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# Executive Summary

The report devises the optimal retention plan for IntelliAuto, which is an automobile manufacturer, embarking on transforming into a smart factory within 8 years. IntelliAuto aims to understand its employees’ turnover probability in the next 8 years to prepare for a retention plan and future negotiations. The report assumes employees with less than 8 years of employment are more likely to leave. The R programming language is used for data processing and developing a logistic regression model to predict the turnover intent of each employee. The goal of the report is to reduce the current probability by 20% and 60% with minimal investment in the retention plan for 10 employees.

The predictive model involves 6 predictors, which are key characteristics correlated with employee tenure. The retention plan targets Professionals, Tech/Sales, Management, Production and Service employees due to their high strategic priority during the digital transformation. Employees with the highest probability in each occupation are selected to retain. While the 20% reduction rate plan is feasible, the 60% one is unachievable due to the resource constraints. However, the sensitivity report of the 20% reduction goal reveals valuable insights to further optimize the retention plan by increasing incentives’ effectiveness, extending the salary budget and re-evaluating the stringent reduction target

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# I. Introduction

## 1. Business Background

IntelliAuto, an automobile parts manufacturer with 5000 employees, is planning for an 8-year digital transformation to a smart factory. The transition primarily leverages IoT, automation and robotics to enhance productivity and profitability. IntelliAuto aims to understand employee turnover to effectively manage its workforce and prepare for future negotiations with important employees.

## 2. Objectives

The analysis determines the crucial occupations for digital transformation and formulates an optimization plan with minimal spending to retain employees with the highest probability. The analysis assumes employees with less than 8 years of employment are likely to leave during the transformation. Consequently, logistic regression is used to predict the turnover probability. Lastly, optimal plans are developed to reduce the current turnover probability by 20% and 60% with the available resources (Table 1 and 2).

|  |  |  |
| --- | --- | --- |
| Department | Effect on reducing the probability of leaving the company in less than 8 years | Cost per hour ($000) |
| Management | 0.01 | 0.8 |
| Professional | 0.02 | 1.0 |
| Tech/Sales | 0.03 | 1.1 |
| Admin | 0.01 | 0.9 |
| Service | 0.03 | 1.2 |
| Production | 0.03 | 1.1 |
| Laborer | 0.02 | 0.9 |

Table 1. Effectiveness and cost of each seminar hour on each occupation

|  |  |
| --- | --- |
| Gender | Effect of $1K salary increase on reducing turnover probability in less than 8 years |
| Male | 0.05 |
| Female | 0.03 |

Table 2. Effectiveness of $1,000 salary increases on each gender

## 3. Data Background

The data is collected from a survey of a random sample of 822 employees, having no missing values and duplication. However, the exploratory analysis found some errors in the `Employment\_Years`, thereby applying winzorization to correct the data (Appendix 1).

|  |  |  |  |
| --- | --- | --- | --- |
| Variables | Variable types | Level | Survey Questions |
| Work\_Hours | Numeric | Null | Number of total weekly working hours |
| Occupation | Character (Nominal) | Professionals, Tech/Sales, Admin, Managerial, Laborer, Service, Production (No level) | Current occupation in the company |
| Age | Numeric | Null | Respondent’s age |
| Education\_Years | Numeric | Null | Respondent’s education years |
| Sex | Factor | Male, Female | Respondent’s gender |
| Union\_Member | Factor | Yes, No | Respondent is currently a union member or not |
| Working\_Years | Numeric | Null | Number of working years since they were 16 years old |
| Employment\_Years | Numeric | Null | Number of years working in IntelliAuto |
| Number\_Promotion | Numeric | Null | Number of promotions in IntelliAuto |
| Future\_Promotion | Factor | Very Unlikely, Unlikely, Not Sure, Likely, Very Likely | Perspective about future promotion opportunities |
| Sex\_Promotion | Factor | Better, Worse, No Effect | Perspectives about gender bias in promotion |
| Aware | Factor | Yes, No | Respondent is aware of the Industry 4.0 or not |

Table 3. Summary table of variables

# II. Problem Formulation

## 1. Turnover Intent Prediction by Logistic Regression

### a. Dependent Variable Determination

Given the assumption, the analysis creates the `Turnover` variable encoding employees with fewer than 8 employment years by 1 and the other by 0. This variable serves as a dependent variable for the regression model to predict the individuals’ turnover probability.

### b. Predictor Selection

Initially, the analysis creates a logistic regression model with all available numeric and ordinal variables. However, the final model must comprise only statistically significant predictors and be free from multicollinearity, causing overfitting and reducing the model’s accuracy (Singh 2024). Therefore, backward elimination is performed to step-by-step remove the unreliable predictors (Table 4).

|  |  |  |
| --- | --- | --- |
| Variables | Involvement | Justification |
| Sex | Involved | Because the effectiveness of available incentives on each gender’s turnover reduction is different, the turnover probability between males and females with similar characteristics may differ. Further, offered incentives can be regarded as positive indicators for future promotion. More importantly, Appendix 4 shows that more males believe they have better promotion opportunities, while females believe their gender hinders their career development. Therefore, `Sex`, ‘Sex \_Promotion` and `Future\_Promotion` are non-negotiable for an accurate predictive model. |
| Future\_Promotion | Involved |
| Sex\_Promotion | Involved |
| Work\_Hours | Not Involved | These variables are statistically insignificant, thereby being removed from the model (Appendix 5). |
| Aware | Not Involved |
| Age | Not Involved | The VIF test, which is utilized to detect multicollinearity in models (Singh 2024), shows a moderate VIF[[1]](#footnote-1) between `Age` (4.893) and `Working\_Years` (4.935) (Appendix 6). Collinearity is understandable because older individuals usually have more work experience. However, `Age` is removed from the model because it is statistically insignificant, while `Working\_Years` meets the selection criterion. |
| Working\_Years | Involved |
| Education\_Years | Involved | Both variables are statistically significant after eliminating disqualified predictors. Hence, the analysis retains these predictors for higher accuracy. |
| Number\_Promotion | Involved |
| Union\_Member | Not Involved | Although this variable is statistically significant after performing all elimination steps, removing it from the model makes the `SexFemale` predictor closer to the significance threshold (Appendix 7). Therefore, elimination is important to ensure accurate predictions. |

Table 4. Justification for predictor selections

### c. Final Model



Figure 1. Final predictive mode of turnover probability (Appendix 8)

|  |  |  |  |
| --- | --- | --- | --- |
| Variables | Coefficients | z-value | p-value |
| Intercept | -0.861 | 0.617 | 0.163 |
| Sex | | | |
| SexFemale | 0.355 | 1.755 | 0.079. |
| Number\_Promotion | -0.761 | -9.298 | 0.000\*\*\* |
| Education\_Years | 0.235 | 6.078 | 0.000\*\*\* |
| Working\_Years | -0.092 | -8.907 | 0.000\*\*\* |
| Sex\_Promotion | | | |
| Sex\_PromotionWorse | -1.382 | -4.565 | 0.000\*\*\* |
| Sex\_PromotionNo Effect | -0.045 | -0.211 | 0.833 |
| Future\_Promotion | | | |
| Future\_PromotionUnlikely | 1.347 | 5.508 | 0.000\*\*\* |
| Future\_PromotionNot sure | 0.148 | 0.318 | 0.751 |
| Future\_PromotionLikely | 1.628 | 5.622 | 0.000\*\*\* |
| Future\_PromotionVery Likely | 1.191 | 4.393 | 0.000\*\*\* |

Table 5. Logistic regression model summary (Appendix 8)

## 2. Employee Identification

The digital transformation impacts all occupations by both creating new opportunities and reshaping existing roles (Fenech et al. 2019). However, the impacts vary across occupations, requiring a strategic focus on the most critical occupations that drive a successful transformation. Consequently, a prioritization framework is developed to select and justify the employee selection (Table 6).

|  |  |  |  |
| --- | --- | --- | --- |
| Priority | Occupation | Total | Justification |
| 1 | Professional | 3 | This occupation in the manufacturing sector encompasses roles such as automation and robotics engineers, playing critical roles in designing, implementing and optimizing the smart factory. Their technological knowledge in machinery operations and quality control is the critical driver for the success of digital transformation (Bilynska et al. 2019). Therefore, retaining these professionals is the primary concern. |
| 2 | Tech/Sale | 2 | The importance of tech and sales employees is amplified significantly during digital transformation. Technicians during this era are responsible for operating and troubleshooting the AI-powered machines and automation systems, thereby demanding a high level of upskilling (Fritzgerald and Wilson 2024). The sales team must evolve to articulate the new value propositions derived from the transformation to communicate effectively to B2B clients (Echchakoui and Ladhari 2024). Therefore, this occupation is vital to ensure the most efficient operations and boost organizational profitability. |
| 3 | Managerial | 2 | The managerial level plays a pivotal role in developing and implementing human, financial and operational strategies to ensure sustainable growth. Further, their effective leadership will significantly foster the culture of innovation and lead the organization through volatility, which is inevitable during the technological transformation era. (Ali 2023). |
| 4 | Production | 2 | Because the factory is the primary focus of the transformation, manual production workers must evolve into skilled operators to ensure quality within the automated production line. Therefore, upskilling key production employees ensures that new technologies effectively enhance the factory’s productivity. (Arica 2022). |
| 5 | Service | 1 | Within a smart factory, the support of service employees, particularly maintenance services, is increasingly vital to ensure a seamless manufacturing process. Their roles require more in-depth knowledge and close collaboration with other teams to diagnose machinery issues instantly. Therefore, upskilling and retaining high-skilled maintenance employees are crucial for sustained factory performance. (Boot 2024). |

Table 6. Justifications for occupation selections

Due to the limited resources available, retained employees must represent high value and possess leadership potential. The only critical individual selection criterion is the completion of a college degree or higher education, equivalent to a minimum of 14 years of education. Combining occupational and educational criteria, 10 employees with the highest turnover probability are identified (Table 7).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ID | Name | Occupation | Education Years | Sex | Probability |
| 51 | A | Professional | 18 | Male | 0.984 |
| 283 | B | Professional | 18 | Female | 0.984 |
| 354 | C | Professional | 16 | Female | 0.974 |
| 35 | D | Tech/Sales | 17 | Female | 0.984 |
| 517 | E | Tech/Sales | 17 | Female | 0.984 |
| 56 | F | Managerial | 16 | Male | 0.98 |
| 76 | G | Managerial | 16 | Female | 0.98 |
| 99 | H | Production | 15 | Male | 0.962 |
| 216 | I | Production | 15 | Male | 0.933 |
| 7 | J | Service | 14 | Female | 0.969 |

Table 7. Summary table of selected employees

## 3. Findings

Following the employee identification, the analysis involves the linear programming model in the Excel solver to devise the optimal plan for the targeted reduction.

### a. Objective and constraint formulation

Table details notations for each employee’s allocated resources and cost for readability (Table 8). Total retention cost minimization is the primary goal of the objective function (Table 9). The primary constraint functions are the limits of seminar hours and salary budget, and the non-negativity condition for all allocated resources (Table 9).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Occupation and Gender | Assigned Seminar Hours | Seminar costs | Amount of salary increase |
| A | Professional |  |  |  |
| B | Professional |  |  |  |
| C | Professional |  |  |  |
| D | Tech/Sales |  |  |  |
| E | Tech/Sales |  |  |  |
| F | Managerial |  |  |  |
| G | Managerial |  |  |  |
| H | Production |  |  |  |
| I | Production |  |  |  |
| J | Service |  |  |  |

Table 8. Table of notations

|  |  |  |
| --- | --- | --- |
| Problem | Formula | Variable Definition |
| Minimize total retention cost (Objective function) |  | : Total seminar cost for 10 employees  : Total salary increases for 10 employees |
| Seminar hour constraint |  | : Total allocated seminar hours for 10 employees |
| Salary budget constraint |  | : Total salary increases for 10 employees |
| Non-negativity constraints for all resource allocations | ,  ,  For all | : allocated seminar hours for each employee  : salary increases for each employee |

Table 9. Summary table of the problem formulation

### a. Reduce the turnover probability by 20%

The probability adjustment formulation is derived from the effectiveness of each incentive on each individual. To attain the reduction target, the effect of two incentives must reduce each employee’s turnover intent by 20% or higher (Table 10).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Employee Name | Occupation | Sex | Target Reduction | Probability Adjustment Formulation |
| A | Professional | Male | 0.2 |  |
| B | Professional | Female | 0.2 |  |
| C | Professional | Female | 0.2 |  |
| D | Tech/Sales | Female | 0.2 |  |
| E | Tech/Sales | Female | 0.2 |  |
| F | Managerial | Male | 0.2 |  |
| G | Managerial | Female | 0.2 |  |
| H | Production | Male | 0.2 |  |
| I | Production | Male | 0.2 |  |
| J | Service | Female | 0.2 |  |

Table 10. 20% probability adjustment formulation for each employee

The optimization model successfully recommended a feasible allocation plan for the 20%-reduction target with the provided resource. The minimum total cost to achieve the targeted probability is $57867, with $40,000 for the salary raise and $17,867 for 16 hours of seminar (Figure 2). While the seminars are more impactful to tech/sales and service employees, the salary increase is influential to the rest.

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Figure 2. Structure of resource allocation plan for the 20% reduction target

The sensitivity report details the optimal resource allocation and its stability against cost fluctuations in the variable cells table (Figure 3). Reduced price indicates how much the unit cost of each incentive (objective coefficients) can change before the original allocation plan and its structure are fundamentally altered (Yuraszeck n.d.). The seminar plan’s **reduced prices** for males are approximately or higher than those of females. The differences are caused by the significant effectiveness of salary increases on males’ turnover intent compared to females.

A table with numbers and numbers

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Figure 3. Variable cells table of the sensitivity report for the 20% reduction target

The constraints table illustrates how the predefined thresholds affect the targeted reduction at the $57,867 minimum cost (Figure 4). 20 seminar hours are a non-binding constraint, with only 16 hours optimally allocated, indicating that seminar hours are not the primary limit for the 20% reduction with minimal expenses. Although stretching the hour constraint has no impact on the optimization plan, reducing the seminar hours to below 16 hours probably makes the plan infeasible because the salary budget is completely utilized. Conversely, the $40,000 salary budget transpires as a binding constraint with a negative 0.2 shadow price. It implies that extending the salary budget by up to $2,667 (allowable increase) will cut the total cost by . Moreover, the fixed reduction rate for all 10 employees is also a binding constraint. With an employee having a -40 shadow price, lowering his/her reduction rate modestly by 1% to 2% will save the total cost by $400 to $800.

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Figure 4. Constraint table of the sensitivity report for the 20% reduction target

### b. Reduce the turnover probability by 60%

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Employee Name | Occupation | Sex | Target Reduction | Probability Adjustment Formulation |
| A | Professional | Male | 0.6 |  |
| B | Professional | Female | 0.6 |  |
| C | Professional | Female | 0.6 |  |
| D | Tech/Sales | Female | 0.6 |  |
| E | Tech/Sales | Female | 0.6 |  |
| F | Managerial | Male | 0.6 |  |
| G | Managerial | Female | 0.6 |  |
| H | Production | Male | 0.6 |  |
| I | Production | Male | 0.6 |  |
| J | Service | Female | 0.6 |  |

Table 11. 60% probability adjustment formulation for each employee

The 60% reduction uses similar formulas for probability adjustment (Table 11). The 60% reduction target is reported to be infeasible even though all resources are maximized (Figure 5 and 6). Given the limited resources, the company should either accept the reduction for only 3 employees or lower their reduction expectation or provide more resources.

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Figure 5. Structure of resource allocation plan for the 60% reduction target

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Figure 6. Summary table of final reduction

# III. Discussion

For the 20% reduction target, IntelliAuto needs a significant effort to cut training costs, thereby making the seminars contribute to the reduction of males’ turnover intent. For females, concerns about organizational career development or gender equality significantly impact their loyalty, which partially explains the low effectiveness of salary increases on their turnover intent.

Regarding the resource constraint, although the $40,000 salary increase is an effective retention tool, the budgetary ceiling is the limitation of the optimization plan. Therefore, IntelliAuto should consider re-evaluating the salary budget to earn greater benefits. Further, a more impactful solution for cost-cutting is to re-evaluate the stringency of the reduction rate. Lowering the targeted rate of the employee with the lowest strategic priority is strongly recommended. This approach appears to be the most efficient cost-cutting approach compared to optimizing training costs or extending the salary budget, which require extensive strategic considerations and value engineering effort.

To achieve the 60% reduction rate, IntelliAuto needs to invest at least $168,000 for salary increase only (Appendix 9). However, although the salary increase can retain important employees, it has no contribution to the overall improvement of skills, morale, and knowledge. Therefore, IntelliAuto needs to increase the effectiveness of seminars and utilize other methods to optimize results to gain actual benefits from the retention plan.

# IV. Conclusion

The analysis devised the optimal retention plan with minimized total costs for Professional, Tech/Sales, Management, Production and Service employees. Only the 20% reduction target was successfully achieved, with the salary increase emerging as the most effective tool. From the sensitivity report, the analysis will recommend several short-term and long-term solutions for the future retention plan.

# V. Recommendation

|  |  |
| --- | --- |
| Recommendation | Justification |
| Re-evaluate Stringent Individual Probability Reduction (Short-term Solution) | To further cut the total cost, IntelliAuto conduct several scenario analyses by marginally reducing the target probability of some specific employees. Firstly, female employees, who have large negative shadow prices, are targeted to re-evaluate the final probability. Consequently, IntelliAuto can modestly increase the final probability by 1% or 2%, and then re-conduct the optimization analysis to find the best-fit strategy. During the re-evaluation process, IntelliAuto should target the rate cut to low-prioritized employees, such as service or production staff. According to Skelton et al. (2020), turnover costs such as hiring expenses or financial losses of lower productivity can be 100% higher than annual salary. Further, even a quite low turnover intent can be harmful if the quitters are valuable to the company (Rusi et al. 2023). Therefore, it is crucial to focus on high-skilled and highly paid employees, including professional, tech/sales, and managerial employees, to minimize financial loss caused by turnover.  For the 60% reduction, the company needs to conduct further market research to examine the general turnover intent in the manufacturing sector to set a more attainable goal. The marginal differences in the final probability between occupations must be more significant, ranging from 5% to 10% or even higher between occupations. |
| Re-evaluate Resource Constraints (Short-term Solution) | For the 20% reduction scenario, IntelliAuto should consider increasing the salary budget by $2,667 to minimize the total cost while keeping the plan’s structure unchanged.  For the 60% reduction scenario, extending budget constraints is requisite to make the target feasible. However, retention contributes almost zero value to the growth of the company. IntelliAuto needs to determine the floor and ceiling of allocated seminar hours to tackle the skill gaps. However, overemphasis on training potentially encounters diminishing returns, negatively influencing employees’ satisfaction and productivity. Therefore, longer-term solutions are essential to reduce employees’ turnover intent. |
| Improve Incentive Effectiveness  (Long-term Solution) | Because spending a large amount of training hours and salary increase potentially diminish productivity, satisfaction and financial stability, IntelliAuto needs to improve the impacts of incentives. Therefore, the company needs to increase its impact on incentive turnover intent reduction. The perceived effectiveness of employees towards the training purpose is positively correlated with training effectiveness. The alignment of content with current job position and responsibility is crucial to the perceived effectiveness. Although the current content might be the best fit for employees, pre-training induction and communication effectively support employees in recognizing the actual values of the training initiatives. To be cost-saving and efficient, IntelliAuto can gather selected employees for a quick meeting, presenting the training roadmaps and focusing on the job-fit aspects of the designed content. |
| Enhance Other Retention Factors | Although salary increase is an effective tool to retain employees, other non-monetary factors such as gender equality, the chance of promotion or recognition are also crucial. Given the differences in perspective about gender bias in career development (Appendix), IntelliAuto needs to scrutinize the issues thoroughly to identify the root causes of the disparity. According to Lijster and Hajal (2023), promotional discrimination is one of the main reasons that leads to female turnover. Therefore, women empowerment initiatives that promote leadership and create a supportive workplace will contribute to the enhancement of female retention. |

Table 12. Short and Long-term Recommendations and Justification for Retention Plan

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# VII. Appendix

**Appendix 1: Perform winzorization for erroneous `Employment\_Years`**

Appendix 2 illustrates that several `Employment\_Years` observations are larger than `Working\_Years` observations, given the descriptions of variables in Table 3. Therefore, winzorization is performed to replace the erroneous `Employment\_Years` (52.25) with the respective `Working\_Years` (45) (Appendix 3).

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Appendix 2. Scatter Plot of All Numeric Variables with Employment Years (R script 2)

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Appendix 3. R script of winzorization performance (R script 2)

A graph of a person and person

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Appendix 4. Perspective of Each Gender about Gender Bias in Promotions (R script 2)

A screenshot of a computer program

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Appendix 5. The initial model showing statistically significant and insignificant predictors (R script 3)

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Appendix 6. VIF results of the initial model (R script 3)

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Appendix 7. Predictive model with `Union\_Member` variable (R script 3)

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Appendix 8. Results of the final model (R script 4)

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Appendix 9. Resource allocation plan of a feasible 60% reduction rate target

1. Moderate VIFs are higher than 4, which require further investigation, while VIFs higher than 10 are signs of serious multicollinearity, which require instant correction (The Pennsylvania State University 2018). [↑](#footnote-ref-1)