Productivity Analysis of Employees in Textile Industry

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Project Goal:

To determine patterns in the internal working of this garment factory and identify key factors that lead to high productivity amongst its teams.

Project Description:

The garment industry is a primary example of industrial globalization. It is highly labour-intensive and with many manual processes still involved. Therefore, to meet the demand of the industry, it is crucial for decision-makers to analyse and predict the productivity of their workers.

This dataset includes important attributes of the garment manufacturing process and the productivity of the employees which has been collected manually and been validated by the industry experts.

We investigate the dataset referencing key attributes such as Incentives provided, Domain of Work, Team Size, Complexity of Work etc., to answer key questions like what attributes differentiate a productive team from a less productive team. Is monetary incentive the primary motivator towards productivity? Is there an optimum team size? Do complicated tasks increase overall team productivity or result in decline of team productivity. Is the trend alike across the Sewing domain and Finishing Domain?

Project Motivation:

The industry provides much needed jobs in rural areas and has functioned as a springboard for workers out of poverty into good paying jobs for generations. The sector employs 1.7m people worldwide. By understanding key factors impacting productivity, we allow a data centric strategy that can cope with an increasing export demand by fine tuning ergonomic factors. Although, this project is minimal, as in, it investigates data across 3 months in one factory, it is a step in the right direction.

Exploratory Data Analysis:

Investigating the relationships among the variables, we observed a high correlation between task complexity, number of workers, overtime. For the purpose of the report, we focus on the significant variables as derived using EDA, MLR and Random Forest. [see figure]1

The factory includes two departments: Finishing and Sewing. Each department consists of 12 teams of varying size and workload. The investigation is summarized in two fragments: Department level investigation and Overall Factory level investigation.

Department Level Analysis:

The two departments, Sewing and Finishing have significant disparity in terms of nature of work. There exists large difference in the skill and complexity of the tasks [see figure]2 . This results in different strategic factors in decision making. Therefore, the dataset was split by departments, and were analyzed independently. This allowed us to study their trends as follows:

Overtime and Increment is measured per team member. [see table]1

Optimum Team size:

> The Finishing department favors large teams. Since the tasks are modular having more members allows for efficient parallel working. Teams with less than 8 members do not meet the expected target productivity. Whereas we see a general upward trend as the team size grows, for instance teams with 20-23 members achieve 130% of targeted productivity. [see figure]7,8
>
> The sewing department favors mid-sized teams of 20-40 members. With this team-size they are able to meet the targeted productivity. Team sizes greater than 40 see a stark deficit in meeting targeted productivity. [see figure]5,6
>
> *Note: As expected due to the nature of work, the sewing department in general sees much larger teams as compared to the finishing department.*

Team Task Complexity:

> Task Complexity is derived from the standard minute value (smv) of the task. Greater SMV indicates a more complex task.
>
> The Finishing department typically has highest productivity when the task is medium complexity (ranges in between 3 to 6 SMV). [see figure][9,10]
>
> The Sewing department is most productive in tasks of low to medium complexity (ranges in between 23 to 33 SMV). As the complexity increases, we see a significant drop in productivity. [see figure][7,8]
>
> *Note: Finishing jobs are typically less complex with mean smv of 3.8 and are largely independent. Compared to sewing jobs which are more specialized with mean smv of 24.2. As discussed in optimum team size, this proves that finishing jobs can be orchestrated in larger groups.*

Overtime:

> Both, Finishing and Sewing tasks show no pattern between overtime and productivity. Sewing shows only a marginal increase in productivity, that too with over 3 hours per team member. [see figure][11,12,13,14]

Incentive:

> Sewing department shows a high positive correlation between productivity and incentive (0.8). This is reflected in the increased productivity on weeks just before the incentive rollout. Finishing department does not receive much incentive to establish any significant relationship. [see figure][16]

Based on our EDA, we leveraged a Random Forest model to predict productivity of a team and analyze the important variables that contribute to the prediction.

For Sewing, the model was able to explain 82% variability in out of sample set with an RMSE of 0.06. The important variables were Incentive, SMV, WIP, Overtime and number of workers

For Finishing, the model was able to explain 27% variability in out of sample set with an RMSE of 0.17. The important variables were Overtime, number of workers and SMV [see table][2]
The important variables, align with our observations in the preliminary EDA. [see figure][17,18]

Overall Factory Level Analysis:

Day of the Week:

The factory operates a six-day week, with the employees getting Fridays as off day.
There are certain specific dips in productivity on Thursdays and Sundays. This dip occurs right before the day off for the employees and on days where most other offices are closed. [see figure][15]

The Multiple Linear Regression model re-confirms the hypothesis. It is observed that both Thursdays and Sundays do indeed have the largest negative co-efficient causing dip in overall productivity of the factory. [see figure][19]

Insights and Recommendations:

1. Finishing and Sewing departments have different factors impacting productivity. Therefore, independent decision making is required for the departments.

2. In case of sewing, larger team size hampers productivity. While similar circumstances support productivity in Finishing. Therefore, we recommend reducing team size to 20-25 for Sewing and increasing to 18-20 for Finishing

3. For both departments, productivity is maximized for mid complexity tasks. We recommend breaking down the Sewing tasks to 23-33 SMV and Finishing tasks to 3-6 SMV

4. Higher overtime does not translate to increased productivity.

5. Mid-month incentives are the most significant drivers of temporary increase in productivity. We recommend distributing incentives across weeks to improve consistency.

6. Workers are least productive on Thursdays and Sundays.

7. Based on current overall productivity, most productive Sewing teams are Team 1, 3 and 2. Most productive Finishing teams are Team 5, 3 and 4

Appendix:

Data Schema

Predictor Variables	Variable Source	Description
Date	Independent	Date
Quarter	Independent	A month was divided into four quarters/weeks
Department	Independent	Associated department with the instance (sewing / finishing)
Day	Independent	Day of the week
Team	Independent	Associated team number (team id)
Targeted_Productivity	Independent	Targeted productivity set by the authority for each team for each day.
SMV	Independent	Standard minute value, it is the allocated time for a task
WIP	Independent	Work in progress. Includes the number of unfinished items for products
Over_Time	Independent	Amount of overtime by each team in minutes
Over_Time_Ptm	Derived	Overtime per team member (in hours) - over_time/60*no_of_workers
Incentive	Independent	Amount of financial incentive that enables or motivates a particular course of action.
Incentive / Team Member	Derived	Incentive/no_of_workers
Idle_Time	Independent	The amount of time when the production was interrupted due to several reasons
Idle_Men	Independent	The number of workers who were idle due to production interruption
No_Of_Style_Change	Independent	Number of style changes mid-way through the manufacturing process
No_Of_Workers	Independent	The number of members in team.

Correlation Matrix

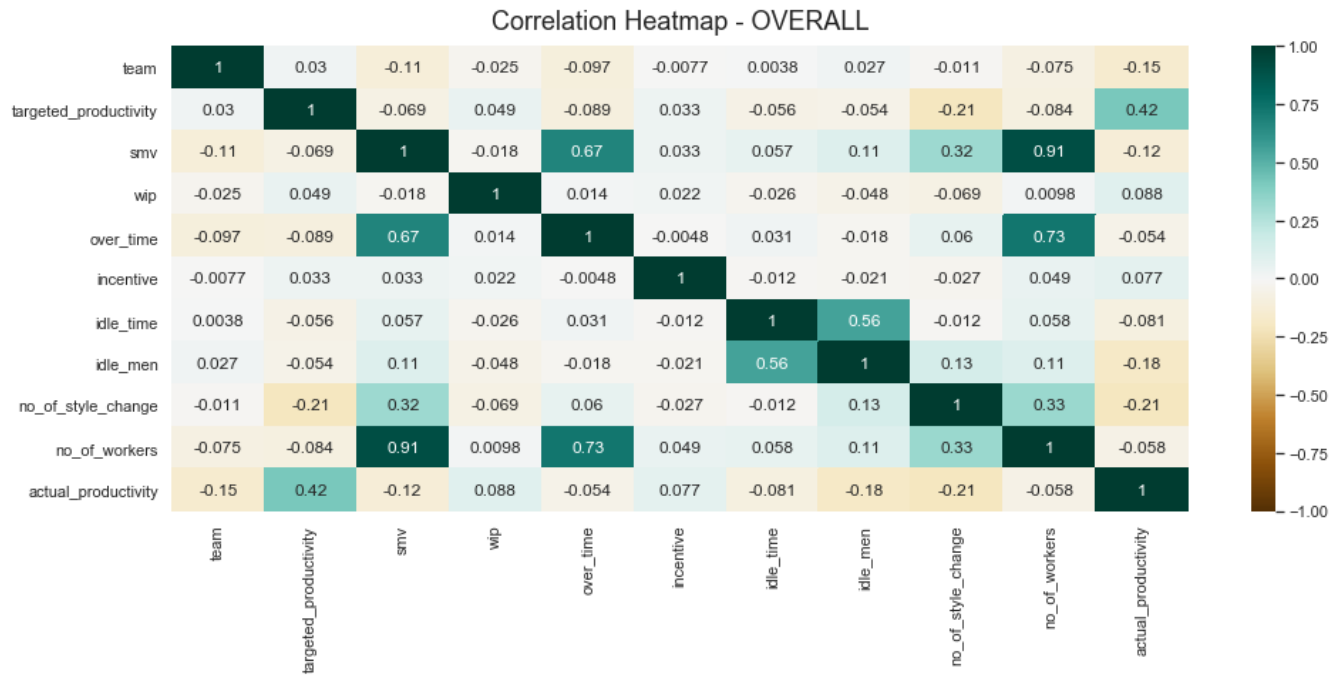

Figure 1: Correlation Of Each Variables on Complete Dataset

Comparison of Key Factors in Departments

Figure 2: Each plot proves the stark differences between key variables in each department – Finishing and Sewing

Team Size Analysis on Productivity

Sewing

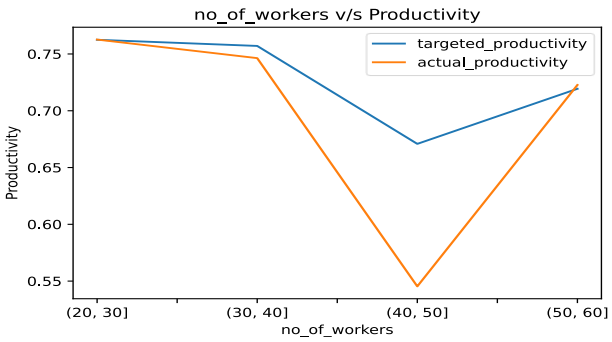

Fig 3 : Team Size vs. Sewing Target, Actual Productivity

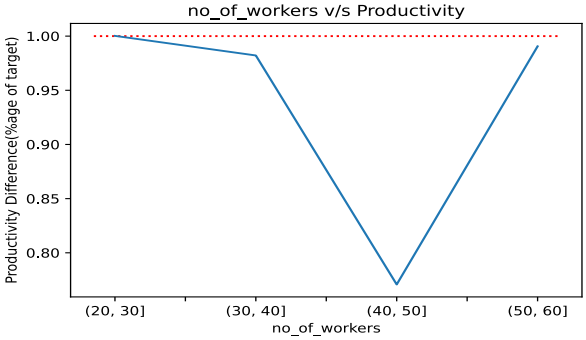

Fig 4 : Team Size vs. Achieved Productivity

Finishing

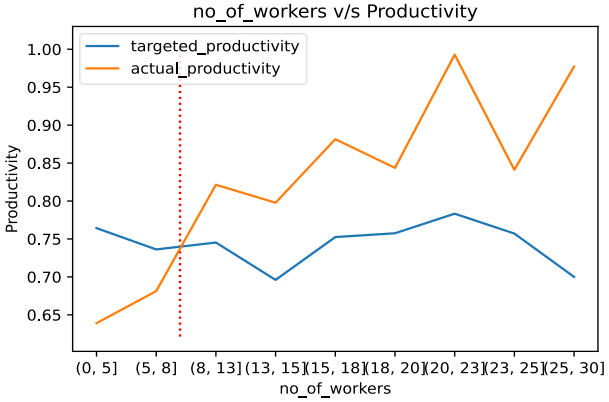

Fig 5 : Team Size vs. Finishing Target, Actual Productivity

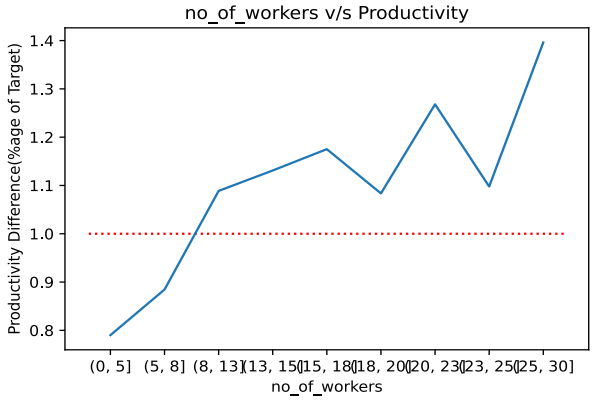

Fig 6 : Team Size vs. Achieved Productivity

Department Task Complexity Analysis on Productivity

Sewing

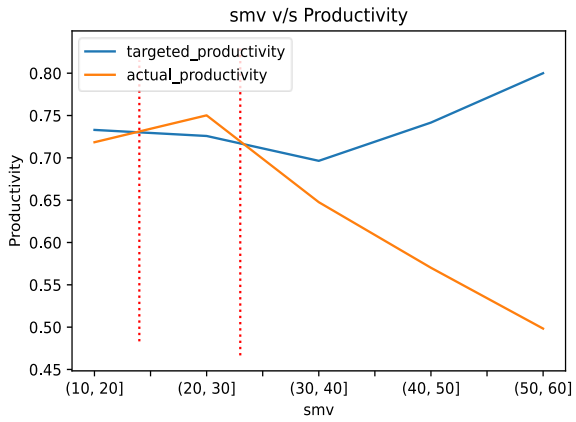

Fig 7 :SMV vs. Sewing Target, Actual Productivity

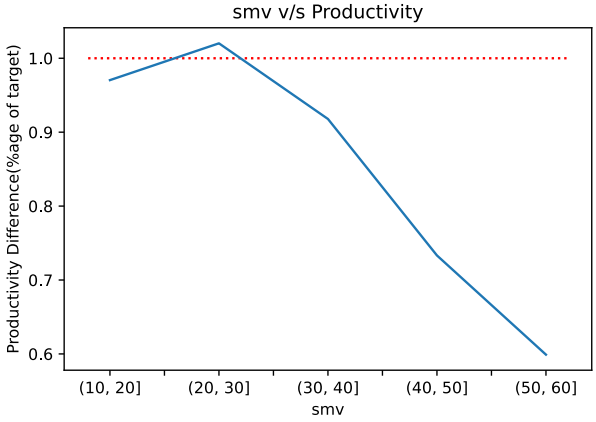

Fig 8 : SMV vs. Achieved Productivity

Finishing

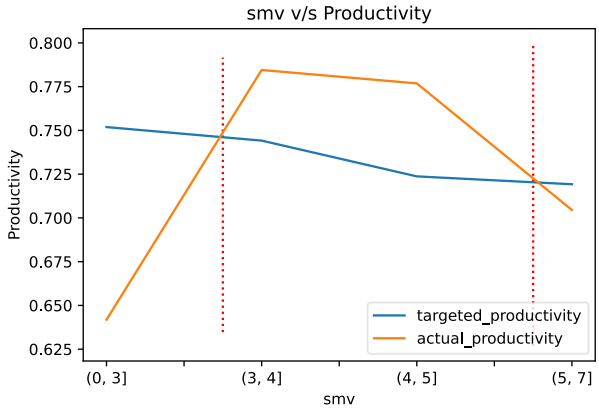

Fig 9 : Team Size vs. Sewing Target, Actual Productivity

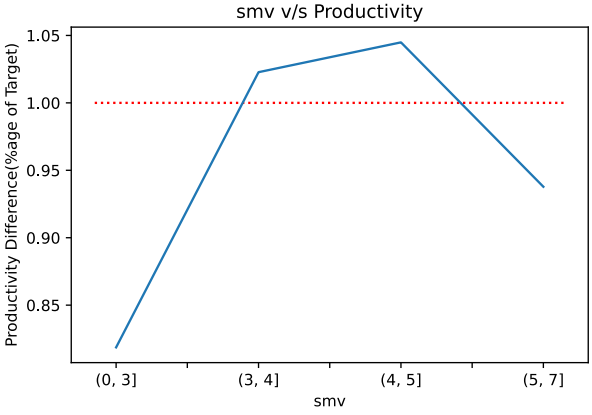

Fig 10 : Team Size vs. Achieved Productivity

Overtime Analysis on Productivity

Sewing

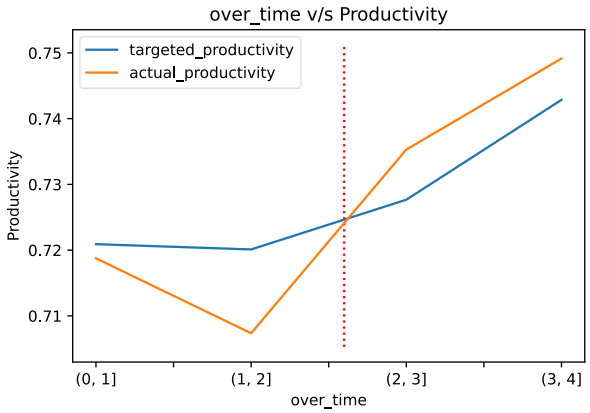

Fig 11 : Overtime vs. Target, Actual Productivity

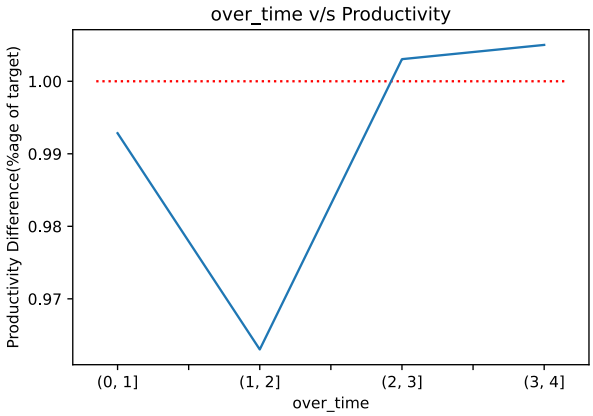

Fig 12 : Overtime vs. Achieved Productivity

Finishing

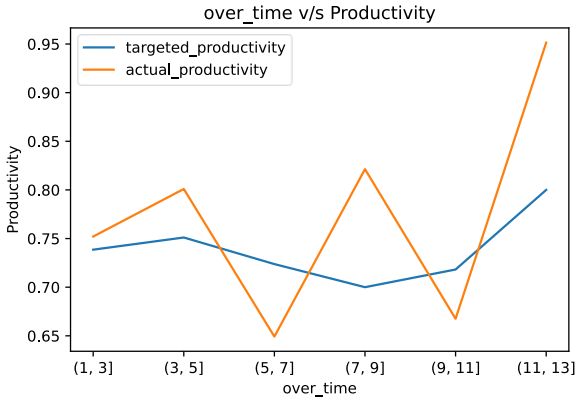

Fig 13 : Overtime vs. Target, Actual Productivity

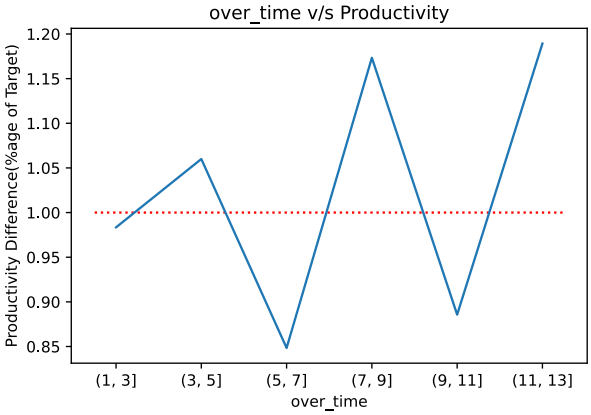

Fig 14 : Overtime vs. Achieved Productivity

Day of Week Analysis on Productivity

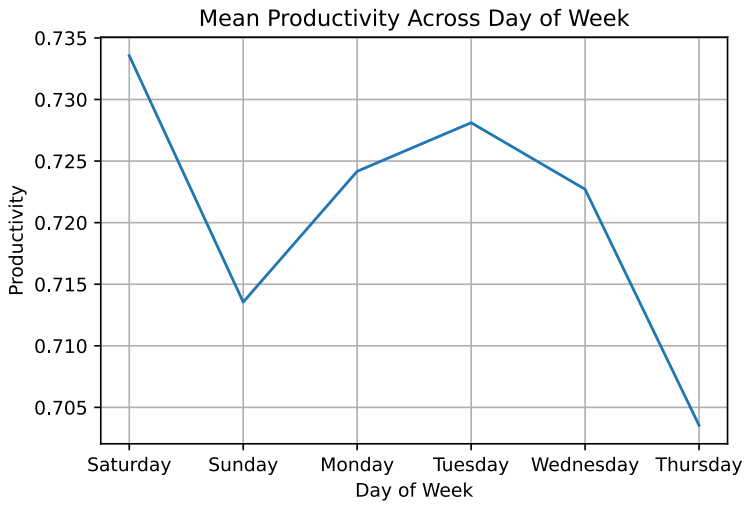

Fig 15 : Day of the Week vs. Actual Productivity

Incentive Analysis:

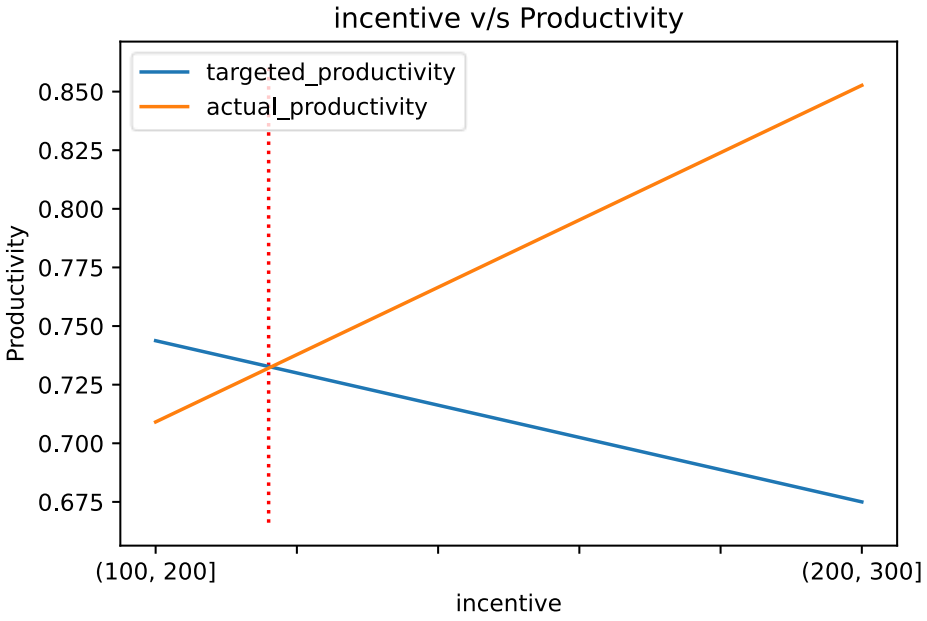

Fig 16 : Incentive vs. Target, Actual Productivity

Random Forest Results:

Model	Accuracy Training Set	Accuracy Test Set	OOS MSE	OOS RMSE	Explained Variance
Finishing	0.77	0.26	0.03	0.18	0.26
Overall	0.84	0.34	0.02	0.13	0.34
Sewing	0.97	0.82	0.00	0.06	0.82

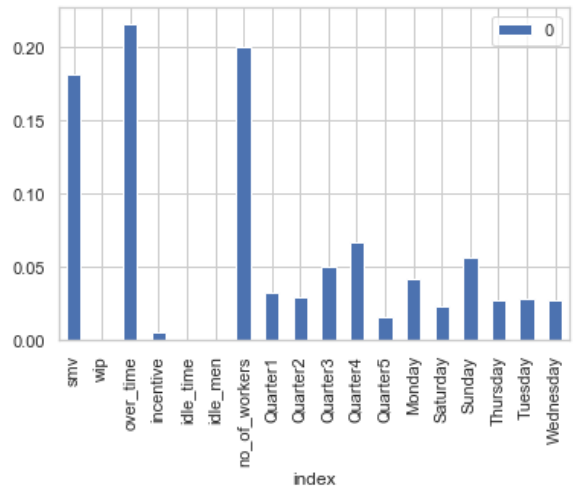

Fig 17 : Important Variables - Finishing

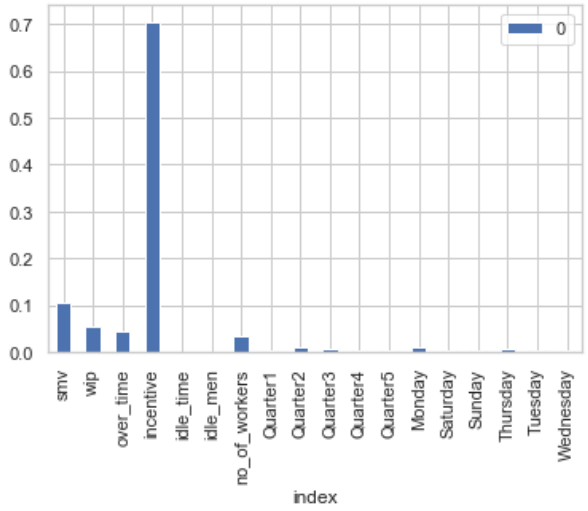

Fig 18 : Important Variables - Sewing

Multiple Linear Regression Coefficients:

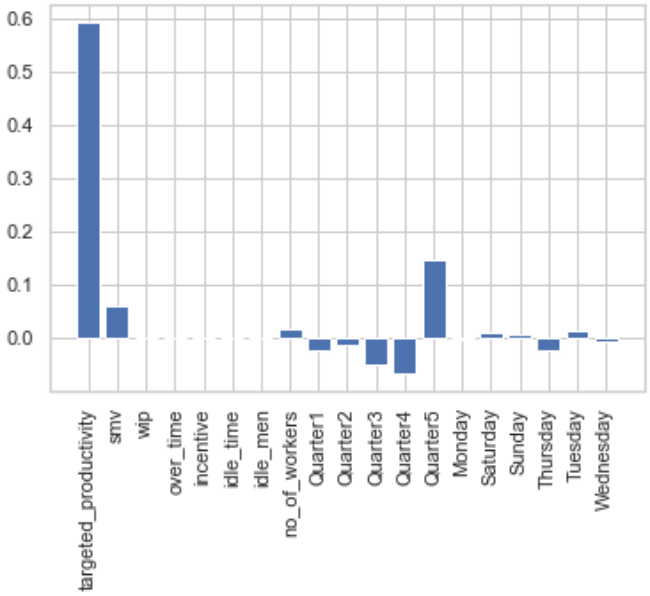

Fig 19 : Coefficient Relationship for Complete Dataset