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THE HIDDEN FACTORY: QUANTIFYING INFORMATIONAL WASTE AND OPERATIONAL CAPACITY LOSS IN MANUFACTURING

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Abstract: *Operational efficiency is critical for sustained competitive advantage in the global manufacturing sector. However, organizational performance is often undermined by the "Hidden Factory" (HF)—an ensemble of non-productive activities that consume resources without generating value. This research empirically investigates the nature and manifestation of the HF within organizational processes, drawing on Lean and Total Quality Management (TQM) principles. A quantitative survey methodology was employed on a stratified sample of employees from diverse industries in Romania. The study sought to quantify loss identification, conceptual awareness, and barriers to improvement. Key findings reveal a substantial organizational disconnect: while formal awareness of the HF concept is low (18–24% of respondents), operational recognition of non-value-added processes is exceptionally high (72%). The dominant losses are organizational and informational, specifically manual processes (44%) and defective communication (42%), indicating a critical need for digital transformation. The primary barrier to improvement is the lack of dedicated managerial support and resource allocation. This study provides empirical data from an emerging European economy, highlighting a shift in organizational waste from physical defects to systemic informational friction. Mitigating the HF—estimated to consume 20–40% of operational capacity—requires strategic leadership commitment to digitalization, process standardization, and Lean Six Sigma methodologies.*

Keywords: *Organizational waste; operational inefficiency; hidden factory; non-value-added processes; systemic informational friction.*

1. INTRODUCTION

1.1. Context and Problem Statement

In a global economy defined by intense competition and rapidly evolving consumer expectations, operational efficiency is a strategic imperative for organizations (Wang et al., 2015). Robust Production and Operations Management (POM) practices have been consistently linked to superior organizational financial performance (OFP) across the manufacturing sector (Wang et al., 2015). Yet, despite significant strategic investments in optimization, a pervasive internal inefficiency known as the "Hidden Factory" (HF) continues to silently erode profitability and productivity (Feigenbaum, 1991).

The Hidden Factory is defined as the undocumented, non-productive organizational activities—including rework, delays, errors, and workarounds—that consume substantial resources without contributing value to the final product or service (Czabak-Górska & Lorenc, 2017; Feigenbaum, 1991). Quality management experts estimate that this endemic inefficiency can consume between 20% and 40% of total plant capacity or operational costs in many organizations (Team, 2025; Walsh, 2021). Furthermore, the associated direct costs from rework and quality compromises alone can add an estimated 15–25% to true production costs, frequently remaining obscured within standard accounting reports (Bhushan et al., 2017).

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This research addresses the critical need for empirical data that quantifies the specific manifestation of the HF, particularly within the context of an emerging European economy (Romania). Understanding the localized patterns of loss and the organizational barriers to their elimination is essential for developing targeted and effective mitigation strategies that move beyond theoretical frameworks.

1.2. Research Objectives

This investigation primarily aims to analyze how the Hidden Factory infiltrates company processes and to identify actionable modalities for reducing non-productive activities. The core objectives that guided this empirical study, based on the foundational research framework, were to:

1. Identify and classify the specific types of non-productive activities (invisible losses).
2. Determine the underlying causes that contribute to the existence and persistence of the HF.
3. Evaluate the degree of employee consciousness and recognition regarding the impact of the HF.
4. Identify the structural and cultural obstacles organizations face in implementing loss reduction solutions.

2. LITERATURE REVIEW: THE HIDDEN FACTORY AND OPERATIONAL WASTE

2.1. Conceptual Foundations of the Hidden Factory

The concept of the Hidden Factory (HF) originated with Armand Feigenbaum (Feigenbaum, 1991) in the context of Total Quality Control (TQC). Feigenbaum described the "Hidden Plant" as the consequence of so much non-conforming or "bad work" being performed that, effectively, an entire secondary, non-value-added facility exists within the main operation (Feigenbaum, 1991). These undocumented procedures introduce significant variation into processes and severely reduce productivity, profitability, and sustainability (Grecu, 2015; Rødseth & Schjølberg, 2014; Yarrow et al., 2000). The HF concept has expanded beyond traditional manufacturing to encompass nearly any work process in any industry (McDowall, 2021).

From an operational perspective, the HF can be categorized into four fundamental domains of loss, which are integral to the measurement of Overall Equipment Effectiveness (OEE) (*Hidden Factory: Unlock Your Full Production Potential | OEE*, n.d.):

- Program Loss: Time scheduled for production but not utilized.
- Availability Loss: Time when production should be running but is not (e.g., unplanned stops).
- Performance Loss: Time when production is running but is not operating at maximum theoretical capacity.
- Quality Loss: Time when production results in non-conforming products that require rework or are scrapped.

2.2. Linking HF to Lean Principles

The activities constituting the HF are closely aligned with the Lean manufacturing principle of Muda (waste) (Barabadi & Nouri, 2023). While classic Lean methodologies identify waste in areas like excessive inventory, unnecessary transport, and overproduction, the contemporary HF often manifests as informational and organizational friction. Invisible losses fueling the HF include (Bhushan et al., 2017):

- Rework and Defects: Products failing to meet quality standards (Defects Muda).
- Waiting Time: Inactivity of personnel, materials, or equipment due to blockages (Waiting Muda).

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- Inefficient Processes: Unoptimized activities leading to wasted effort (Over-processing Muda).
- Lost Knowledge/Communication: Errors stemming from poor information flow (Defects Muda / Non-Utilized Talent Muda).
- Underutilized Employees: Personnel not fully engaged or utilized (Non-Utilized Talent Muda).

The emphasis on informational and human capital losses suggests that contemporary organizations face challenges rooted in systemic friction (Muri—overburden) and inconsistency (Mura—unevenness), rather than solely physical constraints.

2.3. Quantitative Diagnostics and Mitigation Methodologies

Measuring the intangible losses of the HF requires robust quantitative instruments. The most critical technical indicator is the Overall Equipment Effectiveness (OEE), which synthesizes Availability, Performance, and Quality metrics. An OEE value below 60% often indicates significant hidden losses (*Hidden Factory: Unlock Your Full Production Potential | OEE*, n.d.; Team, 2025).

Mitigation strategies rely on structured, continuous improvement methodologies (Czabak-Górska & Lorenc, 2017):

- Value Stream Mapping (VSM): A Lean tool used to visualize the entire process flow, identifying value-added and non-value-added activities, thereby facilitating process optimization and waste reduction (Kihel et al., 2022; Salwin et al., 2021; Setiawan et al., 2021).
- Six Sigma: A disciplined, data-driven methodology that uses the DMAIC (Define, Measure, Analyze, Improve, Control) model to reduce process variation and achieve near-perfect quality (RUS et al., 2014; Uzoechi, 2024). This directly targets the high incidence of errors and rework that drives the Cost of Non-Quality (CoNQ). Successful implementation, as demonstrated by General Electric (GE), can lead to substantial reductions in operational costs (Lebowitz, 2020).
- Root Cause Analysis (RCA): Essential for identifying the fundamental sources of inefficiency (e.g., using the 5 Whys or Ishikawa Diagrams) to prevent problem recurrence (Andersen & Fagerhaug, 2002).
- Performance Management Software (PMS): Modern technological solutions that offer real-time monitoring and loss quantification, which is crucial for tackling informational waste and enforcing standardized processes (Hoffmann et al., 2013).

3. METHODOLOGY

3.1. Research Design and Data Collection

This study utilized a quantitative social survey research design to empirically investigate employee perceptions and experiences regarding operational efficiency and invisible losses. The primary instrument was an elaborate online questionnaire composed of closed, semi-open, and open questions.

The questionnaire was designed to capture information regarding: (a) the identification of invisible losses (e.g., waiting times, errors); (b) the perception of current process efficiency; (c) the impact of the HF on daily activity; and (d) the degree of conceptual awareness (Team, 2025). Ethical measures included ensuring respondent anonymity and confidentiality.

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3.2. Sample Description

A stratified sample was collected, drawing from employees across various departments and companies in Romania. The final analysis included 142 valid responses (N=142). Respondents were drawn from diversified sectors, including industrial production, services, logistics, and IT. The majority of participants occupied operative or execution roles, providing a direct, ground-level perspective on daily operational processes and the manifestation of workarounds.

3.3. Data Analysis

Data was processed using statistical analysis software, focusing on:

- Frequency Analysis: To establish the prevalence of specific types of loss and awareness levels.
- Descriptive Indicators: To summarize general data trends.
- Correlation Analysis: To identify relationships between reported losses (e.g., waiting times and perceived productivity).

4. RESULTS

This section presents the empirical findings derived from the quantitative social survey conducted across diverse industries in Romania (N=142 valid responses). The results are structured to assess employee awareness, quantify the perceived frequency of invisible losses, and illustrate how these losses manifest in key operational performance indicators (KPIs).

4.1. Employee Awareness and Recognition of Inefficiency

The analysis revealed a significant gap between the conceptual understanding of the "Hidden Factory" (HF) and the day-to-day operational recognition of inefficiency. Only 18% of respondents reported prior knowledge of the conceptual term "Hidden Factory". This low rate suggests a generalized failure in formal organizational training regarding Lean and Quality Management vocabulary. Conversely, a commanding majority of respondents, 72%, acknowledged the recurrent presence of inefficient, resource-consuming processes that fail to add value. This disconnect indicates that while the problem is structurally pervasive and evident at the execution level, it lacks formal identification and systemic management within the organizations surveyed.

4.2. Frequency Ranking of Invisible Losses

To classify the specific composition of the Hidden Factory, employees identified the non-value-added activities they encountered most frequently. The results underscore the dominance of informational and organizational friction over traditional physical production waste.

The empirical ranking in Table 1 demonstrates that the highest-frequency losses relate directly to information flow, coordination, and process standardization, confirming a shift from physical Muda to systemic Mura and Muri.

Table 1: Ranking of Most Frequent Invisible Losses Reported by Employees

Rank	Invisible Loss Category	Reported Frequency (Percentage of	Implication

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		Respondents)	
1	Manual Processes (Automatable)	44%	High opportunity for Digitalization
2	Defective Communication	42%	Systemic information friction and coordination failure
3	Excessive Waiting Times	38%	Flow blockage and poor scheduling
4	Frequent Errors Requiring Rework	34%	Inflated Cost of Non-Quality
5	Lost Knowledge/Information	32%	Lack of structured knowledge management
6	Personnel Utilized Below Potential	28%	Underutilization of human capital
7	Lack of Standardization	22%	Process foundation deficiency
8	Unplanned Equipment Downtime	20%	Technical Availability loss
9	Overproduction	12%	Classic inventory waste
10	Unnecessary Internal Transport	8%	Physical motion waste
11	Excessive Inventory	4%	Capital and storage waste

The top two losses—Manual Processes (44%) and Defective Communication (42%) —account for the primary capacity drain. Conversely, traditional physical waste indicators, such as Excessive Inventory (4%) and Unnecessary Internal Transport (8%), ranked lowest. This distribution provides clear empirical direction, suggesting that the most impactful mitigation strategies must focus on organizational process redesign and digital integration.

4.3. Key Performance Indicators (KPIs) and Technical Loss Quantification

To translate the subjective perceptions of the HF into objective quantitative terms, the study utilized standardized Key Performance Indicators (KPIs). The following values are derived from illustrative production examples used to demonstrate the scale of typical technical and quality losses inherent in the HF.

Table 2: Technical and Economic Indicators Illustrating Hidden Factory Loss (Based on Illustrative Case Examples)

KPI Category	Metric	Calculation Example	Result	Interpretation
Availability	Equipment Availability	15 hours function / 20 hours planned	75%	25% of planned time is unutilized due to HF losses (e.g., unplanned stops, maintenance).
Reliability	Mean Time Between Failures (MTBF)	1,500 hours function / 3 defects	500 hours	Indicates opportunity for maintenance strategy improvement.
Maintenance	Mean Time To Repair (MTTR)	9 hours repair time / 3 interventions	3 hours	Measure of maintenance system efficiency.
Quality	Defect Rate	210 defective units / 15,000 total units	1.4%	Directly contributes to the Cost of Non-Quality

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				(CoNQ).
Resource Use	Material Utilization Efficiency	925 kg efficiently used / 1,150 kg total consumed	80.43%	19.57% of material consumption is lost to scrap or inefficiency.
Global Efficiency	Overall Equipment Effectiveness (OEE/RRS)	97% Availability \times 85% Performance \times 90% Quality	74.2%	Value is below the world-class benchmark (85%), suggesting significant hidden capacity loss.

The synthesized OEE value of 74.2% confirms that while the machinery performs reasonably well (97% availability), a considerable portion of capacity is lost through performance and quality deficiencies, which are key components of the HF.1 Furthermore, financial quantification examples showed that a 5% scrap rate on 10,000 units, costing 150 RON per unit, resulted in a monthly hidden loss of 75,000 RON.

4.4. Correlation Analysis and Implementation Barriers

4.4.1. Correlation Between Variables

The statistical analysis performed on the survey data established specific correlations between self-reported operational factors:

Seniority and Loss Observation: A direct, positive correlation was observed between an employee's seniority (length of tenure) within the company and their capacity to observe and identify recurrent inefficient patterns. This suggests that organizational knowledge, accumulated over time, makes the HF more visible to experienced personnel.

Waiting Time and Perceived Productivity: A strong negative correlation was inferred between the self-reported frequency of excessive waiting times (38% of respondents) and the perceived productivity of employees. High incidences of waiting time were directly associated with lower subjective productivity, confirming the operational link between workflow blockages and reduced labor efficiency.

4.4.2. Barriers to Improvement Implementation

Despite the high level of operational recognition (72%) and the presence of employee-generated solutions, the implementation of improvements was consistently blocked by organizational barriers (see table 3).

Table 3: Primary Barriers to Implementing Employee-Generated Solutions

Barrier Type	Finding	Impact
Managerial Support	Lack of explicit managerial support	Solutions, once identified, fail to receive the necessary leadership endorsement for pilot programs or full deployment.
Resource Allocation	Insufficient resources allocated	Prevents the testing and formal implementation of proposed solutions, transforming identified problems into systemic inaction.

These findings highlight that the persistence of the Hidden Factory is often sustained not by a lack of internal knowledge regarding solutions, but by a structural or cultural failure to commit strategic resources necessary to enact change and eliminate the root causes.

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5. DISCUSSION

5.1. The Shift to Informational Waste

The empirical data strongly validates the existence of the HF, confirming its pervasive nature across diverse Romanian industries. Crucially, the ranking of losses indicates a systemic shift in the nature of organizational waste. The overwhelming dominance of informational friction (Defective Communication, Manual Processes, Lost Knowledge) over physical waste (Inventory, Transport) underscores that in contemporary, knowledge-intensive environments, the HF has evolved from a simple manufacturing issue to a challenge of organizational and digital maturity.

The high frequency of Rework (34%) and Errors directly correlates with an inflated Cost of Non-Quality (CoNQ) (Abbasnejad, 2013). Since defective communication is a leading cause, investing in digitalization and standardization systems (such as Performance Management Software and centralized knowledge management) represents the most direct and high-impact strategy for reclaiming the 20–40% lost capacity (Grecu et al., 2020; Hoffmann et al., 2013).

5.2. Managerial and Cultural Implications

The research identified the single greatest barrier to HF elimination as the lack of managerial support and resource allocation for employee-generated solutions (Grecu & Denes, 2024). This structural failure creates a "Hidden Factory" of untapped solutions within the workforce, directly hindering organizational agility and continuous improvement (Walsh, 2021).

This finding is critical when benchmarked against international case studies demonstrating the severe risks of ignoring the HF:

- Boeing 737 MAX: The issues faced were partially rooted in deficiencies related to communication and rigorous verification—classic HF components—resulting in billions in financial losses (Tayan & Larcker, 2024).
- Airbus A380: Production delays led to billions of euros in losses, attributed to a lack of synchronization between departments and design errors, necessitating subsequent standardization of procedures (Clark, 2006).
- Nokia: The company's market failure was partially linked to slow decision-making processes and excessive internal bureaucracy, rendering the organization too rigid to adapt rapidly (SlideUpLift, 2024).

These examples underscore that the successful recovery of lost capacity, exemplified by efforts like BMW's 25% improvement in OEE or GE’s 30% cost reduction through Six Sigma (Arnold, 2007; Lebowitz, 2020), requires committed, long-term managerial investment that prioritizes systemic change over short-term operational goals.

5.3. Research Limitations

This study presents several limitations that should be acknowledged to contextualize its findings. First, the research relies on self-reported data collected through an online survey, which may introduce subjectivity, recall bias, or socially desirable responses, particularly regarding perceptions of inefficiency and managerial support. Second, although the sample of 142 respondents spans multiple industries, it remains geographically limited to Romania, restricting the generalizability of results to other economic, cultural, or organizational contexts where the Hidden Factory may manifest differently. Third, the study focuses primarily on perceptual indicators of invisible losses rather than direct, quantitative measurements taken from operational systems, equipment logs, or cost accounting data; therefore, the estimates of inefficiency reflect employee experiences rather than objective performance metrics. Fourth, the analysis does not differentiate between organizational sizes, maturity levels, or digitalization stages, which could influence both the prevalence and nature of informational waste. Finally, the illustrative KPI calculations included in the Results section serve as explanatory examples rather than empirical measurements derived from the surveyed organizations, limiting their interpretation for statistical inference. These constraints highlight the need for future mixed-method or longitudinal studies incorporating real-time operational data, broader sampling, and cross-country comparisons to strengthen the external validity of the findings.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusion

This research confirms the pervasive presence of the Hidden Factory phenomenon in Romanian organizations, with empirical data validating that employee-recognized inefficiencies (72%) are substantial, even in the absence of formal conceptual training. The primary driver of lost capacity is informational and organizational friction, characterized by manual processes (44%) and defective communication (42%). The central organizational failure is not technical but cultural and structural, manifest in the systematic lack of managerial commitment and resource allocation to implement known solutions. Eliminating the HF is a strategic necessity for enhancing competitiveness, efficiency, and employee well-being.

6.2. Recommendations

Based on the empirical findings, the following strategic recommendations are proposed to mitigate the Hidden Factory:

- Mandatory Lean/TQM Education: Implement formal training on Lean principles (Muda) and quantitative metrics (OEE, CoNQ) to establish a common language and empower all employees to identify and report invisible losses systematically.
- Digitalization and Standardization Focus: Prioritize capital investment in digital solutions (Performance Management Software) to automate manual processes and enforce standardized procedures. This must be the immediate focus to resolve the leading losses associated with information flow and communication defects.
- Implement Structured Feedback Systems: Establish systematic, non-punitive mechanisms (e.g., Kaizen suggestion systems) specifically dedicated to capturing, testing, and funding employee-generated solutions. Management must commit explicit resources to implement these root-cause interventions.
- Adopt Integrated Methodologies: Utilize holistic, data-driven approaches like Lean Six Sigma (DMAIC) to address both flow inefficiency (Lean) and high variation/error rates (Six Sigma) for continuous and sustained operational improvement.

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