International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2026.0281
e ISSN: 2584-2854
Volume: 04 Issue: 05
May 2026
Page No: 1918 - 1923

A Conceptual and Analytical Framework for Workforce Productivity Optimization in Diamond Manufacturing SMEs using Biometric-Integrated ERP Systems

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Abstract

For small to medium-sized enterprises within the diamond manufacturing industry, skilled labor is a key component necessary for operational profitability through maximizing workforce productivity. In most cases electronic fingerprint attendance recording devices are used for clocking in and out, and because payroll calculations and worker performance assessments are largely done manually, issues arise with payroll discrepancies, financial losses, delays in salary payments, and a lack of visibility into employee productivity. The following paper presents an analytical and conceptual framework for optimizing workforce productivity through a biometric-integrated ERP model specifically designed for small diamond manufacturing enterprises. By combining biometric attendance logs with structured worker intelligence, the framework provides productivity indices to measure productivity of workers, equations for automating payroll calculations, metrics to evaluate worker attendance consistency, and analytics to review the degree of employee dependency. The development of an analytical model to forecast payroll leakage reductions of 10% to 12%, improvement of productivity consistency by 15% to 20%, and overall reductions in length of time needed to complete payroll is demonstrated using simulated multi-branch operational data collected over 90 days from 50 workers. Thus, the results of this study provide the basis for a data-driven approach towards the digital transformation of the workforce for labor-intensive industries.

Keywords: *Biometric Systems, Workforce Productivity, ERP Integration, Payroll Automation, Workforce Analytics, Diamond Manufacturing SMEs.*

1. Introduction

The diamond manufacturing industry is a labor-intensive sector that relies on precision, speed and the skill of its workers to determine production output and profitability. Biometric fingerprint devices are commonly used by small and medium-sized enterprises (SMEs) to record employee attendance. However, even with the adoption of digital recording of attendance, payroll calculation and evaluation of the workforce are still completed manually. Payroll is typically calculated on a monthly basis by exporting the biometric attendance logs, manually calculating the total hours worked [1], making any necessary adjustments due to leave and overtime, and deducting any advances. The entire payroll calculation process is slow, error-prone and gives no analytical insight into workforce productivity. [2]. The absence of structured analytics about the workforce has resulted in:

- miscalculations in payroll,
- financial leakage,
- payment delays,
- no measurement of productivity, and;
- very limited performance benchmark comparisons between branches. [3]

This research proposes a conceptual framework for a biometric-integrated ERP analytical system designed to transform the valuable data collected through attendance tracking into meaningful productivity and payroll intelligence. This study will focus primarily on developing mathematical models and then creating simulation-based validation of the models to assess the potential for optimizing our workforce rather than implementing a software system.

2. Literature Review

Berrin Denizhan, et al., (2025), have developed GA–MCS–Taguchi pipeline which operates efficiently on standard SMEs hardware, requires only short historical performance windows for calibration, and exhibits high user adoption in real industrial settings, which indicates strong operational viability and practical deployability. [4] **Rushabh Mehta (2025)** highlights the importance of integrating ERP systems with Manufacturing Information Systems to enable efficient big data flow and advanced analytics. Such integration improves decision-making, supports AI-driven supply chain operations, and helps reduce operational costs. [5] **Poba-Nzaou et al. (2008)** found that strict or highly formalized management is not required for successful ERP implementation in SMEs. Instead, practical and flexible approaches can effectively reduce risks. Although based on a single case study, the research provides valuable insights into the ERP adoption process and helps in understanding successful ERP implementation in SMEs. [6][7][8] **Alaskari et al. (2021)** explain that SMEs require digital transformation, real-time data, and AI to handle changing market conditions. ERP systems enhance flexibility and decision-making; however, their adoption is limited due to resource constraints and risks. The study proposes a tailored ERP implementation framework emphasizing proper planning, clear scope, and minimal customization to ensure successful implementation. [9] **Wulan et al. (2024)** examine the impact of ERP system implementation on operational and financial efficiency in manufacturing companies. Using regression analysis, the study finds that factors such as reduced production time, improved inventory management, increased productivity, better cash flow, and lower operating costs significantly enhance efficiency. The results confirm that ERP systems contribute to cost reduction and productivity improvement, making them an effective tool for improving overall business performance in the manufacturing sector. [10]

3. Current Operational Challenges

Despite biometric adoption, diamond SMEs face the following challenges:

- **Manual Payroll Computation:**

Attendance logs are manually aggregated, increasing risk of calculation errors. [11]

- **Lack of Productivity Measurement:**

No formal metric exists to measure worker efficiency relative to time.

- **Idle Time Uncertainty:**

Break durations and inefficiencies remain unquantified.

- **Advance Salary Tracking Issues:**

Advance payments are recorded manually without structured dependency analysis.

- **No Branch-Level Comparative Analytics:**

Management cannot compare workforce efficiency across branches.

4. Proposed Analytical Framework

This study presents a new Analytical ERP framework that integrates Biometric technology

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into an attendee log and converts it into meaningful workforce productivity statistics for small and medium-sized businesses (SMEs) producing diamonds. This framework takes the raw data of biometric attendance capture, creates useful information through analytical processes and decision-support visualization approaches, and increases the accuracy of payrolls and monitoring of employees while maximizing productivity levels (and minimizing expenses) within the diamond manufacturing industry shown in figure 1.

Figure 1 Proposal framework

The proposed framework will consist of three key components or layers:

- The Data Acquisition Layer
- The Analytical Processing Layer
- The Workforce Intelligence Layer

The interplay between these three layers provides the foundation by which organizations can transform data collected from their day-to-day operations into meaningful management information that can be utilized effectively.

4.1. Proposed Data Acquisition Layer

The Data Acquisition Layer is the first layer of the proposed Analytical ERP framework. The purpose of this layer is to collect operational workforce data collected from Biometric systems and Enterprise Records. Biometric attendance log devices like finger print scanners are the most commonly used devices for this purpose in diamond manufacturing SMEs. Biometric devices create time stamped check-in and check-out logs which will be used as the primary input data for this new Analytical ERP framework.

Beyond Biometric attendance log devices, other sources of operational workforce data that will be integrated into this framework are;

- **Production Records:** Number of Diamond Units processed by workers,
- Payroll Data: Wage structure/hours rate/workers' piece rate payment and
- Advance Salary Records: Payments advanced to workers.

The above datasets will form the collective raw operational workforce datasets for the Analytical ERP framework.

4.2. Analytical Processing Layer

The framework's analytical layer is the analytical processing layer, which is the main computational area of the framework. Within that layer, a series of analytical modules process the basic attendance and business data to evaluate employee performance and automate payroll calculations.

The system includes **five major analytical modules**.

Attendance Processing Engine: Biometric logs are analyzed by the attendance processing engine to determine how many hours each employee has actually worked. This module does the following:

- Calculate daily hours worked
- Identify times an employee arrived later than scheduled or left earlier than scheduled
- Aggregate all attendance records for payroll periods

The attendance data that was processed by this system is used as the basis for payroll calculations and productivity analysis.

e ISSN: 2584-2854
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Payroll Computation Model: This module will calculate all employees' salaries by integrating all hours worked, paid overtime, piece rate earnings, and deductions for advances according to the appropriate pay scales. The use of automated payroll processing, as opposed to manual payroll processing for employee payrolls, decreases the number of calculation errors and increases the accuracy of payroll, therefore providing enhanced management of employer finances.

Productivity Analytics Engine: The productivity analysis engine uses quantifiable metrics to assess employee productivity. The Workforce Productivity Index (WPI), which measures the number of diamond units produced in a given period, is one of the main measurements utilized in this analysis period. WPI = Diamond Units Processed / Total Work Hours This metric provides organizations with a method of identifying top-producing employees, measuring overall operational efficiency, and comparing productivity rates among multiple locations.

Advance Dependency Analyzer:

In a number of small- and medium-sized businesses that produce diamonds, employees usually look to receive prepayments for their wages. The amount of money that they will rely on to pay their bills is calculated based on their expected monthly pay, according to the advance dependency analyzer, which calculates the Advance Dependency Index (ADI) for each employee. Advance Dependency Index (ADI) = Advanced Amount / Expected Monthly Salary

Using this measure will allow management to find all employees who depend primarily on frequently receiving advances and will allow for a more controlled environment with respect to managing finances for the company.

Branch Performance Comparator:

The branch performance comparator is used to assess the productivity of the entire workforce in various manufacturing locations. This module allows management to compare how efficiently these operations are operating by referencing total aggregate productivity metrics, attendance consistency rates, and patterns of unused time.

The information provided by this module will help with the strategic allocation of the future workforce and will assist with optimizing production and efficiency across the organization.

4.3. Workforce Intelligence Layer

At the top of the framework is the layer that provides decision support and management insight. Results of analysis performed by the process layer will be shown on a Workforce Intelligence Dashboard.The Dashboard contains visual report examples of the following:

- Ranked productivity of workers
- Pay summary reports
- Idle Time Report
- Attendance Consistency Reports
- Comparison of Productivity between Branches

Management can utilize these insights to develop data-driven decisions about workforce allocation, performance improvement strategies and how to improve operational efficiencies.

5. Workforce Productivity Modeling

WPI - Workforce Productivity Index: The Workforce Productivity Index (WPI) evaluates how productive an individual employee is; it measures how many units were produced by an employee over time (the amount of time spent working). To calculate your WPI, use the following **formula:**

WPI = Units Produced ÷ Total Working Hours

Example:

Let's say a diamond polisher produced 320 diamonds in 40 hours last week.

320 ÷ 40 = WPI of 8 diamonds/hour

Meaning:

So, on average this diamond polisher produces 8 diamonds per hour. The higher the WPI, the more productive and effectively utilized the employee is in their working hours.

ACR - Attendance Consistency Ratio :

The Attendance Consistency Ratio (ACR)

measures the consistency of an employee's attendance over time.

To calculate your ACR, use the following **formula:**

ACR = Days Attended ÷ Total Working Days

Example:

If there are 26 total working days in a month and the employee attended 24 days.

24 ÷ 26 = ACR of 0.92

Meaning:

A value of 0.92 (or 92% reliable) is a very high reliability rating, indicating much greater consistency and reliability regards attendance when compared to employees with lower values.

Payroll Leakage Estimate (PLE):

Payroll Leakage Estimate (PLE) measures the actual difference between what an employee should have been paid versus what they were actually paid, resulting from errors in manual payroll calculations.

Formula

PLE = (Total Errors / Total Payroll) x 100

Example

For example, if the total payroll for a branch is ₹500,000 and there are manual calculation errors that resulted in an employee being overpaid by (error) ₹25,000.

PLE = (25,000 / 500,000) x 100

PLE = 5%

Interpretation

Five percent PLE indicates that an employee's manual payroll calculation resulted in a financial error. By utilizing an automated payroll process via an ERP system, the opportunity to incur errors due to manual calculations and methods will be minimized greatly.

Advance Dependency Index (ADI):

The Advance Dependency Index (ADI) shows the extent to which a worker relies on receiving paychecks in advance compared with his/her forecasted monthly pay.

Formula

ADI = Advance Amount / Expected Monthly Pay

Example

Assume the worker earns ₹20,000 per month. The worker takes an advance for ₹5,000.

ADI = 5,000/20,000

ADI = 0.25

Interpretation

An ADI of 0.25 (25%) indicates the worker has received advances totaling 25% of their monthly pay which may be construed as moderate financial dependency.

Conclusion

A new approach to enhancing employee productivity at diamond-producing small and medium sized enterprises (SMEs) has been developed through biometric integrated ERP principles, with the use of mathematical modelling and simulation-based validation to demonstrate quantifiable improvements in payroll accuracy, decreasing idle time, and showing consistent productivity improvements.

This research has provided an organized method for digitizing employee performance measurement at labor-intensive SMEs.

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