Addressing*
Direct Costs	Immediate, quantifiable costs directly linked to specific disruptions	TRV penalties, EVF payouts, taxis, hotel costs	*High – measurable and visible*
Operational Inefficiencies	Internal workarounds and short-term fixes triggered by disruptions	Overtime, rescheduling, reactive maintenance, extra customer service	*Moderate*
Indirect Costs	Delayed or diffuse impacts that erode organizational effectiveness	Reputation loss, absenteeism, customer churn, fatigue	*Low – harder to trace*

Systemic Effects	Deep-rooted structural failures in governance, incentives, or routines	Silo thinking, poor data sharing, reactive culture	*Very low – embedded and complex*

Table 2: Onion Model

Each layer of the model reflects a progression in terms of invisibility, complexity and resistance to intervention, which are key aspects analyzed in this study. The model serves two key functions in this study: analytical categorization and qualitative interpretation. The first layer serves as an analytical categorization, where data will uncover cost patterns and dominant QDCs within Company X. This is then anchored by the second layer, which incorporates qualitative and theoretical interpretation by linking cost patterns to propagation logic and governance failures. A single disruption often cuts across all layers, for example, a vehicle malfunction (Direct Cost) may trigger overtime (Operational Inefficiency), harm customer satisfaction (Indirect Cost) and reflect poor escalation protocols (Systemic Effect). This layered logic makes up the foundation of both the findings (Chapter 5) and strategic recommendations (Chapter 6). While the Onion Model addresses the *what* and *where* of QDCs, understanding the *how* and *why* behind their escalation requires the complementary frameworks presented in the next sections.

3.3 Understanding Cost Dynamics: Propagation and Systemic Behavior

While the Onion Model categorizes *where* QDCs occur, it does not explain *how* they propagate or *why* they persist. We integrate four complementary frameworks, each supporting Layer 2's interpretive analysis, to uncover these dynamics:

- *Ripple Effect Theory* (Dolgui et al., 2017): to model how initial disruptions propagate through interdependent operational systems and amplify over time;
- *Systems Thinking* (Senge, 1990; Meadows, 2008): to identify feedback loops, structural inertia and governance blind spots that sustain QDC patterns;
- *Fishbone Diagram* (Ishikawa, 1990): applied conceptually to structure categories of root causes that may underlie recurring deficiencies;
- *Cost of Quality (CoQ)* (Juran, 1989): to distinguish between preventive, appraisal, internal failure and external failure not merely as isolated outputs but as outcomes of deeper logics.

Together, these models enable the study to interpret cost patterns not merely as isolated outputs but as outcomes of deeper systemic logics. In Chapter 5, we apply these models not for exhaustive causal mapping but as conceptual tools to understand propagation chains, feedback breakdowns and prioritization logic.

3.3.1 The Ripple Effect Model: Explaining Cost Propagation and Escalation

Ripple Effect Theory, which comes from supply chain risk analysis (Dolgui et al., 2017), posits that disruptions in tightly coupled systems often trigger nonlinear amplification effects. Should minor failures remain uncontained, they will cascade throughout dependent structures, thus compounding operational strain and generating disproportionate downstream costs. In this thesis, the model frames how Quality Deficiency Costs (QDCs) move across organizational units. For example, a vehicle failure may initially produce only a Direct Cost (e.g., an EVF payout), but if unmitigated, it can propagate into Operational Inefficiencies (e.g., overtime), Indirect Costs (e.g., customer dissatisfaction) and eventually expose Systemic Effects (e.g., inadequate triage routines or ownership gaps). These costs and effects are felt by various Company X domains, even if the minor fault didn't start in either. Therefore, Ripple Effect Theory adds temporal logic to the Onion Model. Whereas the Onion Model categorizes cost layers, Ripple Theory explains the escalation dynamics between them. It highlights why early containment is critical; once ripple chains form, costs do not grow linearly but rather exponentially, escalating throughout the system. This insight underpins the strategic emphasis on upstream intervention and system-level prevention discussed in Chapter 6.

3.3.2 Systems Thinking and Fishbone Analysis: Uncovering Feedback Loops, Structural Influences and Root Causes

Systems Thinking frames QDCs not as isolated failures but as manifestations of broader structural dynamics. Rather than seeking linear cause-effect relationships, it emphasizes how reinforcing feedback loops, delayed responses and organizational silos sustain and contribute to the emergence, propagation, and escalation of QDCs. For example, the consistent connection between operational delays and increasing Customer Handling costs indicates that systemic weaknesses, rather than isolated breakdowns, further exacerbate disruptions, such as inadequate coordination among traffic planning, crew deployment and customer communication. While the model makes no attempts to model Company X full organizational system, it supports the Layer 2 interpretation of QDC escalation patterns by asking whether observed financial symptoms reflect underlying issues in structure, learning, or governance. It also informs the identification of leverage points in Chapters 5 and 6, specifically where learning loops, cross-unit coordination, or structural redesign might stop the spread of costs. Complementing this, the Fishbone Diagram (Ishikawa, 1990) provides a structured tool for organizing potential root causes of recurring deficiencies. Though not applied as a full diagnostic method here, it informs the analysis of how governance gaps, procedural flaws, or infrastructure bottlenecks contribute to recurring cost types, especially in high-impact categories like Replacement Traffic and Corrective Maintenance. Together, these models enable the thesis to move from surface-level attribution, from "what happened, to systemic interpretation, "why it keeps happening."

3.3.3 Cost of Quality (CoQ) Framework: Prioritizing Investment and Action

The Cost of Quality (CoQ) framework (Juran, 1989) provides a lens to assess the maturity and strategic logic of an organization's quality management approach, categorizing costs into four types:

- **Prevention costs**: Investments in infrastructure, planning, or training to avoid quality failures.
- **Appraisal costs**: Activities that monitor or inspect for quality (e.g., pre-departure checks).
- **Internal failure costs:** Failures detected before reaching the customer.
- **External failure costs**: Failures that affect the customer, often resulting in compensation, rebooking, or reputational loss.

In this thesis, CoQ is utilized not as a traditional accounting tool but as an interpretive framework to diagnose and understand cost governance issues at Company X. Its utility lies in revealing whether the organization primarily acts before or after quality failures occur—an indicator of reactive versus proactive system design.

As will be shown in Chapter 5, Company X QDC portfolio is heavily skewed toward external failure costs, particularly within categories like Customer Handling and Unplanned Replacement. Company X current cost logic emphasizes containment over prevention, institutionalizing downstream financial exposure. This observation reinforces one of the thesis's core arguments: that Company X current cost logic emphasizes containment over prevention, thereby institutionalizing downstream financial exposure. These misalignments are emphasized by the CoQ model, which also provides guidance on when upstream reinvestments could generate structural returns. In combination with the Onion Model and Ripple Effect Theory, CoQ allows this thesis to go beyond surface-level cost quantification. It supports a strategic reorientation of QDC governance, away from passive compensation routines and toward early-stage containment, triage and risk anticipation.

3.4 Model Selection Rationale and Alternatives

The theoretical frameworks adopted in this thesis were selected to collectively support the investigation of Quality Deficiency Costs (QDCs) as complex, systemic and propagation-driven phenomena. The final framework integrates five models, each fulfilling a distinct analytical function:

- **Onion Model**: Developed specifically for this study in collaboration with Company X, it categorizes QDCs by visibility and depth, aligning with Layer 1's cost mapping.

- **Ripple Effect Theory**: Captures the temporal amplification of disruptions, helping explain how localized failures evolve into organization-wide cost burdens.

- **Systems Thinking**: Reveals feedback loop breakdowns and organizational inertia, supporting analysis of cost persistence and escalation logic.

- **Fishbone Diagram**: Offers a structured method to group possible root causes across categories like process, governance and infrastructure.

- **Cost of Quality (CoQ)**: Differentiates between preventive and failure-driven costs, enabling strategic prioritization in financial governance.

These models were selected not in isolation but as complementary components of an integrated framework. Their joint application bridges descriptive financial analysis with interpretive system diagnosis, consistent with the thesis's abductive research logic and multi-layered empirical structure.

Alternative models were considered but ultimately excluded for specific reasons:

- **Failure Mode and Effects Analysis (FMEA)** was deemed too granular and engineering-focused for the organizational-level scope of this study.
- **Total Cost of Ownership (TCO)**, while useful in asset-intensive settings, lacks sensitivity to propagation dynamics and is not well-suited for analyzing cascading effects.
- **Lean Six Sigma or QMS-oriented frameworks** were set aside due to their strong focus on process optimization rather than disruption response and systemic feedback.

The final framework aligns with both the research question and the layered methodological design of the study. It enables Company X to transition from ad hoc cost tracking toward a more proactive, governance-aware approach to managing Quality Deficiency Costs.

4. Methodology

4.1 Research Strategy

This study was formally commissioned by Company X's Business Control and Strategy departments with the task of mapping QDCs to understand how they arise, escalate and persist across the company'sCompany X operations. In order to contextualize findings, the study employs an interpretative research strategy that analyzes quantitative data supported by qualitative input.

The research approach distinguishes between

- *The quantitative mapping of QDCs using internal financial and operational data (Layer 1).*
- The subsequent interpretive discussion of these quantitative patterns using established theories, complemented with anecdotal context from Company XStakeholders. (Layer 2).

The quantitative foundation is subject to a theory-informed, abductive approach, which means that the analysis involves an iterative process of moving between empirical findings and theoretical frameworks. The abductive reasoning approach (Bell, Bryman and Harley, 2019), which iterates between quantitative data and theory, aligns with a hermeneutic stance (Gustavsson, 2004). This approach facilitates a better understanding of the most plausible interpretations that explain the observed QDC patterns and dynamics within Company X. The iterative process involves the complementary qualitative inputs from Company X stakeholders in the form of The research involved informal interviews (n=3), but it primarily relied on continuous meetings throughout the process to validate findings and continuously revise the scope of the thesis. This guides the methodological orientation towards organizational sense-making regarding complex cost structures, rather than statistically testing pre-defined hypotheses. Analytical rigor was maintained by validating quantitative records, while illustrative perspectives from the three interviews are considered alongside this primary data without forming a basis for robust qualitative triangulation. This positions the study largely as a theory-informed interpretation of quantitative data, where financial mapping provides the empirical base and theoretical application aims to deepen structural understanding. The authors' roles as traffic coordinators at Company X benefit the study through an insider perspective that will aid in better understanding observed data and the operational context. While valuable, it also presents a risk of interpretative bias. To mitigate this, the study employs safeguards including maintaining a methodological distinction between quantitative findings and interpretive discussion, transparently framing the limited qualitative input as purely illustrative and iterative critical reflection with academic supervisors and Company X stakeholders to challenge assumptions.

4.2 Research Design

This thesis utilizes a two-layered research design to diagnose Quality Deficiency Costs (QDCs) across Company X operations. Layer 1 focuses on quantitatively mapping and categorizing these costs using Company X internal data. Layer 2 builds on this foundation by interpretively analyzing the high-impact cost categories or patterns identified in Layer 1, providing a deeper understanding of their implications.

The Onion Model, detailed in Chapter 3.2.1, is used as a framework to organize and analyze data, helping to understand the complexities of Quality Deficiency Costs (QDCs) in both research layers. In Layer 1, is this structure used to organize financial and operational data primarily sourced from Company X internal SAP system, with supplementary data potentially drawn from operational systems (e.g. systems for real-time vehicle movement tracking and disruption information systems) where relevant to understanding cost origins or impacts. Costs are normalized against Business area 1, Business area 2 and total revenue. Which helps reveal proportional burdens and potential systemic blind spots as suggested by the quantitative patterns.

Layer 2 focuses on selected high-impact categories or patterns identified in Layer 1, such as Customer Handling, by systematically prioritizing these areas based on criteria like financial significance and propagation patterns. This involves further scrutiny of quantitative data, such as time-series, cost center distributions and variance patterns. To understand the persistence and escalation of costs in these areas. The interpretation of *why these costs persist or escalate* is then deepened using the complementary theoretical models presented in Chapter 3: Ripple Effect Theory, Systems Thinking, Fishbone Diagram (used conceptually) and the Cost of Quality (CoQ) framework. This enables a structural discussion of propagation dynamics, potential feedback failures and reactive spending patterns indicated by the data.

The two layers are methodologically distinct but analytically integrated:

- Layer 1 asks: Where and to what extent do QDCs concentrate quantitatively?
- Layer 2 investigates: Why might these quantitative patterns of cost persistence or escalation occur and what do they imply?

As stated in Section 4.1 and detailed further in Section 4.4, any qualitative insights from the three informal interviews or ongoing stakeholder meetings are used complementarily in Layer 2, only to offer occasional illustrative context for specific systemic patterns or theoretical interpretations, not to draw causal conclusions or form the primary basis of the Layer 2 analysis. This layered design, which emphasizes a quantitative core and is aided by qualitative analysis. This allows the study to connect financial analysis with organizational theory, using a reasoning approach called abductive logic explained earlier.

4.3 Quantitative Cost Analysis: Scope, Structure, and Data

This study uses a two-tiered quantitative approach to identify, categorize and analyze Quality Deficiency Costs (QDCs) at Company X. The aim is to identify specific areas where costs are concentrated, how these costs propagate and potential inefficiencies within the organization.

4.3.1 Layer 1: Network-Wide Mapping of QDC Patterns

Layer 1 maps QDCs across Company X operations using financial and operational data from 2019–2024, sourced from SAP, and other systems used by Company X. Costs were grouped by frequency, volume, operational origin and traceability. A normalization procedure aligned each category against Business area 1, Business area 2 and total revenue to assess proportional impact. To identify systemic pressure points, a “clumping logic” was used—grouping related cost drivers into broader categories. Some indirect or cross-functional costs are underrepresented due to system limitations, but the mapping still allows for a high-level diagnosis of recurring inefficiencies. Projections for 2025 were included using Company X internal forecasts. All quantitative inputs were validated in collaboration with Company X business controllers. A full list of included cost categories is provided in Appendix 1.

4.3.2 Layer 2: Targeted Deep-Dive into High-Impact Cost Areas

The second layer of the analysis builds upon the mapping of QDCs in Layer 1, as cost categories that exhibited one or more of high financial significance, ambiguous ownership, and disproportionate escalation were selected for further examination. We selected these categories, along with Company XBusiness Control and Strategy, based on these criteria.

- Escalating or significant cost magnitude,
- Cross-functional propagation patterns, and
- Weak traceability or attribution uncertainty.

The deep dive focuses on a deeper financial examination, paired with complementary qualitative insights to understand why the selected QDCs recur or intensify. However, it is important to emphasize that this analysis does not seek to statistically validate causality. Rather, it applies analytical tools such as time-series comparison, cost center mapping and inter-unit cost variance analysis. While the core data remains quantitative, Layer 2 integrates qualitative input, sourced from interviews and stakeholder discussions, to contextualize systemic trends and ambiguous cost behavior. The methodological design and limitations of this input are discussed further in Section 4.4. These patterns are then interpreted through the theoretical lenses introduced in Chapter 3—particularly Ripple Effect Theory, the Onion Model, Systems Thinking and Cost of Quality (CoQ). The analysis manages to link observed financial consequences to broader systemic, behavioral and governance dynamics.

4.3.3 Data Scope and Source Integrity

The quantitative dataset spans 2019 (benchmark year for Company X) to 2022-2024, with 2025 projections included based on Company X internal forecasts. In agreement with Company X, the pandemic years 2020–2021 were excluded due to abnormal patterns in travel behavior and cost structures.

All extracted data originated from verified internal systems, including:

- SAP cost center logs.
- Expenditure records linked to disruptions (e.g., penalties, corrective maintenance, staff overtime, emergency transport),
- Planning and forecasting systems for future budgeted QDCs.

Data selection and validation were done together with Company X Business Control and Strategy teams to make sure the data matched Company X internal classification of Quality Deficiency Costs (QDCs). This helped reduce errors like missing, repeated, or wrongly classified data and ensured the analysis followed the same rules Company X uses in managing its operations.

4.4 Qualitative Data Collection and Analysis

To provide context for certain quantitative findings, this study includes limited qualitative input from three informal interviews with Company X staff in strategic, operational, and financial roles. These interviews followed a brief discussion guide but were neither recorded nor formally analyzed, which limits the depth of qualitative insights. Instead, the qualitative information is used mainly to describe and help interpret ambiguous or deeply rooted cost patterns in Layer 2 of the analysis. While these interviews carry some qualitative significance, ongoing and continuous meetings with Company X stakeholders provided most of the qualitative input.

The qualitative material is not used to establish cause-and-effect relationships or make broad generalizations. Instead, it serves as a guiding framework to help contextualize and interpret ripple effects, governance gaps and other identified issues. Limitations, including the small sample size, informal approach and lack of coding or triangulation. Are discussed in Section 4.6.

4.5. Ethical Considerations

This research complies with the General Data Protection Regulation (GDPR) and Company X's internal ethical standards. Several safeguards were implemented to protect data integrity, participant rights and commercial confidentiality:

- **Confidentiality and Anonymity:** All internal financial and operational data were securely handled and published only in aggregated form. Interviewee identities remain anonymous.
- **Informed Consent:** Participants were briefed on the study's purpose, the use of their input, and their right to withdraw; verbal consent was obtained in all cases.
- **Data Security:** Access to sensitive records (e.g., SAP logs, cost center data) was restricted to authorized researchers.
- **Reporting Transparency:** All results were reviewed with Company X to ensure alignment with disclosure policies. A more detailed internal report was submitted to the company.

- **Research Integrity:** Findings were presented with methodological transparency, consistent with academic standards of fairness, reliability, and independence (fwell & Poth, 2018).

4.6 Methodological Limitations

Although the methodology was applied carefully, some limitations affect how widely the findings can be applied and how precisely they explain the issues:

1. Commercial Sensitivity and Data Exclusion:
Certain operational and financial records could not be disclosed due to confidentiality. Aggregation and anonymization were necessary to protect Company X.

2. Limited Qualitative Scope:
The study includes only three informal interviews and insights from stakeholder meetings. No formal coding or triangulation was used, which restricts the explanatory depth of the qualitative insight.

3. Attribution and Causality Gaps:

Company X systems do not connect disruption codes to the resulting costs, making it difficult to trace causes accurately. Trafikverket's classification system adds further complexity to identifying root causes. This study did not use regression or statistical tests, as it focused on describing patterns rather than proving causation.

4. Risk of Interpretive Bias:
The researchers' insider roles improved contextual understanding but risked bias. This was mitigated through analytical separation between Layers 1 and 2 and iterative review with supervisors and Company X stakeholders.

5. Organizational Specificity:
The Onion Model and cost typologies can be adapted to other settings. However, the empirical findings in this study are specific to Company X and need to be adjusted to fit different local systems and governance structures before they can be generalized.

5. Findings and Discussion

5.1 Introduction to Findings

This chapter presents the core empirical findings of the study. Layer 1 (Sections 5.2–5.4) maps and categorizes Quality Deficiency Costs (QDCs) by systematically analyzing internal financial data to identify specific patterns and trends. The Onion Model was used to separate direct costs, operational problems, and deeper system issues. This helps show where costs build up and which cost types grow the most. These findings are subsequently subject to interpretation in Layer 2 (Section 5.5 onward), selected case examples and thematic deep dives utilize relevant theories such as Ripple Effect Theory, Systems Thinking and the Cost of Quality (CoQ) to explain why certain costs persist, escalate, or evade ownership. Together, the two layers transition the thesis from financial mapping to structural diagnosis. These findings form the basis for the strategic recommendations outlined in Chapter 6 and they include a detailed understanding of cost dynamics and systemic issues, thereby guiding the formulation of targeted strategies.

5.2 Overview and Strategic Function of the Cost Mapping (Layer 1)

Layer 1 forms the empirical foundation of this thesis. It quantifies Company X Quality Deficiency Costs (QDCs) across operational categories and uses proportional normalization. The analysis of Business area 1 Revenue (BA1) reveals where the escalation of costs outpaces the growth of revenue, which is aided by the Onion Model that structures costs from Direct to Systemic layers and exposes how surface-level expenditures. Like EVF payouts or hotel reimbursements, reflect deeper operational or governance deficiencies. The first layer of the analysis serves two functions: it allows for diagnostic mapping to reveal where costs are concentrated and identifies any visibility gaps, along with determining whether there is systemic friction across Company X operations. Secondly, it identifies the categories that are subject to an investigation in Layer 2 based on growth, attribution ambiguity and escalation potential. Therefore, it provides a quantitative starting point, guides the focus of the second layer of analysis, and acts as a decision-making tool to highlight areas for further investigation. It converts financial outcomes into analyzable patterns, enabling the interpretive turn in Layer 2, where structural persistence and propagation dynamics are identified.

5.3 Definitions of Costs and Cost Category Logic

To enable a structured analysis, it was decided together with Company X that QDC data was to be aggregated into consolidated categories for a more narrow scope. These categories function as analytical units for both financial mapping (Layer 1) and interpretive diagnosis (Layer 2).

Grouped Category	Definition	Rationale
Hotel and Accommodation	Lodging for passengers or staff during disruptions	Indicator of reactive service logic and contingency strain
Replacement Traffic	Substitute transport (bus, taxi) due to cancelled/delayed trains	High-cost mitigation mechanism following service failure
Quality Deficiency Fees	Penalties from Trafikverket for traffic plan deviations	Regulated external cost with compliance implications
Corrective Maintenance	Emergency/unplanned technical repairs	Linked to operational faults and rolling stock degradation
Productivity Loss	Unused staff time due to disruptions	Latent internal inefficiency, often underreported
Recruitment and Overtime	Costs for emergency staffing, replacements	Human resource strain signal under irregular conditions
Customer Handling	EVF payouts, refunds, service recovery, cross-operator handling	Visible endpoint of cascading service failures

5.4 First Layer Analysis Quantitative Overview of Quality Deficiency Costs at Company X(2019-2024)

This section presents the core financial analysis that forms the foundation of Layer 1, which is crucial for understanding the subsequent analysis. It outlines the growth, composition, and strategic burden of Quality Deficiency Costs (QDCs) from 2019 to 2022-2024, using data validated internally from Company X SAP system.

The primary benchmark for normalization is Company X Business area 1 revenue (BA1), chosen in agreement with Company X.

This section is divided into two parts:

- 5.4.1 analyzes QDC growth trajectories and their impact on revenue, identifying significant financial concentrations and notable systemic trends.
- 5.4.2 examines how disruptions propagate across organizational layers, introducing five escalation archetypes that underpin the interpretive Layer 2 analysis.

5.4.1 Cost Growth and Distribution Patterns

Between 2019 and 2024, Company X Quality Deficiency Costs (QDCs) grew by +37%, while BA1revenue remained flat. This divergence caused QDCs to rise significantly as a share of BA1 revenue, marking a sharp decline in cost efficiency and highlighting systemic difficulties in disruption management and cost containment. The rising QDC-to-BA1 ratio signals budgetary fragility and strategic vulnerability.

Cost Category	*2019*	*2024*	*CAGR*
Customer Handling	**87**	**100**	**+3.3%**
Corrective Maintenance	**65**	**98**	**+8.7%**
Replacement Traffic	**37**	**58**	**+10%**

Productivity Loss	**21**	**35**	**+10%**
Hotel & Accommodation	**3**	**5**	**+17%**
Quality Deficiency Fees	**4**	**6**	**+11.0%**
Recruitment Costs	**3**	**4**	**+12%**
Personnel (Overtime etc.)	**16**	**16**	**–0.1%**

Table: Growth of QDC Categories (2019–2024), indexed for sensitivity purposes

By 2024, three categories : Corrective Maintenance, Replacement Traffic and Customer Handling accounted for almost 80% of total QDCs. Among the various categories, passenger-facing ones exhibited particularly sharp proportional growth, indicating a shift in cost dynamics. Though minor in absolute terms, Hotel & Accommodation costs grew at a 17.5% CAGR—more than doubling their share of BA1turnover—indicating potential gaps in structured preventive practices that could affect overall cost management. While it grew from a small baseline, should it be neglected, it may over time evolve into a significant QDC category. Furthermore, Productivity Loss, increasing by 10.6% CAGR, reflects an increasing strain on internal capacity and latent inefficiencies in staff deployment. In contrast, Personnel Overtime remained flat (–0.2% CAGR), which raises concerns about hidden workload pressures. The discrepancy between rising Productivity Loss and static Overtime suggests informal overwork and insufficient recovery capacity. This could point to unmonitored inefficiencies and shrinking recovery margins that accumulate in silence until they become visible as degradation of performance. It is clear that the increasing costs stemming from productivity losses indicate that Company X uses their staff in increasingly inefficient ways. Although these strains are not recorded as direct costs, they fall under the Indirect and Systemic layers of the Onion Model, which supports the thesis's assertion of invisible cost accumulation beyond formal accounting boundaries.

The distribution of burden across Onion Model layers also shows signs of systemic drift. Although Corrective Maintenance and Replacement Traffic remain predominant, the expansion of Customer Handling signifies a shift in cost absorption from internal technical systems to customer-facing compensation. This phenomenon implies that disruptions are not contained at the source but escalate until they have a notable detrimental effect on reputation and costs become unavoidable.

Although Company X conducts preventative measures like planned maintenance and reserve staff upkeep, the current CoQ profile remains skewed toward external failure costs. Company X cost governance appears structurally reactive, increasing long-term financial exposure and reinforcing cyclical vulnerability. More broadly, the dataset shows little sign of preventive investment working as intended, such as early detection systems, scenario planning, or redundancy, which are crucial for addressing the systemic vulnerabilities identified earlier. These findings offer not only a diagnosis but also a directional warning. The system is absorbing failures instead of redesigning itself to prevent them. Section 5.4.2 builds on this understanding by tracing the propagation logics that transform local disruptions into systemic cost burdens, as it reveals escalation chains and governance failures that demand upstream strategic attention.

5.4.2 Patterns of Escalation and Propagation: How Initial Disruptions Amplify Costs

The initial analysis, referred to as Layer 1, indicates that Company X Quality Deficiency Costs (QDCs) rarely remain confined to their initial source. Layer 1 refers to the first level of analysis, focusing on the immediate impact of disruptions. Instead, they propagate through organizational layers—amplifying into broader financial, operational, and reputational burdens. Between 2019 and 2024, costs associated with Hotel & Accommodation (+17% CAGR), Productivity Loss (+10.6%) and Corrective Maintenance (+8.7%) outpaced both revenue and Personnel Overtime (–0.2%). Such growth indicates a structural shift: disruptions are being absorbed not through targeted resolution but via indirect, reactive cost domains, which reveals deeper governance and system-level fragilities. It means that instead

of directly resolving issues with more work hours, costs are clearly leaking into other areas, such as extensive customer compensation, the arrangement of replacement traffic and increasing lost productivity because the system is too strained or inefficient to manage disruptions within its existing resource flexibility (even with some overtime). To illustrate how QDCs move throughout the organization, the following subsection introduces five escalation archetypes distilled from cost patterns and internal case data. These are interpreted through the Onion Model, Ripple Effect Theory, and Systems Thinking, which collectively help to reveal how seemingly discrete failures evolve into entrenched cost structures. Together, these archetypes form the diagnostic backbone for further analysis.
To further clarify and synthesize these findings, Appendix 4 summarizes the five identified escalation archetypes, linking their triggers, propagation logic and deeper structural significance. Appendix 5 summarizes a typical escalation pathway from a common failure, such as a vehicle fault.

Operational-to-Customer Escalation: Disruptions originating in technical or infrastructural failure, such as rolling stock malfunction, crew mismatch, or external blockage, typically initiate Corrective Maintenance and reactive reallocation. If recovery is delayed or incomplete, these failures cascade into Customer Handling costs via Replacement Traffic, Hotel bookings and discretionary payouts. For instance, one mechanical failure may eventually result in bus replacement and accommodation costs, which highlights how Insufficient initial mitigation attempts do not prevent downstream expenses related to customer handling, for example. As one traffic coordinator put it, “We can estimate a bus cost, but we don’t see the total accumulation.” This archetype exemplifies ripple amplification (Dolgui et al., 2017): a localized failure propagates through operational and customer-handling functions, thus moving between all Onion Model layers. From 2019 to 2024, EVF and Resplus grew by 11–20% CAGR. In particular, Resplus alone grew by 30% in terms of volume, reflecting the widening downstream burden.

Internal Friction Escalation: Certain QDCs are not caused by disruption per se but also by structural coordination failures. Examples include misaligned scheduling cycles, reactive crew substitutions, and fragmented cross-unit communication. These disruptions generate latent friction, often surfacing in categories like Productivity Loss or Overtime Budgeting.

Between 2022 and 2024, internal unproductive time grew by 23% CAGR, with ~50% of that increase attributed to one single category of classified unproductive time alone. Upstream correction is hampered by these frictions' invisibility. Their recurrence reinforces reactive reasoning and siloed accountability, which highlights the ongoing organizational misalignment.

Systemic Repetition: Cost categories like Customer Handling, Corrective Maintenance and Service Recovery demonstrate stable but recurring escalation. Despite repeated issues (e.g., door malfunctions on specific trainsets (Traffic Controller at Company X, 2025), interventions remain reactive. One traffic coordinator described these as “costs we know will happen again—we just plan for them.” This reflects single-loop learning, a concept introduced by Senge (1990), where organizations repeatedly address failure symptoms without altering the underlying design or policy. Systemic repetition is not a failure of awareness but of institutional adaptation.

Interface Breakdown Escalation: When disruptions occur across organizational boundaries, such as between Company X and Trafikverket, coordination gaps frequently leave Company X absorbing costs it did not directly cause. The Laxå and Malmö–Lund case examples (Section 5.5.2) illustrate how unclear jurisdiction, fragmented escalation channels, and slow information flow generate internal cost spikes despite the origin of the disruption being external. These cases illustrate not only cost migration but also governance fragmentation: the absence of shared protocols or accountability at inter-organizational interfaces.

Symbolic Volatility Escalation: Categories like Hotell & Logi and discretionary Service Recovery, while modest in scale (i.e. small share of Company X’s revenues), exhibit high cost volatility and reputational sensitivity. From 2019 to 2024, Hotell & Logi rose 17% CAGR, with 70% of passenger hotel costs concentrated on 5 specific subsegments of BA1. Costs are frequently driven by perceptions of service failure, reputational risk, or managerial discretion rather than operational need.
As the Head of Customer Service stated, "These gestures may be small in kroner, but they are huge in perception." Symbolic volatility does not follow strict cost logic; rather, it reflects emotional cues, media exposure, and trust dynamics.

Conclusion: These five escalation archetypes show that Company X QDCs are partly systemic outcomes shaped by structural design, organizational learning, and interface governance, not simply operational byproducts**.** Each archetype identifies specific intervention failures and emphasizes the importance of layered governance logic—one that anticipates how small-scale incidents can spread to cause widespread and long-term financial costs. Making these propagation chains visible allows Company X to shift from reactive containment to strategic prevention. This serves as the strategic backbone for the subsequent interpretive Layer 2 analysis.

The escalation patterns identified in Section 5.4.2.1 reveal not only cost growth but also specific structural factors, such as governance flaws that facilitate escalation. Specifically, three interlocking governance deficiencies—**delayed containment, fragmented attribution and absence of preventive architecture**, enable QDCs to persist and propagate unchecked.

Delayed Containment: The inability to intercept disruptions early leads to their escalation, which manifests as EVF payouts, hotel costs, or service recovery expenses. The 3% and 17% CAGR growth in Customer Handling and Hotel & Accommodation, respectively, suggests missed containment opportunities. From a Systems Thinking perspective, such growth reflects weak feedback loops and an inability to act on early warning signals. Hidden costs such as frontline overload and eroded customer trust accumulate silently, yet they structurally undermine resilience.

Fragmented Attribution: The lack of clear lines of ownership in multiple QDC categories—such as Productivity Loss, EVF, and Service Recovery—contributes to governance deficiencies. Layer 1 mapping shows that no unit tracks full disruption chains from origin to outcome, an argument that was supported by multiple Company X stakeholders. Ripple Effect Theory emphasizes that costs often emerge far from their trigger, and without closed feedback loops, upstream actors remain unaccountable. Tactical decisions in one part of the system routinely externalize costs to others.

Lack of Preventive Architecture: Company X financial dataset reveals insufficient investment in preventive controls such as redundancy, early detection, or system robustness.

The dominance of external failure costs in Company X CoQ profile highlights a reactive cost structure, as it indicates a focus on addressing failures after they occur rather than preventing them. For example, Productivity Loss rose 10.6% CAGR, yet no trace of effective parallel investment in redundancy, early detection, or system robustness is present. This situation suggests that organizational logic is oriented towards post-failure response rather than disruption avoidance. These governance failures can be analyzed using the Fishbone Diagram framework introduced in Chapter 3 to identify root causes and potential solutions.

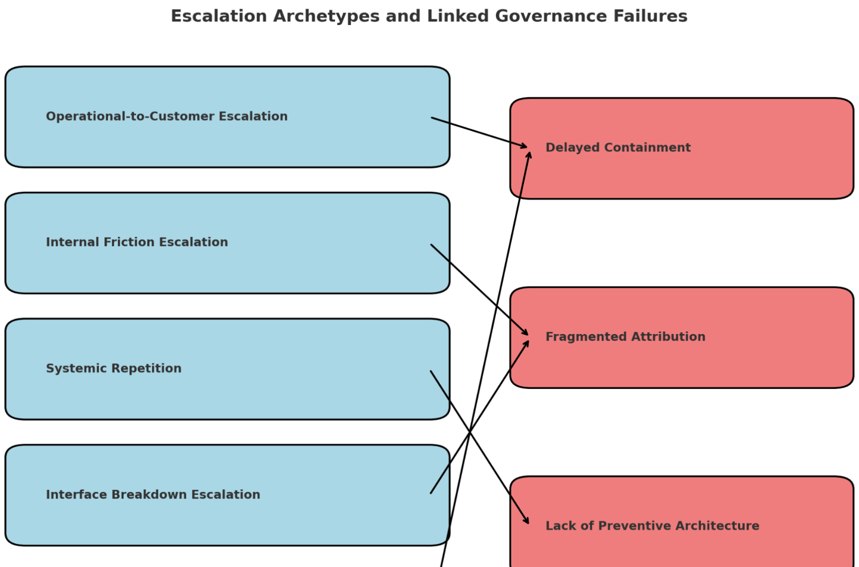
Fishbone Dimension	Identified Escalation Enabler
Management	No unified disruption ownership; fragmented accountability
Methods	Escalation playbooks are informal, ad hoc, or absent
Measurement	Impacts tracked post-facto, with little connection to origin
Process	Containment and redundancy routines applied inconsistently

Together, these gaps explain why QDCs not only persist, they **entrench**. Company X system is not merely reactive by circumstance, it is structurally unequipped to intervene upstream.

5.4.2.3 Strategic Implications and Transition to Layer 2

The previously discussed propagation chains and governance failures reveal a significant institutional weakness: Company X cost structure focuses on addressing existing issues, such as operational disruptions, rather than implementing preventive measures to avoid these issues.

Minor disruptions are allowed to escalate into systemic cost burdens because the organization



lacks early-warning systems, feedback integration, and clear accountability.

Three strategic implications follow:

Latent Costs Remain Structurally Invisible
Untracked burdens, such as staff burnout, customer distrust, and reputational erosion, do not appear in financial systems. Yet they erode resilience and distort the organization's true exposure to disruption.
Tactical response replaces strategic intervention.
Operational logic prioritizes reactive gestures: refunds, buses, and goodwill payouts. These mitigate symptoms but leave root causes untouched. Without systemic intervention, cost cycles repeat.
Escalation is Embedded, Not Exceptional
As the five archetypes showed, escalation is not a deviation from the norm; it is a **structural feature** of Company X disruption governance. Fragmented feedback, delayed response, and ownership gaps make cost propagation the default trajectory.

These insights transition the thesis from cost mapping to systemic diagnosis. Section 5.5 grounds these structural dynamics in real-world events. Through case-based analysis and a thematic deep dive into Customer Handling reveals how and why these failures recur, as well as where targeted leverage points for reform may lie.

5.5 Second Layer Analysis: Quantitative and Qualitative Exploration of Prioritized Cost Categories

5.5.1 Introduction to Layer 2 Analysis and Discussion

Layer 2 of this thesis transitions from descriptive cost mapping to interpretive diagnosis. While Layer 1 quantified the economic burden of Quality Deficiency Costs (QDCs) across Company X operations using structured financial data, this second layer investigates *how* and *why* these costs persist and escalate within the organization. The purpose is to identify the structural and behavioral factors that allow costs to spread, focusing on areas with weak accountability and control, rather than making generalizations. This analytical layer aims to reveal governance failures, feedback breakdowns, and systemic inertia, which are often overlooked by conventional accounting tools. It builds on the assumption—shared by Ripple Effect Theory, Systems Thinking and the Cost of Quality (CoQ)—that operational disruptions are rarely isolated events, as they are symptoms of broader organizational and systemic design.

Three real-life disruption examples—Malmö–Lund, Laxå, and Kumla–Mosås—from Section 5.5.2 show how localized failures developed into multi-layered cost chains. These show how localized failures developed into multi-layered cost chains. Using the Onion Model and ripple effect theory, each case is seen to show escalation dynamics across levels of governance and finance.

Section 5.5.3 provides a focused deep dive into Customer Handling—a QDC category ranked by Company X stakeholders because of its size, growth trajectory, and external visibility. Here, cost data is placed in context with internal performance measures and stakeholder insights to follow how institutional fragmentation and reactive behaviors maintain ongoing burdens.

These examples help one examine more general institutional trends and strategic leverage points in sections 5.5.4 and 5.5.5. They combine results on structural fragmentation, organizational learning, and feedback loop design to find why Company X QDCs resist mitigating—and what changes might allow upstream containment?

Here, structural diagnosis takes precedence instead of generalizability. The objective is to do a structural diagnosis, interpret cost persistence through governance capacity, organizational learning, and interdepartmental responsibility, thus favoring structural diagnosis over statistical analysis. Between Layer 1 mapping and the strategic advice produced in Chapter 6, these sections act as a diagnostic link.

5.5.2 Case Examples: Cost Escalation and Propagation

Through three detailed cases taken from internal Company X data, this section applies the theoretical frameworks from Chapter 3: Ripple Effect Theory, the Onion Model and Systems Thinking. Selected for their representativeness of recurrent circumstances, these examples show how QDCs begin, propagate, and grow.

Case Example 1: A third-party accident on the Malmö–Lund corridor that forced a full operational standstill. Although Company X did not cause the failure, it incurred significant QDCs because of inadequate redundancy and reactive handling.

Case Example 2: A two-day disruption on Västra Stambanan caused by extreme weather, compounded by infrastructure fragility and rolling stock underperformance. This event illustrates cascading failure chains, systemic design weaknesses and reinforcing feedback loops.

Case Example 3: A hotbox alarm and mechanical failure near Kumla triggered a regional operational collapse and highlighted vulnerabilities in Company X contingency coordination, evacuation routines, and cost attribution mechanisms.

Each case ends with a formal cost profile and theoretical interpretation, therefore tying the disruption dynamics to Company X's larger capacity for resilience and governance. Thus, this multi-layered section provides the backdrop for understanding the actual financial impact of QDCs as well as for highlighting where structural reform is most desperately needed.

5.5.2.1 Case Example 1: Vehicle Malfunction on a Key Route

Initial Trigger

At 15:50 on April 24, 2025, a major accident involving a non-Company X train between Malmö C and Lund C stopped all traffic on this vital southern corridor during peak evening hours. Although Company X was not responsible for the initial incident, the subsequent infrastructure closure by Trafikverket impacted all operators. Consequently, Company X faced significant operational and financial burdens as its services and passengers were directly affected by the disruption.

Propagation Pathway of the Disruption (See the appendix 6 for full flowchart)

The track closure brought an immediate standstill to all Company X services on the Malmö–Lund segment, leaving trains held, rerouted, or terminated mid-journey. In the midst of this, standard substitute transport plans rapidly failed as providers were overwhelmed, exposing critical vulnerabilities and forcing Company X to deploy its limited bus fleet. This improvised measure proved insufficient for the passenger volume, leading to long queues, reduced throughput, and immense staff pressure. Simultaneously, Company X authorized a 'goodwill' manual compensation policy (up to 3,000 SEK per person), triggering extensive manual processing and a significant administrative backlog for customer service and partners like Third party 1. These local issues then propagated through the network, as disrupted crews and trains caused cascading delays on at least 17 other services, overwhelming communication channels.

Scope and Recorded Direct Costs

The event received the internal order number, resulting in directly recorded costs index of 0,05. This figure primarily includes immediate expenses such as bus deployment, emergency accommodations, and authorized manual reimbursements. Critically, however, this sum fails to capture the event's broader structural impact, which rippled through its operational, reputational, and systemic dimensions.

Broader Cost Implications and Theoretical Interpretation

Direct Costs, also the most apparent financial impact, included recorded expenditures for shuttle bus deployments and discretionary reimbursements for hotels and alternative transport. While these were manually recorded and visible components in Company X Quality Deficiency Cost (QDC) system, they likely represent only an incomplete account of total outlays, especially considering the extensive passenger rerouting and compensation involved.

Significant **Operational Inefficiencies** emerged quickly and hampered recovery for days. Mismatched rolling stock and crews, disrupted schedules, and a surge in compensation claims strained customer service and diverted administrative teams. Critically, the failure to secure pre-contracted substitute transport forced Company X into a fragile, labor-intensive, ad hoc response.

Beyond direct expenses and operational strains, the disruption incurred substantial **Indirect Costs**, including reputational damage and passenger dissatisfaction, illustrating the systemic fragilities highlighted by the theoretical frameworks. Congestion in digital channels, while not a direct financial cost, further strained resources and capacity.

The event also revealed **Systemic Effects** in two key dimensions:

A governance gap: Company X absorbed significant costs from an external incident without a formal compensation mechanism from Trafikverket or the responsible party, highlighting issues in responsibility attribution.

Operational vulnerabilities: Company X dependence on ad hoc solutions for alternative transportation and compensation exposed deficiencies in its adaptability and resilience.

This scenario exemplifies Ripple Effect Theory (Dolgui et al., 2017), since the external disruption of the Malmö–Lund corridor initiated a chain reaction throughout several organizational levels, demonstrated by the following delays and strained communication channels. Technical difficulties evolved into systemic challenges due to third-order effects, including heightened customer service demands and reputational damage. From a Systems Thinking perspective (Senge, 1990), the occurrence illustrated a reinforcing feedback loop. As the deadlocked situation persisted, recovery alternatives decreased, operational delays intensified, and the absence of redundancy increased the pressure, further amplifying the disruption's effects instead of facilitating a return to normalcy.

Brief Concluding Remark

This instance illustrates how external events trigger substantial Quality Deficiency Costs(QDCs) for Company X, compounded by internal issues such as insufficient redundancy, limited inter-operator resilience, and dependence on human compensatory actions . This emphasis on reactive expenditure underscores shortcomings in Company X administration, planning, and cost allocation by exposing the absence of proactive strategies and strategic foresight. This analysis solely represents Company X viewpoint, as Trafikverket was excluded. Consequently, evaluations of inter-organizational accountability rely exclusively on Company X data and necessitate validation in future research that includes Trafikverket's perspective to fully grasp these cross-actor dynamics.

5.5.2.2 Case Example 2: Severe Two-Day Disruption on Västra Stambanan Due to Catenary Ice in Laxå.

Initial Trigger:

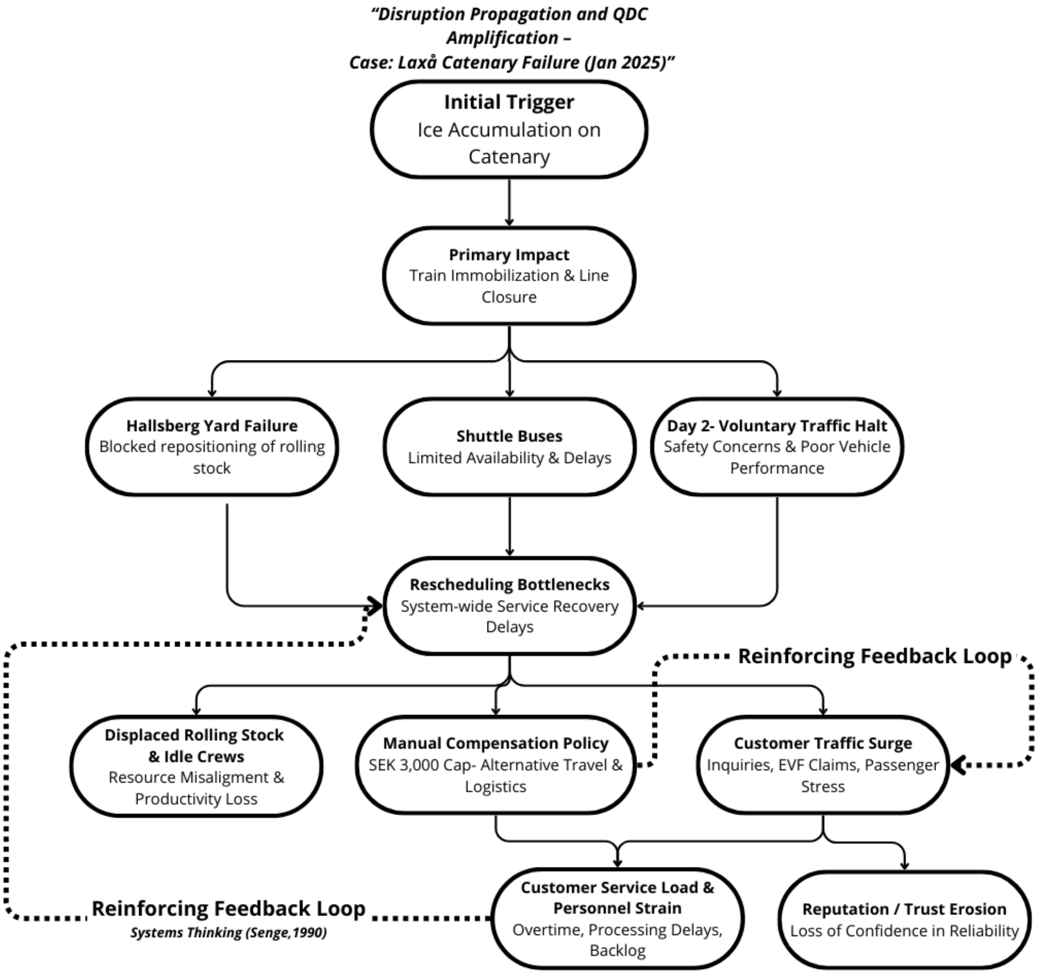
Severe winter conditions on January 1, 2025, caused ice accumulation on the overhead catenary system near Laxå, leading to electrical malfunctions that immobilized two Company Xtrains. The Swedish Transport Administration, Trafikverket, classified this as a weather-related infrastructure collapse. Trafikverket halted all traffic between Hallsberg and Skövde—a vital segment of the Västra Stambanan (Western Main Line)—due to safety concerns, resulting in a total line suspension during a peak vacation travel period.

Propagation Pathway of the Disruption

The disruption occurred over a span of two intense days. On Day 1, halted trains necessitated urgent cancellations and rerouting through Nässjö. The situation was made worse by electricity problems at the Hallsberg yard, hindering stock movement, and adverse weather conditions rendering most shuttle bus efforts ineffective. As a result, crew logistics deteriorated due to workers reaching work-hour constraints, and Trafikverket encountered increasing coordination challenges. On Day 2, although partial service resumed, Company X ceased operations once more due to safety issues and inadequate vehicle performance in cold conditions. The incident generated a further wave of disturbances, increasing staff and inventory displacements. Company X implemented a manual compensation policy of 3,000 SEK, which later overwhelmed customer service lines.

Scope and Recorded Direct Costs:

This disruption impacted a minimum of 65 Company X departures. While its internally recorded costs) reached index cost of 0,3 primarily covering tangible outlays like shuttle buses and passenger reimbursements, this sum **fails to capture the full scope** of QDCs generated across the system.



Broader Cost Implications and Theoretical Interpretation

The incident's effect rippled throughout all QDC tiers. Direct costs comprised required expenses for transportation, reimbursements, and probably substantial overtime. Operational inefficiencies were significant: stuck resources resulted in extended productivity losses and a series of rebookings, while the manual compensation process stressed customer service (including Third party 1), hence increasing staffing costs. Indirect costs were significant, as passenger stress over a peak holiday season diminished trust—a crucial concern considering

Company X’s already low sentiment ranking (Chapter 1)—further amplified by clogged and unclear digital communications. The event systematically revealed two primary vulnerabilities: inadequate vehicle resilience in cold conditions and substantial governance deficiencies, underscored by dependence on manual compensation and the critical absence of a mechanism to allocate infrastructure-related expenses to Trafikverket. This scenario exemplifies Ripple Effect Theory (Dolgui et al., 2017). A localized infrastructure failure escalated over two days due to early containment failure, resulting in a multi-node disruption affecting cancellations, staffing, and customer management. It also illustrates Systems Thinking (Senge, 1990) via distinct reinforcing feedback loops: The operational misalignments of Day 1, caused by inadequate vehicle performance and staff constraints, contributed to the escalation of disruptions on Day 2. The essential, yet reactionary, responses worsened the disruption, highlighting an absence of efficient balancing mechanisms. This corresponds with the insights from Company X Head of Customer Service, indicating that operational shortcomings "at both Company X and Trafikverket" influence customer experiences. Ultimately, Company X absorbed most financial and reputational consequences, highlighting a significant misalignment in inter-organizational responsibility structures. This is evidenced by the lack of a formal compensation mechanism from Trafikverket.

Brief Concluding Remark

This two-day disruption highlights Company X fragility under compound stress, revealing how latent technical, infrastructure and organizational vulnerabilities turn localized weather failures into major crises. The true QDC impact far exceeds the recorded 0,3 cost index, exposing structural flaws, poor redundancy and limited containment capacity. While addressing the full scope requires further study, it's clear such events will recur without strategic investments in asset resilience, automation and Trafikverket coordination. Crucially, as this study reflects only Company X perspective, interpretations involving inter-organizational accountability are provisional and need validation with Trafikverket's input.

5.5.2.3 Case Example 3: Vehicle failure and Evacuation on the Kumla–Mosås line.

Initial Trigger

On January 3, 2025, at 10:57, a hotbox alarm near Kumla, indicating a door malfunction that necessitated quick passenger evacuation. This situation required a brief halt of both tracks (Kumla–Mosås), obstructing traffic on this vital line. Single-track operations recommenced at 11:04, with complete service reinstated by 15:11 (Company internal system data, 2025).

Propagation Pathway of the Disruption:

The detailed flowchart illustrating this pathway can be found in the appendix 7 .

The mechanical breakdown on the train in question quickly evolved into a multi-stage operational disruption. Following the 10:57 hotbox alert and subsequent track closure (Kumla–Mosås), congestion persisted long after single-track operations resumed at 11:04, with full capacity not restored until 15:11. At 11:24, the causing train itself was cancelled for the Mosås–Stockholm C segment. Its passengers were evacuated and rebooked onto two alternative services , while others required pre-booked taxis. To acknowledge the severe impact, passengers who had boarded between Gothenburg and Kumla heading towards Örebro S/Stockholm C were offered full fare credits plus a 500 SEK compensation voucher. The disruption's effects rapidly spread beyond this single train. To prevent further network congestion, Company Ximposed booking restrictions at the key Laxå interchange for the remainder of the day. To maintain service continuity along the corridor, taxis were proactively booked for the Töreboda–Laxå–Hallsberg section, a measure affecting eleven consecutive long-distance trains heading towards Stockholm.

The disruption led to significant changes in passenger flows, strained logistics and increased the coordination burden on Company X operations, planning and customer service teams.

Scope and Recorded Direct Costs

The event was logged internally with an order number, with 0,03 total cost index recorded to it. This amount reflects visible expenditures for taxi logistics, immediate passenger compensation and emergency service coordination. However, this figure significantly underestimates the broader Quality Deficiency Costs (QDCs) that were activated across the deeper layers of the Onion Model.

Broader Cost Implications and Theoretical Interpretation:

The event triggered costs across all four layers of the Onion Model, which categorizes costs into direct, indirect and systemic inefficiencies. Direct Costs primarily covered confirmed taxi services (Töreboda–Hallsberg), passenger compensation (refunds and 500 SEK vouchers) and evacuation crew mobilization.
Significant operational inefficiencies resulted from train cancellation of substitute services , so upsetting the intended rolling stock and staff allocation. Along with this, the Laxå closure affected 11 long-distance trains, resulting in reactive ticketing and congestion and severely straining control, planning, and communication teams. Teams in traffic control, operational planning, and customer communication, who had to keep service continuity among great uncertainty and increased coordination complexity, were under strong pressure. Indirect Costs included a surge in customer service workload (including Third party 1) due to voucher handling and complaints, likely increasing handling times. From a passenger perspective, the sudden evacuation and change of travel plans, irrespective of safety needs, would likely be perceived as a service failure, thus contributing to reputational damage and reduced trust. Moreover, the initial disruption's misalignment of rolling stock and crew propagated inefficiencies throughout the day's remaining timetable, which compromised the deployment of much of Company X's assets. Finally, systemic inefficiencies were exposed, including fragile fault isolation (where a single door fault caused a shutdown), vehicle redundancy gaps, network vulnerabilities such as the Laxå chokepoint, and a lack of standardized, automated contingency planning, all of which highlight the need for a more robust and integrated approach to system management. These issues collectively reinforce Company X reactive governance approach. Theoretically, this case demonstrates Ripple Effect Theory, where a single technical fault leads to widespread disruptions and reflects Systems Thinking (Senge, 1990), as Company X efforts to restore service flow through taxis and rebookings were hindered by the critical constraint of the Laxå closure, illustrating the interconnectedness and complexity of the system. This created a classic 'Limits to Growth' dynamic (Senge, 1990): The Growth Effort is exemplified by Company X attempts to reroute trains, arrange taxis and manage passengers, while the limits refer to the physical and logistical bottlenecks caused by the Laxå interchange restriction. The Slowing Action is exemplified by the logic that Company X pushed hard for reactive solutions to deal with the limit (e.g., taxi deployment, rebookings onto already strained services), further increasing coordination complexity, which in turn created new potential bottlenecks, ultimately having

the potential to slow down the overall recovery process. In essence, the system could not overcome the constraints. This reliance on ad hoc measures can also be considered 'Shifting the Burden' away from investing in core vehicle reliability and robust, *standardized* contingency plans.

Brief Concluding Remark on Case Example 3

This case demonstrates how a single technical failure—the door malfunction—can trigger disproportionate QDCs (far exceeding the recorded 0,03 cost index) due to underlying systemic fragilities within Company X network. It points out the urgent need for upstream investments in vehicle reliability and automated handling protocols to prevent likely recurrences. Importantly, this analysis reflects only Company X perspective, especially regarding inter-organizational issues with Trafikverket. Therefore, conclusions about shared governance or interface failures must be considered provisional and require future validation through research incorporating all involved parties.

5.5.3 A Deeper Look at a Key Cost Category: Customer Handling

One important Layer 1 QDC is Customer Handling, which helps one to grasp how operational interruptions turn into financial liabilities. Company X participants agreed that careful review of this cost category is essential. First, this part breaks out the Customer Handling sub-components—that is, Customer Service (5.5.3.1) and Passenger Compensation (5.5.3.2). Then it uses the Onion Model, ripple effect theory, and cost of quality (CoQ) to examine Escalation Dynamics (5.5.3) in order to identify the systemic causes of the ongoing cost increase.

Between 2019 and 2024, Company X outsourced customer service, managed by Third party 1, underwent marked shifts in both case volume and interaction complexity. Incoming cases grew by 33.5%, while handled cases rose by 36.8%, reflecting a compounding support burden. The compound annual growth rate (CAGR) for handled interactions (6.46%) exceeded that of incoming requests (4.63%), indicating possible inefficiencies in resource allocation or process management, as more resources might be needed for each interaction. EVF-related cases saw a particularly sharp increase, as they rose with a 11% CAGR, while

Average Handling Time (AHT) increased with 23%. Reopened cases showed even longer handling times. These trends point to an increasing proportion of complicated, high-friction problems—amplifying direct costs and intensifying the demand on support systems.

The increase in case volumes and handling times has led to a surge in customer handling costs. For instance, Resplus has experienced significant increases in both volume and cost per incident. Between 2019 and 2024, Resplus volumes rose by 30%, while the average cost per incident rose by 44%. These increases reflect rising disruption rates and a compounding effect from procedural escalations, aligning with the thesis's escalation archetype of Operational-to-Customer amplification. Head of Customer Service at Company X provided insightful analysis confirming that case volumes are tightly coupled to service delivery failures at both Company X and Trafikverket. According to Head of Customer Service, "The volume of incoming customer cases mirrors the quality of the delivery. Should the trains run poorly, customer service volume increases. She also pointed out that the chatbot, first unveiled around 2021–2022, significantly helped lower manual chat volumes, implying that current cases mostly involve more complicated problems for which self-service solutions cannot provide answers, thus explaining the rise in average handling times (AHT) for issues via phone. The introduction of digital channels, like the chatbot, has added complexity to customer service operations, impacting how cases are managed. Messenger was discontinued for GDPR-related reasons; chat use dropped by 19.3%. In contrast, Phone contacts surged by 9.1%, while answered calls climbed by 27% and AHT dropped by 3.7%. Implying better routing. Head of Customer Service confirmed this change, saying that customer preference especially during times of disturbance, leans toward "speaking to a human" and that increasing staff from autumn 2022 improved responsiveness following a difficult summer. She also emphasized that AHT increases are not purely indicative of inefficiency but often reflect product complexity. For example, "Handling night train bookings takes much longer than day trains," she explained, illustrating how underlying service features influence resolution.

Although the Onion Model places Third party 1 in the Direct Cost layer, deeper system inefficiencies are a contributing cause to its rising load. Deficiencies in communication during disruptions, slow escalation protocols, and reactive compensation structures all funnel pressure into Third party 1. Head of Customer Service described Company X case-logging tool as “a blunt instrument” and noted its limited diagnostic value, confirming that feedback to upstream departments is often informal or ad hoc. The quantitative trends and qualitative perspectives both reveal an overstretched customer service increasingly burdened by failures it does not cause and cannot prevent. Without structural changes, more proactive disruption management, improved communication systems and feedback integration, Company X direct handling costs and latent service inefficiencies will keep building unrestricted

5.5.3.2 Passenger Compensation and Related Handling (EVF, Service Recovery, Refunds, SMS, External Tickets)

Company X compensation expenditures, comprising EU-mandated EVF payouts, goodwill reimbursements (Service Recovery), disruption-related refunds (Krediteringar), SMS communication, and cross-operator ticket purchases, remains a central and persistent QDC category. Between 2019 and 2024, total costs rose from 19 to 32 index, despite significant pandemic-related volatility. Krediteringar dominated this category, peaking at 48 in 2022 and stabilizing at 34 by 2024, indicating a significant fluctuation in compensation costs over the years. EVF compensation increased considerably, from 11 to 14 in 2024. This cost in particular is highly dependent on Company X punctuality, as it constitutes outlays to customers for delays longer than 60 minutes.
Meanwhile, Service Recovery showed large fluctuations (3–13), suggesting that proactive compensation strategies are inconsistently deployed. It is important to note that Company X is increasingly reimbursing passengers with non-direct cash payout compensations, which may explain the recent decrease in Service Recovery. Smaller components like SMS (2) and external tickets (3) reflect downstream coordination effort rather than cost magnitude. Head of Customer Service noted that the EVF process itself has become increasingly manual following a major system change in Trafikverket’s MPK platform. Previously, automation rates for EVF cases reached 80%, but after MPK’s implementation, significant manual intervention was required. This issue also speaks to a systemic dependency, given that Company X uses the infrastructure that Trafikverket owns. Not all QDCs may be fully

addressable, such as this one, but how you manage them can have an effect on the outcome, as better management can mitigate some of the externally caused QDCs' impacts.

Ripple Effect Theory explains that a delayed or cancelled train can trigger a series of compensation payouts, rerouting expenses and increased service demand. This illustrates the interconnected nature of Company X cost structure. These costs do not reflect isolated events but rather demonstrate the systemic amplification of initial failures.
The CoQ framework confirms that this is an external failure-dominated portfolio. Compensation expenditures are post-event responses rather than cost-avoidance strategies. The variability in Service Recovery—sometimes high, sometimes negligible—suggests that even low-cost proactive measures are applied inconsistently.
The Onion Model categorizes these costs as Direct Costs, yet it highlights that the underlying causes are often found in deeper, less measured layers of the organization. For instance, poor vehicle quality (as raised by Head of Customer Service), communication gaps and fragmented ownership are all systemic effects that drive compensation volume upward.
Strategically, Company X cost structure is predominantly reactive, which is evidenced by the high compensation expenditures that occur after service failures, highlighting a focus on addressing issues after they arise rather than preventing them. As Head of Customer Service stated, “Historically, the passenger had to reach out to us. That’s starting to change, but we’re not there yet.” This reactive posture ensures that the most visible costs are incurred after the damage to customer trust is done. To exit this pattern, Company X must reallocate attention and budget toward early containment, automated rerouting, proactive notifications, and inter-operator coordination mechanisms. Without such upstream reinforcement, compensation costs will continue to reflect not just service failures, but the cost of failing to prevent them

5.5.3.3 Escalation Dynamics within Customer Handling

Customer Handling costs typically emerge at the end of a disruption chain, not its beginning. They are rarely discrete events but rather reflect propagation dynamics stemming from upstream operational or technical breakdowns. The Onion Model positions these (like EVF payouts and support costs) as visible endpoints of a wider organizational sequence where initial issues cascade across departments before surfacing. Such behavior reflects a strategic misalignment in Company X disruption logic, as succinctly put by Head of Customer Service: “The biggest cost isn’t the delay. It’s what happens afterwards.” Problems often flow downstream until they become expensive and obvious, rather than being contained early. The situation is sometimes exacerbated by well-intentioned but uncoordinated 'goodwill' actions, as one traffic controller noted ("Sometimes we behave with goodwill... Although we are not sure exactly what the final cost will be..."), which can create unintended consequences, especially for partners like Third party 1, when centralized escalation logic is absent. Ripple Effect Theory explains the spread of uncontained disruptions, while the CoQ framework categorizes these as costly “external failures” resulting from upstream prevention and appraisal shortcomings. Systems Thinking reinforces this, with evidence pointing to a lack of strong feedback loops and single ownership across the full disruption chain, meaning customer service insights often fail to inform upstream management This leads to compounding escalation; rising costs, such as Resplus credits and decreasing trust feed into each other, exemplifying an “Operational-to-Symbolic Degradation” archetype. Strategically, studying escalation dynamics shows that the capacity to control expenses and maintain reputation is significantly reduced once a disturbance gets to the customer-facing level. Reversing this means moving government toward upstream prevention. This calls for structural changes: better predictive systems, robust fleet management, well defined escalation routes, formalized feedback loops.. Without these transformations, Customer Handling costs will remain persistent symptoms of Company X uncontained systemic vulnerabilities.

5.5.4. Discussing Potential Systemic Effects: Organizational Learning and Structural Coordination

Layer 1's patterns of propagation point to rising Quality Deficiency Costs (QDCs). This increase exposes more fundamental organizational structural inefficiencies in Company X. Input from Company X’s Head of Customer Service, and traffic controllers points to these flaws—often related to institutional learning failures and divided cost ownership. Systems Thinking, ripple effect theory, and the Cost of Quality (CoQ) paradigm all help us to see them.

5.5.4.1 Potential Challenges in Organizational Learning

The persistence of high-burden QDC categories like Customer Handling and Corrective Maintenance suggests structural constraints in Company X ability to convert experiential knowledge into preventive organizational routines. Although formal systems are in place, the recurrence of known failures indicates flaws in institutional learning.

From a Systems Thinking perspective, Company X appears caught in a single-loop learning cycle (Senge, 1990): operational deviations are corrected, but underlying structures and assumptions that cause them remain unchallenged. Recurring problems, especially in vehicle performance and disrupted communication, show an ongoing lack of double-loop learning, in which organizations challenge the very standards guiding their operations. "We address the issue as it arises, yet the underlying system remains unchanged," one operational stakeholder said. Unintentionally delaying deeper change, this reactive standing lets cost drivers remain within the company instead of forcing upstream redesign.

Company X's Head of Customer Service points out these learning gaps. With data inconsistently interpreted and lacking the diagnostic depth required for systemic improvement, she characterizes the customer service logging system as a "blunt instrument." Although consumer insights might guide short-term planning, they are not ingrained in systems of continuous improvement, which results in disjointed feedback lacking strategic value. This corresponds with the Cost of Quality (CoQ) model. A concentration of QDCs in "external failure" costs, which are accounted for following passenger impact, points to underinvestment in prevention and a governance logic based on mitigation. This situation arises even though one is aware of constant vehicle and communication problems within. Head of Customer Service calls for official structural changes to turn this trajectory around: building cross-functional forums for operational insights and investing in diagnostic tools; channeling customer-facing data to planning and fleet management. Systems Thinking's idea of creating balancing loops for systematic learning and self-correction speaks to these ideas. This scenario contrasts with the present situation whereby, despite efforts, deep learning isn't always institutionalized; as another controller admitted about learning from past events, "I don't have a concrete example," echoing Senge's criticism of mere single-loop adaptation. Company X has to commit to create strong feedback loops and promote double-loop learning to solve the observed problems. Without this dedication, the company will probably keep managing symptoms instead of addressing underlying causes. Every new disturbance runs the risk of feeding bad habits, which erodes trust, wastes resources, and causes avoidable expenses. Dealing with this inertia calls not only new behaviors but also a basic change from reactive containment to systemic foresight.

5.5.4.2 Potential for Fragmented Ownership and Coordination Challenges

The Layer 1 observation that QDCs span multiple departments inherently suggests fragmented cost ownership. This cross-departmental nature, without clear end-to-end accountability, predictably leads to coordination challenges, a systemic effect in complex organizations (Senge, 1990). A finance-connected individual noted, "We track the costs, but we can't influence how they arise nor how they are absorbed in multiple organizational levels," which illustrates a perception of siloed management. A traffic controller described common coordination failures, particularly with external actors or substitute transport, citing *"a lot of miscommunication or information asymmetry,"* and noted that emergency bus coordination ("bussakuten") often relies on personal initiative rather than codified routines. This scenario highlights a disconnect where real-time tactical decisions, aimed at prioritizing efficiency or goodwill, are detached from downstream cost ownership. As a result, customer service managers like Head of Customer Service are left to handle the fallout from choices they didn't influence.

The disparity promotes divided accountability. Head of Customer Service's advocacy of "gemensama möten (forum)" (common meetings) and "Tvärfunktionella team" (cross-functional teams) highlights a supposed need for improved cross-functional mechanisms. The Fishbone Diagram, particularly its 'Management' dimension, helps conceptualize how a lack of clear end-to-end process ownership sustains inefficiencies. For instance, as Head of Customer Service observed, poor train quality (an operational issue) directly drives customer service costs, which shows how root causes in one area manifest as costs elsewhere. Fragmented QDC data across multiple systems can further worsen these visibility challenges. Such systemic fragmentation, if unaddressed, leads to diffuse prevention efforts and reactive budgeting. A striking example of these underlying issues is the escalation in Company X Hotell & Logi and Oproduktivitet cost categories, which can be described as 'symbolic volatility.' Although these categories represent a small proportion of total QDCs, they have shown the highest compound annual growth rates (CAGR) since 2019, particularly concentrated in specific operational domains.

5.6 Synthesis of Layer 2 Discussion

The second-layer analysis concludes that Company X Quality Deficiency Costs (QDCs) are mainly due to structural issues rather than just operational byproducts. Layer 1 mapped the financial scale of QDCs, providing a foundation for Layer 2 to explore their systemic roots, such as a reactive service architecture, fragmented cost ownership, and deficient learning loops. Three core findings stand out:

- QDCs escalate through predictable propagation chains, where initial technical or scheduling failures cascade into downstream financial burdens due to failures in early containment.
- Company X current governance structures are ill-equipped to interrupt this trajectory. Stakeholder input from Company X Head of Customer Service and operational managers highlights issues such as underdeveloped cost attribution, escalation protocols, and systemic feedback mechanisms, and most importantly, a lacking perspective on cost lineages.
- Preventive logic is structurally underrepresented, with resource allocation (as per CoQ insights and Arnell's observations) skewed towards managing 'external failure' costs rather than proactive, preventive investments.

If current escalation trajectories persist, Company X QDCs may exceed 21% of Business area 1 Revenue by 2027, as key categories (Customer Handling, Replacement Traffic, Corrective Maintenance) grow at compound annual rates of 3.3%-9.2%, severely outpacing revenue growth and weakening Company X capacity for preventive reinvestment.

6. Conclusions and Strategic Implications

6.1 Summary of Key Insights

This thesis shows that Company X Quality Deficiency Costs (QDCs), which account for a significant share of Business area 1 Revenue (BA1), are not only random anomalies but also structurally embedded patterns within the system. By integrating the Onion Model, Ripple Effect Theory, Systems Thinking and Cost of Quality (CoQ) frameworks, the thesis offers important observations about the structural patterns of Quality Deficiency Costs (QDCs) within Company X's system.

- The Onion Model provided multi-layered cost visibility (Direct, Operational, Indirect, Systemic), enabling comprehensive diagnosis.
- Ripple Effect Theory highlighted predictable propagation chains, demonstrating how Quality Deficiency Costs (QDCs) migrate from initial technical faults to customer-facing consequences.
- Systems Thinking and CoQ analysis exposed systemic drivers of cost persistence, such as weak accountability and reactive routines, which lead to high external failure costs and significant unrecorded hidden costs like brand erosion.

The absence of a centralized function owning the entire disruption lifecycle and its QDCs exacerbates issues like weak accountability and reactive routines, which are systemic drivers identified by Systems Thinking and CoQ analysis. Although various departments manage different aspects of Quality Deficiency Costs (QDCs), no single unit is fully responsible for structural mitigation or preventing escalation chains. This fragmentation leaves systemic cost drivers unresolved and creates critical blind spots in financial traceability and preventive accountability. Ultimately, these findings demonstrate that Company X rising costs are not only a consequence of external events but also of its organizational design and decision logic, rather than mere technical unpredictability. The analysis suggests that without structural reform focused on establishing clear ownership and shifting toward proactive governance, cost growth will likely continue along its current trajectory and remain resistant to localized interventions.

6.2 Strategic Takeaways for Company X

The study shows that Company X Quality Deficiency Costs (QDCs) are not random but are sustained by systematic patterns. These include reactive governance, divided cost control and insufficient preventive systems.

6.2.1 Reframe Cost Governance Around Preventive Leverage Points

The main finding is that Company X current approach to reactive cost control, which focuses on compensation and containment, overlooks critical opportunities for cost prevention. Therefore, prevention strategies need to be implemented earlier in the process. Tangible initiatives to achieve those goals include more advanced automated triage systems that would flag upstream signals of disruption, such as infrastructure deviations and forecasted crew shortages, and provide operational managers crucial "heads-up" time to intervene proactively before issues fully materialize. Further develop and implement standardized protocols that reduce improvisation, minimize discretionary errors, and ensure consistency in management.

The value of such upstream investments is supported by Ripple Effect Theory, which aims to reduce disruption propagation, and Cost of Quality (CoQ) logic, which highlights how investing in prevention can lower overall failure costs. If 2024 had matched 2019's best-practice cost ratios, Company X could have avoided an estimated 92 cost index in preventable QDCs.

6.2.2. Establish Cross-Functional Ownership of Propagation Chains

The analysis reveals a significant issue: Quality Deficiency Costs (QDCs) tend to rise across departments, yet responsibility remains limited to individual departments. To address the issue of rising QDCs and misaligned responsibility, Company X must establish robust cross-functional ownership of disruption chains. Incorporating more cost-lineage tracking into financial and operational reporting would allow for tracing the financial impact from any given disruption through all its downstream Quality Deficiency Cost consequences, such as linking specific payouts or maintenance costs back to their root causes. Additionally, an introduction of shared KPIs for teams whose work directly impact each other (e.g., Operations Control Center, service planning and Third party 1) would encourage an approach that fosters collaboration and a focus on overall system performance, rather than siloed optimization where one team's efficiency might inadvertently create problems for another. When teams succeed or fail together on shared goals, true cooperation is fostered. Together, these actions aim to reframe QDC management by shifting the focus from merely identifying where costs are absorbed to understanding their points of origin. This enables the creation of accountability chains that accurately reflect the propagation logic of disruptions, driving more effective and systemic cost control.

6.3.3 Prioritize Addressable QDC Categories First

Using 2019 as a benchmark and cross-validating with 2024 Excel data, we identified the most addressable QDCs. These are characterized by clear propagation patterns, ownership gaps, and preventive potential. The propagation of these costs is evident as they often start small and ripple through the system. They have clear ownership gaps, indicating a lack of clarity about who is responsible for managing or preventing these costs, as the interconnectedness between these other QDCs is sometimes overlooked. This suggests a potential for improvement if responsibility and accountability are better assigned.

Customer Handling: Encompasses all costs for customer interactions during and after disruptions; this category is highly addressable due to its significant 'ripple potential' (where operational issues rapidly escalate into high customer service loads). Improving processes, responsibilities, and coordination here presents a major opportunity for cost reduction.

Corrective Maintenance: Primarily driven by vehicle faults, this category stands out due to its high frequency and its significant tendency to spread into other QDCs like cancellations and delays. It also lies on the intersection of technical reliability and operational planning, often leading to and complicating challenges such as late turnarounds and vehicle allocation, as well as managing passengers, should the train be very delayed or even cancelled.

Unplanned Replacement Traffic: proved to be a high-priority target for any serious effort to reduce Quality Deficiency Costs at Company X. Its prominence stems first and foremost from its immense financial scale, consistently costing the company over 56 cost index annually. This figure alone makes it one of the most significant and visible drains within Company X QDCs. However, the argument extends beyond mere cost. This category is

particularly compelling because a not-so-insignificant portion of its expenses appears to be driven by how it is managed on an operational and higher level, and therefore it may be considered
'addressable' inefficiencies. The current system, often activated under extreme pressure, suffers from suboptimal routing decisions made on the spot, costly ad hoc procurement processes, and communication gaps between Company X operational control, transport providers, and stranded passengers. These aren't intractable issues; they are logistical and informational weaknesses that can be improved. Crucially, the impact of poorly managed replacement traffic extends significantly beyond its direct budget line. It is a major determinant of customer experience during disruptions. Failures here directly fuel passenger frustration, erode trust, and inevitably lead to a surge in Customer Handling costs, including complaints and compensation payouts.

The same logic of addressing inefficiencies and improving coordination can also be applied to Customer Handling and Corrective Maintenance. All of these categories are also inherently tied to each other, as whenever replacement traffic is called upon, it is either due to an external event, e.g., signal failures, or an internal one, e.g., a vehicle fault, which is definitely addressable. Therefore, invest in smarter planning, for example, keeping larger buffers of reserve components and not relying solely on a J-I-T principle. Better coordination and clearer communication also offer high leverage, as they have a large effect on customer trust

6.3.4. Institutionalize Learning Loops and Cost Traceability

The final structural shift required is informational and focuses on integrating genuine cost awareness into Company X daily operational routines. This moves beyond simply recording costs and aims to create a shared understanding of how actions translate into financial consequences across the organization. To achieve this, there needs to be a link between disruption events and their total financial impact.

This involves tracing the complete 'cost lineage' of any disruption, from its initial trigger (e.g., a signal failure) to all downstream QDCs like staff overtime, replacement traffic expenses, EVF payouts, and call center surges. Reaching this visibility will equip managers with a realistic understanding of the true stakes, and with further research it can offer clear data to justify preventive investments and make financially sound operational decisions.

Establish formal feedback loops to feed stakeholder insights into planning and budgeting. This procedure means that Company X should make use of intelligence from frontline teams directly in their strategic decision-making processes. This approach breaks down information silos and allows future plans and budgets to be proactively designed against known failure points.

Form QDC retrospectives that trace one ripple chain from root to final costs across multiple departments. By having teams collaboratively dissect one specific disruption's journey, mapping its costs from root cause to residual impact across multiple departments, Company X can foster a shared understanding of interdependencies and therefore make it easier for managers to pinpoint systemic weak points, communication failures, and crucial leverage points for targeted improvements.

Together, these initiatives change Company X approach from reactive, isolated event debriefing to an integrated, proactive, and data-driven cycle of continuous governance, which makes cost awareness a shared responsibility and a key driver of ongoing improvement.

6.3 Contribution and Future Research

This thesis argues that Company X Quality Deficiency Costs (QDCs) are not only random costs but also consequences of organizational management, as it demonstrates how Company X are impacted by disruptions and how they handle attribution issues. The central strategic insight is that Company X must view QDCs not as isolated anomalies but as part of a broader systemic issue. Instead, they should be considered cumulative indicators, signs of weak cost feedback, fragmented governance, and siloed accountability. Such an approach requires designing systems and decisions that make costs visible, and by understanding these cost structures, Company X can shift from reactive to proactive approaches.

6.3.1 Contribution to Practice (for Company X)

This thesis offers a structured, data-integrated, and theory-informed framework for diagnosing and managing QDCs more effectively. Its primary contributions to practice include

An actionable visibility tool: The Onion Model categorizes QDCs across Direct, Operational, Indirect and Systemic layers, and by doing so, it provides a diagnostic tool to understand how costs arise, migrate, and compound within Company X.

A propagation logic lens:

By using Ripple Effect Theory and Systems Thinking, the thesis shows how small disruptions can grow into larger financial issues and how weak feedback systems let these costs continue.

Strategic targeting and prioritization: Using internal Company X data, the study identifies key QDC categories—most notably Customer Handling, Corrective Maintenance, and Replacement Traffic—that have high addressability and propagation risk, marking them as priorities for reform due to their scope, frequency, and cross-functional influence.

Operational leverage points: Through Layer 2 deep dives and case examples, the study pinpoints several specific interventions (detailed in Section 5.5.5), including upstream triage protocols, cross-unit disruption ownership, integrated customer handling workflows, and centralized escalation routines.

A business case for governance reform: The findings encourage organizational adjustments to break down silos and embed prevention. By linking financial accountability to disruption chains rather than isolated departmental budgets, Company X can achieve both immediate cost savings and long-term resilience.

This thesis offers Company X a comprehensive cost awareness model linking organizational behavior to financial performance, enabling leaders to take targeted action.

6.3.2 Contribution to Theory and Methodology

The study contributes to the literature by demonstrating how Systems Thinking, Ripple Effect Theory and CoQ are integrated into a cohesive framework in a railway context. It provides a new perspective on both the theoretical and methodological aspects of QDC analysis.. This model facilitates the integration of Systems Thinking, Ripple Effect Theory, and CoQ.
and paired with the study's abductive logic, effectively combines into a hybrid approach that integrates both qualitative and quantitative methods for mapping QDCs. Furthermore, it links financial data with organizational and systemic theories, which provides insights into QDCs and a framework for further applied research.

6.3.3 Future Research

Several avenues emerge from this study that warrant further investigation, both to extend generalizability and to deepen explanatory precision:
Cross-operator replication: Apply the Onion Model and propagation logic to other rail operators or urban transit systems. This would test whether Company X QDC issues are unique or reflects broader systemic patterns within European rail governance.

Valuation of hidden costs: Future research can aim to calculate the actual financial cost of things like loss of customer trust, for example, by using specific advanced statistical or accounting methods. Even though these 'soft' costs are somewhat overlooked in data due to being hard to quantify, they do have a considerable impact

Evaluation of interventions: Conduct longitudinal studies to assess the impact of implemented leverage points, such as improved triage systems and shared ownership models.

Deeper verticals within QDCs: Extend qualitative studies beyond Customer Handling to other QDC contributors, such as Corrective Maintenance and Replacement Traffic, and their significance to better understand their impact.

Actor boundary governance: Look into shared accountability between train operators and infrastructure owners like Trafikverket. This includes researching fairer cost-sharing schemes, more robust compensation protocols, and effective cross-organizational feedback systems to address attribution gaps and improve overall rail system resilience.

6.4 Methodological Reflections

This paper investigated the emergence, propagation, and persistence of Quality Deficiency Costs (QDCs) inside Company X operational and governance structure using a layered, abductive research design. This approach purposely gave explanatory depth for internal system diagnosis over statistical generalizability. The study was abductive so that it was able to alternate between input from stakeholders, cost patterns, and theoretical framework and thus let emerging themes guide the scope of the study. The Quantitative layer applied the Onion Model and its structured cost mapping logic to classify QDCs across visibility and systemic depth to identify aggregated trends and dominating cost categories. Although this layer was limited in scope, it served as a tool for diagnosis. It presented examples of governance gaps, escalation dynamics and cost ownership fragmentation, clarifying patterns suggested by quantitative and case-based data.

The theoretical frameworks Ripple Effect Theory, Systems Thinking, Cost of Quality (CoQ), the Onion Model and the Fishbone Diagram,were integral not only as analytical tools but also as methodological guides. They shaped the qualitative interpretation and case selection (e.g., the focus on Customer Handling was informed by Onion Model stratification and Ripple Effect propagation). This fit within the abductive logic, and furthermore, they provided a structured and comprehensive approach for understanding how QDCs propagate. Its interpretive scope, which emphasized systemic interactions over individual anomalies, was well-suited for uncovering the root causes behind the recurring inefficiencies. Ultimately, while the approach is limited in regard to broad generalizability, the integrated abductive methodology was both appropriate and necessary for capturing the complexity of Company X environment and delivering actionable insights.

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8. Appendices

Appendix 1: Included Cost Categories

The following cost categories were included in the Layer 1 quantitative mapping of Quality Deficiency Costs (QDCs) at Company X. Costs difficult to quantify such as customer dissatisfaction, goodwill and so on were excluded. These cost categories were developed in collaboration with Company X Business Control unit and reflect internally classified QDC expenditures for the period 2019–2024:

1. **Hotel and Accommodation (Passengers)** – Lodging costs for passengers affected by disruptions
2. **Hotel and Accommodation (Staff)** – Lodging costs for staff unable to return home due to service interruptions
3. **Replacement Traffic (Unplanned)** – Emergency transport such as buses or taxis arranged reactively
4. **Replacement Traffic (Planned)** – Pre-arranged substitute transport services activated during disruptions
5. **Quality Deficiency Fees** – Financial penalties imposed by Trafikverket for operator-caused deviations (e.g., J-coded events)
6. **Corrective Maintenance** – Technical repairs and maintenance directly triggered by operational failures
7. **Sick Leave** – Absenteeism linked to stress or strain associated with service disruptions
8. **Productivity Loss (excluding breaks)** – Lost working time due to disruptions, excluding scheduled rest periods
9. **Recruitment Costs** – Costs for hiring temporary or replacement staff due to operational instability
10. **Overtime** – Additional working hours caused by unplanned events or rescheduling needs

11. **Vacation Buyouts** – Compensation for unused vacation days due to staff shortages or disruption handling
12. **EVF Compensation** – Statutory passenger compensation in accordance with EU passenger rights regulations
13. **Service Recovery** – Discretionary compensation (e.g., goodwill gifts, vouchers) for affected passengers
14. **Customer Service (Third party 1)** – Costs associated with outsourced customer support, including EVF case handling
15. **Refunds and Credits** – Passenger reimbursements and disruption-related customer compensation
16. **Ticket Purchases from Other Operators** – Costs incurred when Company X arranges alternative travel through external rail operators
17. **Customer Communication (SMS)** – Expenses related to sending SMS updates or alerts during disruptions

Explanation of different costs in the analytical Deep dive.

Resplus

A national coordination system for multimodal travel in Sweden.
Covers journeys that combine different operators, e.g., trains and regional buses.
Used when Company X service disruption affects a trip involving multiple carriers, requiring joint compensation.

Appendix 2: EVF (Compensation for Delay)

Refers to EU Regulation 1371/2007. Passengers are entitled to financial compensation when a train is delayed beyond a certain threshold.
Represents the largest share of customer compensation cases.

Service Recovery

Proactive actions or goodwill compensation offered when the customer experience is negatively affected – e.g., lack of information, poor treatment, faulty air conditioning.
Intended to repair the customer relationship, even if no formal delay occurred.

Credit Refunds

Reimbursements for ticket-related issues such as service disruptions, duplicate purchases, or technical errors in the ticketing system.
Typically linked to ticketing or payment system failures.

Corrective Maintenance

Unplanned maintenance to fix broken components or vehicles during operations.
Unlike preventive maintenance, this is reactive and often leads to higher costs and operational disruptions.

Customer Care (Kundomhändertagande)

An umbrella term for all costs related to handling affected customers during disruptions – including communication, compensation, and service actions.
Includes Customer, EVF, SMS alerts, service recovery, Resplus compensation, etc.

Substitute Transport (Ersättningstrafik)

Transport services that replace cancelled trains – includes both planned (e.g., for track works) and unplanned (e.g., vehicle faults) disruptions.
Examples: bus, taxi, rental car – along with all related coordination and logistics costs.

Hotel & Accommodation

Costs for overnight stays, either for passengers stranded en route or for personnel displaced from their home base.
Often triggered by disruptions, reroutings, or fleet shortages.

Appendix 3 : Analytical Function

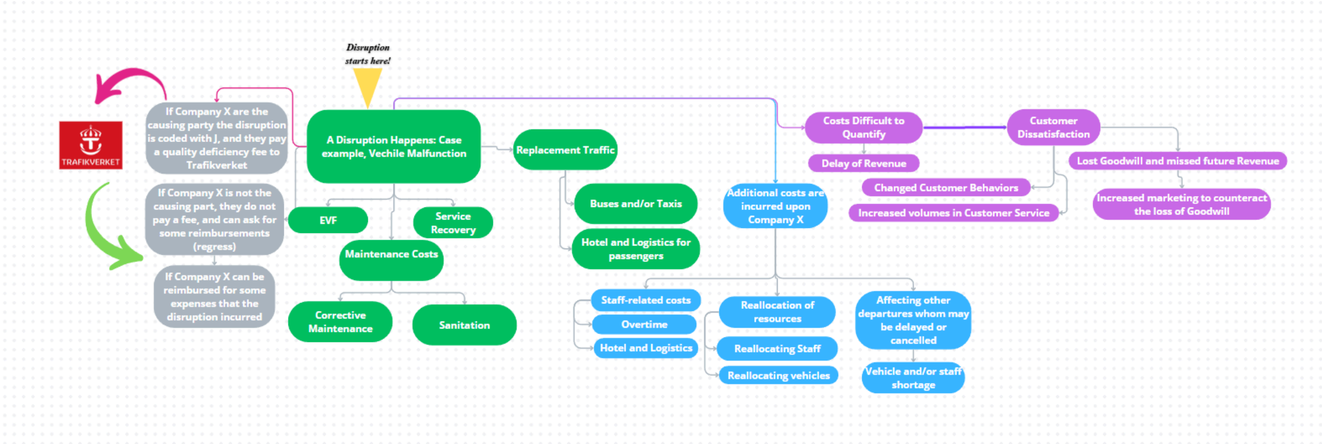
Model	Analytical Function	Applied In
Onion Model	Classifying cost visibility and systemic depth	Case profiling, escalation mapping
Ripple Effect Theory	Tracing propagation from initial failure to cost	Disruption chains and cost migration
Systems Thinking	Identifying feedback failures and systemic inertia	Structural interpretation
Cost of Quality (CoQ)	Differentiating reactive vs. preventive cost logic	Governance critique
Fishbone Diagram	Structuring potential root cause domains	Diagnosis of organizational failure points

Table 1.: Overview of TRV deviation codes and their effects on Company X operations.

Appendix 4: Escalation Archetypes

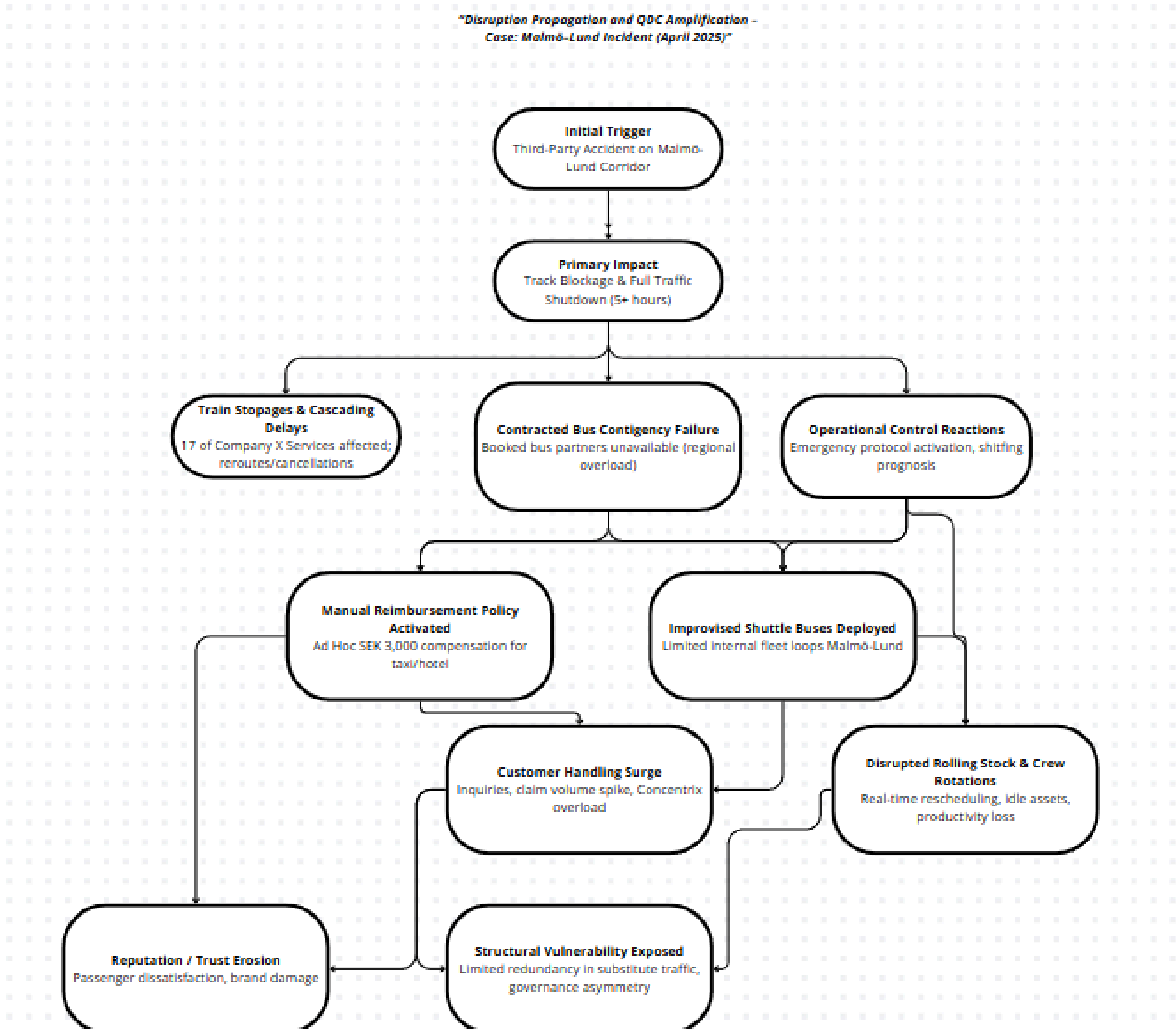
Escalation Archetype	Trigger	Propagation Path	Systemic Insight
1. Operational-to-Customer Escalation	Technical failure (e.g., train malfunction)	→ Corrective Maintenance → Replacement Traffic → EVF / Customer Handling	Classic ripple logic; visible costs lag initial cause; prevention failure across units

2. Internal Friction Escalation	Planning misalignment or inter-department delays	→ Productivity Loss → Overtime / Recruitment Pressure	Latent inefficiency; friction accumulates in staff metrics without detection
3. Systemic Repetition	Recurring disruption patterns	→ Repeated Replacement Traffic / Customer Compensation year-on-year	Absence of learning mechanisms; signals single-loop governance (Senge, 1990)
4. Interface Breakdown Escalation	Inter-actor boundary failure (e.g., Trafikverket–Company X)	→ Uncoordinated handoffs → Company Xabsorbs downstream costs not of its own making	Structural misalignment in responsibility sharing; limited cross-institutional protocol
5. Symbolic Volatility Escalation	Small incident + reputational visibility	→ Discretionary Hotel / Service Recovery payouts	Improvisation dominates response; symbolic damage outpaces financial scale



Appendix 5 : Flow Chart of a Typical Disruption: Covering all costs

Appendix 6 : Case 1:



Appendix 7: Case 3: