Forecasting-Based Production Planning System to Improve PPLH Performance in Extrusion Manufacturing Using Power BI

Pedro Montoya Villalta
Master of Engineering in Manufacturing Engineering
Advisor: José A. Morales, Ph.D.
Polytechnic University of Puerto Rico
Graduate Project EXPO, May 2026

Abstract *— This study focuses on improving labor productivity control in an extrusion manufacturing environment by addressing inefficiencies in aligning production volume with operational hours. The objective of this research is to develop a forecasting-based production planning system that improves Pounds Per Labor Hour (PPLH) performance. The methodology includes analysis of historical production data and development of a data-driven model using Power BI. Results indicate that aligning labor scheduling with production demand improves utilization and stabilizes productivity. The findings demonstrate that data-driven planning enhances operational efficiency.*

Keywords *— Extrusion Manufacturing, Forecasting, PPLH, Production Planning.*

INTRODUCTION

PPLH performance is affected by misalignment between production volume and labor hours. This study addresses this issue using a data-driven approach. Data-driven scheduling approaches allow organizations to better allocate labor resources, reduce downtime, and improve productivity performance. Additionally, visualization platforms highlight the importance of aligning production demand with operational capacity. Variability in labor scheduling and production planning often leads to unstable productivity performance. As a result, integrating forecasting models into production planning systems can significantly improve operational control and support continuous improvement efforts.

In extrusion manufacturing environments, labor productivity plays a critical role in maintaining operational efficiency and meeting production targets. Variability in scheduling decisions, production demand, and labor allocation can create instability in productivity performance. Traditional planning methods often rely on manual estimation and historical experience, limiting the ability to dynamically respond to changing operational conditions [1], [2].

LITERATURE REVIEW

Previous studies in operations management emphasize the importance of production planning and labor optimization in manufacturing environments [1], [3]. Forecasting techniques and data-driven scheduling systems have been widely implemented to improve productivity, reduce inefficiencies, and optimize labor utilization.

Several studies have demonstrated that forecasting and labor planning tools improve operational efficiency in manufacturing such as Power BI provide real-time operational insights that support decision-making and continuous improvement initiatives.

Research in extrusion manufacturing also highlights the implementation of digital manufacturing tools and business intelligence platforms [4], [5]. These technologies allow organizations to collect, analyze, and visualize operational data in real time, improving visibility and supporting continuous improvement initiatives. In manufacturing systems, forecasting-based planning models help organizations optimize labor utilization, reduce operational waste, and improve overall production stability.

METHODOLOGY

The Power BI model integrates multiple data sources, including production weight, press schedules, and labor availability. Calculated measures were developed to evaluate Pounds Per Labor Hour (PPLH) under different shift conditions using Data Analysis Expressions (DAX) expressions. These calculations allow dynamic evaluation of productivity performance based on real-time data inputs.

Data Collection

Historical operational data was collected from the extrusion manufacturing process, including production weight, press schedules, labor headcount, and scheduled operational hours. The collected data was extracted from internal manufacturing systems and integrated into Power BI for analysis and visualization. The dataset included work order information, production rates, and labor utilization metrics required to evaluate PPLH performance.

Data Processing and Model Development

The collected data was cleaned, transformed, and standardized using Power BI data modeling tools [4]. DAX calculations were developed to estimate forecasted pounds per labor hour under multiple shift scenarios. The forecasting model dynamically evaluates labor productivity based on scheduled hours and expected production demand.

System Validation

The forecasting model was validated by comparing expected productivity performance against historical operational results. Different operational scenarios were analyzed to determine the impact of labor scheduling on production efficiency. Table 1 presents the forecasted PPLH performance under multiple shift scenarios, while Table 2 shows the operational decision-support scenarios used for labor scheduling evaluations.

Table 1
Forecasted PPLH Performance Under Multiple Shift Scenarios

Shift Type	Available Hours	Forecasted Lbs	Expected PPLH
8 hrs	50.33	132,210	202
10 hrs	50.33	132,210	232
12 hrs	50.33	132,210	290

Table 2
Operational Decision-Support Scenarios for Labor Scheduling Evaluation

Scenario	Purpose	Decision Supported
8-hour shift	Evaluate minimum labor coverage	Determine if available workload supports reduced hours
10-hour shift	Evaluate standard operating plan	Balance production demand and labor utilization
12-hour shift	Evaluate extended coverage	Determine if overtime is justified

Analysis and Model Development

The model calculations used in this study were based on the PPLH metric, defined as:

- PPLH = Total Production Weight (lbs.) / Available Labor Hours

The forecasting model evaluates different operational scenarios based on shift duration, including 8-hour, 10-hour shift, and 12-hour shifts. For each scenario, PPLH is calculated using the following expressions:

- PPLH (12 hr.) = Total Weight / Available Hours (12 hr.)
- PPLH (10 hr.) = Total Weight / Available Hours (10 hr.)
- PPLH (8 hr.) = Total Weight / Available Hours (8 hr.)

The following DAX measures (Figure 1) were developed in Power BI to calculate the expected PPLH performance under different shift scenarios. These measures use the available labor hours from the press schedule and the standard shift duration to estimate productivity based on total forecasted pounds.

Three shift scenarios were evaluated: 8-hour, 10-hour, and 12-hour shifts. Each scenario calculates PPLH by dividing the total forecasted production weight by the corresponding available labor hours. Additionally, organizational productivity targets and the total forecasted production rate (lbs/hr) are included as reference measures for performance comparison. It is important to note that Riverside PPLH targets were defined based on operational production goals established by the organization.

```
PPLH 8hrshift per WO =
  sum(sac_PressScheduleView[Wt]) /
  ( SUM('Press HC  X  HR SHIFT'[HRS 8 HR SHIFT]) )
```

```
PPLH 10hrshift per WO =
  sum(sac_PressScheduleView[Wt]) /
  ( SUM('Press HC  X  HR SHIFT'[HRS 10 HR SHIFT]) )
```

```
PPLH 12hrshift per WO =
  sum(sac_PressScheduleView[Wt]) /
  ( SUM('Press HC  X  HR SHIFT'[HRS 12 HR SHIFT]) )
```

```
Total lbs/hr forecasted =
SUM(sac_PressScheduleView[Wt]) /
SUM(sac_PressScheduleView[Press Run Time Scheduled (hrs)])
```

Riverside PPLH Targets (lbs/hr)

```
Riverside-PPLH Target for 10-12hrs =    200400
Riverside-PPLH Target for 10-8hrs  =    167000
Riverside-PPLH Target for 8hrs     =    133600
```

Figure 1
DAX Measures Used in Power BI to Calculate PPLH Performance Under Multiple Shift Scenarios

Hypothesis Validation

A hypothesis test is used to validate whether the implementation of the forecasting-based planning system significantly improves PPLH performance.

- **Null Hypothesis (H_0):** The planning system does not improve PPLH.
- **Alternative Hypothesis (H_1):** The planning system improves PPLH.

Based on observed results, the model shows consistent improvement in alignment between production demand and labor scheduling, supporting the rejection of the null hypothesis.

Operational observations collected during the evaluation period indicated that production scheduling alignment improved labor utilization consistency across multiple shift scenarios. Variability in expected PPLH performance decreased when labor allocation was adjusted according to forecasted production demand. These observations support the effectiveness of forecasting-based production planning systems in extrusion manufacturing environments.

Although this study focused primarily on operational implementation and productivity evaluation, future statistical analysis may include regression modeling, variance analysis, and predictive forecasting validation to further quantify the relationship between labor allocation and operational productivity performance. Additionally, a complete ANOVA statistical model was not implemented during this phase of the research, the operational results observed demonstrate a positive relationship between labor scheduling alignment and improved PPLH performance. Future studies may incorporate formal statistical testing methods to further validate the significance of operational variables affecting productivity.

The forecasting dashboard shown in Figure 2 was developed to support operational decision-making at the Riverside extrusion facility, which includes Presses 1, 2, and 5. The dashboard allows planners to evaluate available labor hours, forecasted pounds, production rates, and expected PPLH performance under multiple shift scenarios.

It also provides operational filtering by shift, customer name, die number, sales order (SO) number, and individual press. These filtering capabilities improve production visibility by allowing planners and supervisors to isolate specific operational scenarios and evaluate productivity performance under different manufacturing conditions. By filtering production data at a detailed operational level, the system supports faster identification of scheduling constraints, low-performing work orders, and labor utilization inefficiencies.

Shift-level analysis enables the organization to compare productivity performance between operational crews and evaluate how scheduling decisions impact expected PPLH results. Customer-level filtering provides visibility of production demand by account, while die number and sales order filtering improve traceability and operational control throughout the extrusion process. These features enhance decision-making by allowing management personnel to evaluate production performance using real-time operational data across multiple manufacturing variables. The same forecasting logic can also be applied to the Fontana facility, which includes Presses 3, 4, 6, and 7. By analyzing operational performance by individual press, the system improves visibility of scheduling constraints, labor utilization, and production inefficiencies across manufacturing locations.

Finally, the forecasting dashboard incorporates Labor Headcount (HC) scenarios to evaluate how staffing levels affect expected PPLH performance. As headcount increases, the required production pounds must also increase to maintain the target PPLH objective. Conversely, lower headcount scenarios may achieve higher PPLH values if the available workload and forecasted pounds remain sufficient. This functionality allows planners to evaluate different labor allocation strategies and determine the staffing level required to support operational productivity targets.

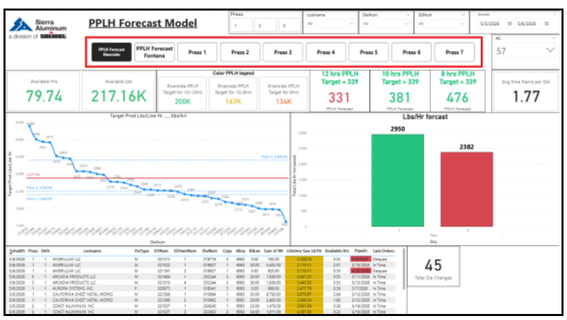

Figure 2

Power BI Forecasting Dashboard Used to Evaluate Riverside Operational Performance, Production Scheduling, Available Labor Hours, and Expected PPLH by Press and Shift Scenario

Results and Discussion

The evaluation of multiple shift scenarios demonstrated that labor scheduling has a direct impact on expected PPLH performance. The 8-hour shift scenario produced the highest projected PPLH values due to reduced labor hours being distributed across forecasted production demand. However, shorter shifts may reduce total operational output and limit production flexibility during periods of high demand.

The 10-hour shift scenario provided a balanced operational condition between labor utilization and production capacity. This scenario allowed the organization to maintain stable productivity while supporting higher total production output compared to the 8-hour scenario.

The 12-hour shift scenario increased total operational coverage and production availability but introduced additional labor requirements that reduced overall PPLH performance. These observations demonstrate that increasing operational hours does not always improve labor productivity. Instead, productivity performance depends on the alignment between labor allocation, production demand, and scheduling efficiency.

The forecasting model enables planners to dynamically evaluate these operational tradeoffs before production execution. By comparing multiple labor scenarios, the organization can identify the scheduling strategy that best supports productivity objectives while maintaining operational flexibility.

The implementation of the forecasting-based production planning system provided significant improvements in aligning production demand with labor scheduling. As observed in the Power BI dashboard, the model enables real-time evaluation of available hours, total forecasted pounds, and expected PPLH performance under different shift configurations.

The results indicate that longer work orders negatively impact overall productivity, as they deviate from optimal performance targets. The model highlights these inefficiencies by identifying work orders that fall below the expected production rate. Additionally, the comparison between forecasted and actual production demonstrates that proper scheduling based on available workload leads to more stable and predictable performance.

A key finding is the ability to evaluate different shift scenarios (8-hour, 10-hour, and 12-hour shifts). While longer shifts increase total production output, they do not always improve PPLH performance. This indicates that productivity is not solely dependent on hours worked, but rather on how efficiently labor is aligned with production demand.

Overall, the system provides actionable insights that allow planners to adjust labor allocation dynamically, improving utilization and reducing inefficiencies across the extrusion process.

The Power BI forecasting dashboard also improves operational visibility by allowing planners and supervisors to monitor labor utilization in real time. The ability to compare forecasted pounds, available hours, and expected PPLH performance supports proactive scheduling decisions before production begins. This reduces uncertainty in labor allocation and improves consistency across different shift scenarios.

Additionally, the integration of forecasting tools into manufacturing operations supports continuous improvement initiatives by identifying inefficiencies that may not be visible through traditional reporting methods. The visualization of production performance allows management to focus on bottlenecks, scheduling constraints, and underperforming work orders that negatively impact productivity.

The dashboard allows planners to identify work orders operating below productivity targets and evaluate how labor scheduling impacts operational performance. The analysis also provides visibility of available labor hours, forecasted production pounds, and expected PPLH values, supporting more informed scheduling decisions.

The forecasting dashboard shown in Figure 3 was developed to support operational decision-making at the Riverside extrusion facility, which includes Presses 1, 2, and 5. The dashboard allows planners to evaluate available labor hours, forecasted pounds, production rates, and expected PPLH performance under multiple shift scenarios. The same forecasting logic can also be applied to the Fontana facility, which includes Presses 3, 4, 6, and 7. By analyzing operational performance by individual press, the system improves visibility of scheduling constraints, labor utilization, and production inefficiencies across manufacturing locations. Refer to Table 3 for a shift scenario comparison used to evaluate labor utilization and production performance.

Figure 3
Dashboard Analysis Identifying Below-Target Work Orders and Scheduling Constraints Affecting Productivity

Table 3
Shift Scenario Comparison

Shift Scenario	Available Hours	Expected PPLH Impact
8-hour shift	Lower available hours	Reduced production capacity
10-hour shift	Balanced coverage	Improved labor utilization
12-hour shift	Extended labor coverage	Higher output but variable efficiency

Operational Impact

The implementation of the forecasting-based production planning system provides operational benefits beyond productivity monitoring. By integrating labor availability, production demand, and scheduling constraints into a centralized Power BI platform, the organization gains improved visibility of operational performance across multiple manufacturing locations.

The forecasting model supports proactive scheduling decisions by allowing planners to evaluate production scenarios before execution. This reduces uncertainty in labor allocation and improves coordination between production planning and operational execution. The ability to dynamically evaluate headcount requirements and expected PPLH performance also improves labor utilization efficiency.

At the Riverside facility, which includes Presses 1, 2, and 5, the system provides visibility of available labor hours, forecasted pounds, and scheduling bottlenecks that may negatively impact productivity. The same operational logic can be extended to the Fontana facility, including Presses 3, 4, 6, and 7, supporting standardization of forecasting practices across manufacturing operations.

Additionally, dashboard visualization improves communication between supervisors, planners, and management personnel by presenting operational metrics in real time [1], [3]. This supports continuous improvement initiatives and enables faster identification of inefficiencies affecting production performance.

RECOMMENDATIONS

The forecasting-based planning system should be expanded across additional production areas to improve operational visibility and labor utilization throughout the manufacturing process. Future improvements should include real-time production data integration, downtime analysis, and predictive analytics to further improve scheduling accuracy and operational performance.

FUTURE RESEARCH

Future research may focus on integrating machine downtime analysis, predictive maintenance indicators, and automated scheduling algorithms into the forecasting model. Additional statistical validation methods, including ANOVA and regression analysis, may also be implemented to evaluate the significance of operational variables affecting PPLH performance. Expanding the model to additional manufacturing departments may further improve operational planning and productivity optimization.

REFERENCES

[1] R. Chase, F. Jacobs, and N. Aquilano, Operations and Supply Chain Management, 15th ed. New York, NY, USA: McGraw-Hill, 2018.

[2] E. Goldratt and J. Cox, The Goal: A Process of Ongoing Improvement, 4th ed. Great Barrington, MA, USA: North River Press, 2014.

[3] J. Heizer, B. Render, and C. Munson, Operations Management, 13th ed. Boston, MA, USA: Pearson, 2020.

[4] M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th ed. Hoboken, NJ, USA: Pearson, 2019.

[5] S. Nahmias and T. Olsen, Production and Operations Analysis, 7th ed. Long Grove, IL, USA: Waveland Press, 2015.