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# Macro-Level Manpower Planning with Time-Window

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## Abstract

This paper focuses on determining the minimum number of overtime hours needed to meet the organization's Key Performance Index (KPI) at one of the Asian service companies, given the number of customer service officers available. The company also wants to identify the optimal number of cases each staff should handle to ensure they are optimally utilized and KPIs are met. Using the historical data, we identified the optimal balance of simple, moderate, and time-consuming cases a single staff should receive in a month. Based on the distribution, we determined the estimated duration needed to clear these cases. In addition, we developed a mathematical model that allows the user to determine the amount of sale applications the department can clear within the stipulated working hours. Additionally, if the forecasted demand is too much for the sale department, the model could also be used to derive the number of working hours the department has to work overtime to meet a percentage of their demand. Based on the extra time needed, the model can also derive the additional manpower required to meet the KPI. The model and the provided historical data confirmed that the department has been constantly overworking since the surge in demand. We validated our model using the actual data from the operation, and the one-month planning model developed was able to attain a good result with a mean absolute error of less than 5%.

## Keywords
Manpower planning, data analysis, mathematical model**.**

## 1. Introduction
Our client is a company that provides premium service to buyers and sellers who want to sell their apartments, and the whole purchase process needs to be completed within an 8-week timeframe. There is also an exception when the process is not completed within 8 weeks, provided the buyers and seller are agreeable before signing the sale and purchase agreement contract. According to the data, the company has processed 25,000 sale applications yearly for the past three years and an average of at least 2,000 cases monthly. Therefore, a reliable team is required to process many applications every month. All the staff in the company are full-time employees, and they need unique skill sets and professional knowledge to serve the customers.

There are various steps a buyer needs to take to purchase an apartment from the buyers via the online platform. The buyer and seller need to provide necessary documents, such as ownership of the house from the seller, the financial status of the buyers, and the relationship between the buyers and their share. The documents also include the intention and option to purchase from the seller. The sellers also need to state the mortgage tenure, interest rate, mortgage amount, and mode of finance. The company must also evaluate the current property price and the sale value. If the gap between the sale price and the current market price of the apartment is positive (Sale price – current market price > 0), the seller needs to pay the gap to the buyers in cash; it is called cash over valuation (COV), as most of the bank loan couldn't cover the gap. However, if the property sale price is less than the market value, the buyer can take up to 80% of the loan based on the current sale amount. Figure 1 shows the sale application process. The 8-week time window only starts when all the document checks are done, and the staff in the company will open a case with a unique case ID. In this paper, we are only interested in the following three steps in the sale application process: registration, approval, and completion of the sale process. The service level agreement (SLA) is to complete the sale process (completion date – registration date) within eight weeks.

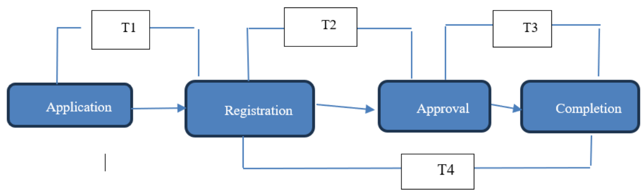


Figure 1. Graphical presentation of sale application process

The diagram above refers to the sale application process, and the duration between each process is denoted as T2, T3, and T4. T2 refers to the time between approval and registration, T3 refers to the time between completion and approval, and T4 is the duration between completion and registration. Due to digitalization, much of the application's data is stored digitally. The data ranges from customers' demographics, financial status, number of service officers available monthly, and duration taken from one stage to another. Due to digitalization, most of the application's data are stored in the company data servers and ready for analysis. In recent years, with the recent development and adoption rate of data analytics in the company, the management has been keen to embark on a data analytics journey. It aims to provide valuable insights into service performance related to SLA and improve customer satisfaction. In the meantime, the company also needs to ensure that the staff is fully utilized but not working overtime and that the staff job satisfaction and retention rate is high.

In the next section, we will conduct the literature review related to manpower or resource planning and scheduling and identify the gaps in the literature. In section three, we define the business problem, followed by exploratory data analysis and share the insights. We then developed the models based on the business problem, and computational results will be shown. Finally, we will recommend the company with actional insights and step forward to achieve the operational efficiency.

## 2. Literature Review

Akyurt et al (2021) looked at the macro-level planning for an airline company. The airline's workforce planning stage is one of the earliest steps in the airline planning hierarchy. This means that if a shortage of manpower arises during the operations stage, the airline would most probably not be able to solve it. Before this, the airline found themselves to be inefficient at scheduling their pilots between sending them for training or placing them in the work rotation. Using a multi-objective non-linear programming model, the team was able to obtain a solution that minimizes multiple objectives. Considering the possibility of future changes, the duration of transition training and pilot requirements were adjusted to envision the changes in model results. New employment increased when either training duration or pilot skill requirement increased. The model was, however, more sensitive to pilot requirements than training duration.

Black et al. (2023) used a mixture of known and unknown future demands to determine the number of jobs that must be completed daily. Any jobs not completed by the end of the due date will incur a penalty cost and need to be completed by the next day. The authors presented two distributionally robust resource optimization models inspired by the service industry to solve this problem. The first model was non-parametric, and the second one was a parametric model, where the number of uncertain jobs due each day was created as a binomial random variable with an unknown success probability. The authors performed extensive computational experiments to establish the performance of their algorithms and compared the decisions from the parametric and non-parametric models to assess the benefit of including binomial information.

According to Brucker (2002), the topic of scheduling has been researched by many organisations since the early 1950s. It was used to provide organisations with the optimal decision regarding the use of their limited resources to either maximise or minimise their objective. Manpower optimization helps a company maximize the benefits it can receive from its employees. However, as time passed, problems and objectives started getting more complex, and planners started relying on Decision Support Systems (DSS) to make decisions. DSS uses large amounts of data and computerized programs to identify trends or scheduling solutions which are difficult for the average planner to see. The results can then be used to either support or provide the firm with actions or policies which could help them better reach their objective.

Llort et al. (2019) wanted to optimise the number of consultants a consultancy firm needs for each department for the next 3 years. To solve their problem of uncertainty in their strategic capacity planning, the researchers used a method called Mixed-Integer Linear Program (MILP) on IBM's ILOG CPLEX Optimisation studio package. With the main objective being profit maximisation, the team was able to quantify the impact of adopting the policy of automatic promotion versus restricted promotion. Overall, the model provided the firm with justifications regarding their decisions as they could plan further ahead using the predicted outcomes of their decisions.

Ma et al. (2014) used a six-step methodology to solve passenger load and check-in counter requirement problems at one of the busiest airports in Asia. The authors combined the optimisation and simulation models. The first part of the methodology used past historical data, such as past load, flight information, and region, to develop a decision model for passenger load to forecast passenger load and transfer load. Other information, such as passenger arrival patterns, average service times, and queue times, were then derived from the historical data. Together with the derived information and forecasted passenger loads, these data were inputs for the simulation model to determine the optimal number of check-in counters required and resource utilisation to meet the service level agreements.

Ma & Choy (2018) used a consultancy project and developed it into a classroom case study to teach students about macro-level manpower planning for the training of staff and budgeting purposes in the company. In this case study, students were given 15 months of historical demands and the number of staff available to service the demand. Students developed a mathematical model for this purpose. They ran multiple business scenarios, which comprised changing the number of shortlisted applicants versus the number of staff and the staff utilization rate. The authors shared how this course has been delivered to thousands of undergraduate students annually in the university.

Liang & Lee (1985) manpower planning is linked to the operational process. The authors developed a systems approach to integrate the gross level of manpower planning and the detailed level of policy execution. This integrated system could improve the effectiveness of policymaking.

Based on the literature review, we identified a shortage of macro-level manpower planning, especially with a long time frame of eight weeks. Thus, we need to gain domain knowledge from our clients and develop a customized model for macro-level manpower planning with a time window. The authors will build several models to determine the time needed to service the demands and the number of staff required to meet the service level agreement to complete the sale process within eight weeks.

## 3. Business problem description

Currently, the company doesn't have an existing model for management to use to identify the amount of time required to service each sale application and how much time is needed at each stage. CSOs depend on their experience to gauge how long they need to process a sale application. This allows them to plan their schedule to ensure all their cases can be closed within eight weeks. Recently, however, CSOs have been constantly working through the weekends to meet the Key Performance Index (KPI) set by the company, which is to clear at least 80% of the cases within the eight-week timeline. With the growing number of CSOs working overtime, the company fears their staff will resign from the job, and there will be a lack of CSOs who cannot meet customer demands. Therefore, the IT department wishes to use the data collected, analyze it, and develop mathematical models to quantify the time required to meet each month's sales demand.

The first analytics problem is to identify the number of demands a given number of CSOs can clear without working overtime. This would allow the sales department to translate their forecasted demand and number of employees into the overtime hours the department has to take. Alternatively, if they cannot fulfill all the demands, management wants to know their minimum demand to clear if they still wish to meet their KPI. The second analytics problem is identifying the optimal number of case types based on the difficulty level each CSO should receive to ensure CSOs are optimally utilized, and KPIs are met.

In this paper, we aimed to develop a mathematical model that allows the management team to perform macro-level planning to maintain or improve their service levels while optimizing manpower resources for sale flat. This paper will mainly utilize Microsoft Excel as our analytics tool to build our model and SPSS modeler when advanced analytics tools are needed.

## 4. Data exploration and analysis

The company has given the authors 61,410 records of sale applications for the past three years. This dataset only includes sale applications that were completed and fully processed. It doesn't contain records that were canceled halfway through the sale application. Some records are probably a human error and only make up 0.011% of the total records; they were also removed. After removing these records, we were left with 61,313 records. The authors have used two main datasets in this paper. The historical "CSO numbers" and "Number of Sale Applications Received" were used. There are more than ninety data fields in the application data, but most of the data columns were blank. For this paper, the authors mainly focused on the time duration between different stages or phases of the sale application, and other information, such as the applicant's financial status, might be useful to determine the difficulty level of the cases.

The number of records provided by the company roughly coincides with the numbers in the "Number of Sale Applications Received" dataset. Since it only provided us with completed cases, sales applicants canceling their applications can explain the difference in the months. During the data preparation stage, the authors created four new columns for calculating and rounding up the duration between "application to registration," called T1; "registration to approval," called T2; "approval to completion," called T3, and finally "registration to completion," called **T4**. The authors also realized that the sum of T2 and T3 may not equal T4 as we may have some rounding error due to week.

T1 = duration between the application to registration
T2 = duration between registration to approval
T3 = duration between the approval to completion
T4 = duration between registration to completion

The following summary statistics for T1, T2, T3 and T4 have been generated.

Table 1. Summary statistics for various durations

| **Original Data is Rounded-up in Weeks** | | | | |
|---|---|---|---|---|
| | ***T1*** | ***T2*** | ***T3*** | ***T4*** |
| Mean | 2.29 | 3.46 | 5.81 | 8.53 |
| Median | 2.00 | 3.00 | 6.00 | 8.00 |
| Mode | 1.00 | 2.00 | 6.00 | 8.00 |
| Standard Deviation | 1.85 | 1.89 | 2.16 | 1.95 |
| Range | 76.00 | 55.00 | 77.00 | 78.00 |
| Minimum | 0 | 1.00 | 0 | 2.00 |
| Maximum | 76.00 | 56.00 | 77.00 | 80.00 |

Table 1 shows the summary descriptive statistics for all the durations, such as T1, T2, T3, and T4, rounded up to the nearest week from the date given. It takes an average of 2.29 weeks for an applicant to submit the documents needed for a sale application (T1). After registration, the sale process will take an average of 3.46 weeks to get approval from the company. The duration taken from registration to approval is denoted as T2. After approval, the application takes an average of 5.81 weeks from approval to completion T3. The final measurement is the total duration taken, T4, the time taken from registration to completion, and an average of 8.53 weeks is needed for an application to be completed since registration.

Next, the authors will analyse each duration in detail. The T2, T3, and T4 distributions are based on the number of weeks taken. The frequency column shows the total number of applications within the weeks. Cumulative relative frequency (CumRF) is the sum of relative frequencies that are less than or equal to the given weeks in the first columns. It is shown as a percentage of the overall application number. The tables and histogram for T2, T3, and T4 will be shown.

Table 2. Distribution of registration to approval duration

| Registration to Approval (T2) | | |
|---|---|---|
| ***Weeks*** | ***Frequency*** | ***CumRF*** |
| 1 | 5,586 | 9.11% |
| 2 | 15,512 | 34.41% |
| 3 | 14,802 | 58.55% |
| 4 | 10,903 | 76.33% |
| 5 | 7,249 | 88.16% |
| 6 | 3,999 | 94.68% |
| 7-10 | 2,907 | 99.42% |
| >10 | 355 | 100.00% |

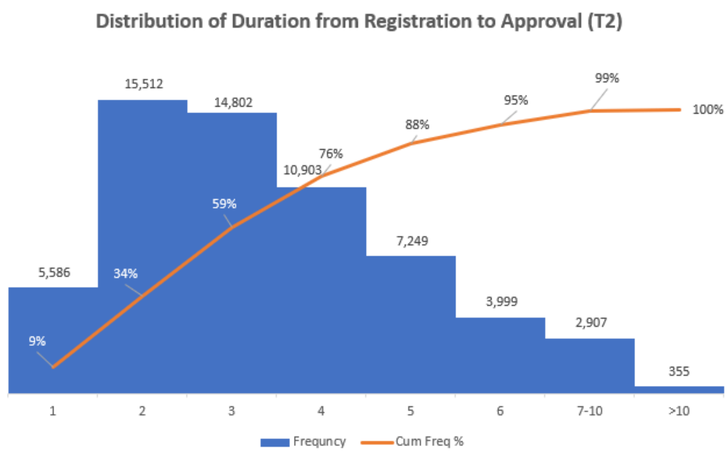


Figure 2. Histogram of duration from registration to approval (T2)

Table 2 and Figure 2 show that 59% of the applications are approved within three weeks of registration. This could imply that the company is efficient at processing the first batch of registration documents and approves the applications quickly, endorsing them once uploaded to the website. More than 75% of the applications are approved within the first four weeks after registration. In addition, 88% of the applications were approved within five weeks, meaning less than 12% were approved in more than five weeks.

Table 3. distribution of approval to completion duration (T3)

| Approval to Completion (T3) | | |
|---|---|---|
| ***Weeks*** | ***Frequency*** | ***CumRF*** |
| 0 | 25 | 0.04% |
| 1 | 309 | 0.54% |
| 2 | 1,838 | 3.54% |
| 3 | 4,604 | 11.05% |
| 4 | 7,975 | 24.06% |
| 5 | 11,449 | 42.73% |
| 6 | 14,375 | 66.18% |
| 7 | 13,371 | 87.98% |
| 8 | 4,291 | 94.98% |
| 9 | 1,049 | 96.69% |
| >12 | 2,027 | 100.00% |

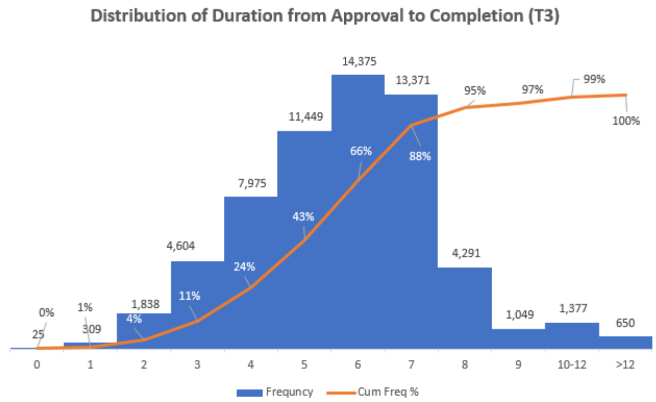


Figure 3. Histogram of duration from approval to completion (T3)

Based on Table 3 and Figure 3, the graph showed a negatively skewed graph, with the mean hovering at the 6-week mark. This could imply that the approval-to-completion process is tedious, and CSOs must spend a long time checking through the documents to complete it. It might be a bottleneck in the business process. A further analysis of the business process will reveal more insights on the time required from approval to completion.

Table 4. Distribution of registration to completion duration (T4)

| Registration to Completion (T4) | | |
|---|---|---|
| ***Weeks*** | ***Frequency*** | ***CumRF*** |
| 2 | 1 | 0.00% |
| 3 | 8 | 0.01% |
| 4 | 22 | 0.05% |
| 5 | 138 | 0.28% |
| 6 | 594 | 1.24% |
| 7 | 1,041 | 2.94% |
| 8 | 49,268 | 83.30% |
| 9 | 2,682 | 87.67% |
| > 10 | 7,559 | 100.00% |

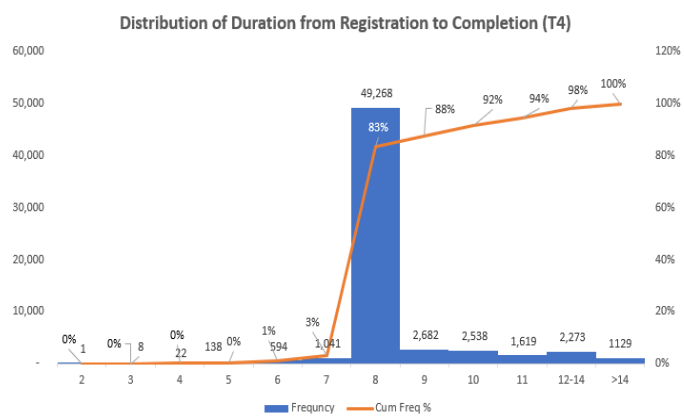


Figure 4. Histogram of duration from registration to completion (T4)

Figure 4 shows a graph that is disproportionately registration to completion time (T4). According to Table 4, 83.3% of the cases are completed within the 8$^{th}$ week. Alternatively, less than 2.94% of the cases are solved in less than seven weeks, while 16.70% of the other cases take more than eight weeks to complete.

When comparing the data about T2, T3, and T4, it seems like CSO rushed through from registration to approval (T2) to ensure they have enough time to process the applications from approval to completion. However, the completion date was found to be set automatically by the system once the registration date had been keyed into the system. Therefore, the long duration in T3 might be due to the CSO already completing the necessary paperwork but not being able to complete the case until the appointment date that has already been set.

The average number of CSOs for the past three years ranges from 33 to 44. The minimum number of CSOs is 31, while the maximum is 44. The company reported that the number of CSOs changes due to internal transfers between departments and unavoidable staff resignations. The company believed there was a steady growth in demand, and thus, the number of CSOs remained stable over the years while sales applications fluctuated drastically over time. The highest demand is 3069, while the minimum monthly demand is only 770.  This is due to the seasonality and the demand for the popular locations compared to the less mature estates. There are certain months in the year; for example, the number of sale applications is low during the December holiday season as most applicants will be away for a family holiday with the children. Most applicants would prefer mature estates as the areas have schools, shopping centers, and more amenities. Thus, yielding a higher sale price than the new or unmatured estate. There may be a lack of facilities in the neighborhood, which is quite far away from the city center and isolated places. However, the company might give more discounts or incentives to encourage more applications in less mature estates to ensure enough demand for the sale process.

Figure 5 shows the number of sale applications versus the number of CSOs over the past three years. Although the number of sale applications fluctuated quite drastically over the period, the number of CSOs also changed over the years. This means that staff work overtime during peak demand to fulfill the service level agreement.

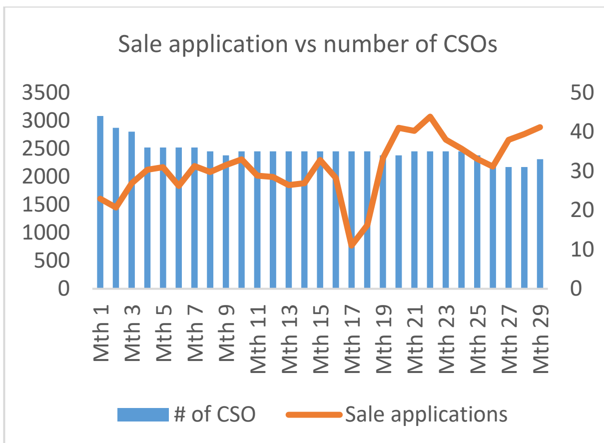


Figure 5. Sale applications vs number of CSO

Table 5. CSOs number over three years

| | *Average* | *Min* | *Max* |
|---|---|---|---|
| Mth 1-12 | 37 | 34 | 44 |
| Mth 13-24 | 35 | 34 | 35 |
| Mth 25- 29 | 33 | 31 | 37 |

Table 5 shows the number of CSOs in the company over the past two and a half years (i.e. 29 months). In the first year, the average number of CSOs was the highest, 37, with a minimum of 34 and a maximum of 44. The management has identified that in the first year, most of the time, staff didn't need to work overtime. Since then, the number of staff has reduced to an average of 35 and 33, with a minimum of 31 at the month of 27. With the increasing demand but a lower number of CSOs, staff were required to work overtime to complete the same number or higher demand.

## 5. Models Development

After the initial data exploration, the authors aim to build a mathematical model to determine the time required to complete all the applications or cases. The following information is needed for the mathematical model.

- Number of T2 Cases for Each Month
- Number of T3 Cases for Each Month
- Number of Working Days Per Month
- Number of CSOs per Month
- Utilisation rate
- Estimated Service Time
- Case Difficulty Ratio

Based on the authors' experience and with the consultation with the management, it is noted that not all the applications need the same amount of time. Thus, rather than using an average processing time for all cases, let us define three difficulty levels (C1, C2 and C3) for all the cases. C1 represents most cases, which are simple and straightforward, and CSO spends the least amount of time processing them. $C_2$ represents cases that require additional time to process due to certain uniqueness in the case, and we call it a Moderate difficulty level. Finally, C3 represents the most difficult cases that the CSO has to spend more time to process. Each month's total number of T2 and T3 cases is multiplied by the distribution of case difficulty level and time required to complete each case. This would provide us with the total time required to clear both T2 and T3 cases for each month. Summing together both values provides us with the total hours required to complete all the cases in the month.

The case difficulty ratio will be first based on historical time spent and overworking before being cross-referenced with the actual on-ground scenario. Using the historical data, at the 50th percentile, the phase T3 case takes 1.67 more time to complete than the T2 phase. Therefore, for service time per case, we will use the T2 duration as the base and multiply this duration by 1.67 to achieve the duration of T3. This simplifies the service time calculation and allows for future changes as it is one of the input parameters.

Time Require for T2 = T2 demand × Case Difficulty Distribution × Service duration of each case difficulty

Time Require for T3 = T3 demand × Case Difficulty Distribution × Service duration of each case difficulty

Total Time required for the month = Time Require for T2 + Time Require for T3

The daily working hours for the staff is eight hours. The model assumes 22 working days in a month as they need to work 5.5 days, including a half day on Saturday. Staff are not 100% efficient; they only spend a proportion of their time servicing the customer; at other times, they are also needed to support other business operations like preparing the quote and liaising with various vendors. Staff utilization rate denotes the percentage of time an employee will spend on the sale cases. Based on the data analysis and the management's advice, we set the utilization rate at 60% as it provides a certain level of leeway from the actual ground situation. We can run a sensitivity analysis by varying the utilization rate between 60% to 80% and determine the impact on the number of cases that can be cleared. In the base model, we use the 60% utilisation because underestimating the CSO's ability to clear demand is better than overestimating and overworking them.

To determine if the CSO has overworked, we divide the number of hours needed by the number of hours available for each month. According to the company, CSO didn't constantly overwork in the first year. Therefore, using that time frame as the base for not overworking is safe. Using Excel Solver, we can derive the case distribution, providing us with the average overworked value of 100%. $W_1$, $W_2$, and W3 are the weights for C1, C2, and C3 case difficulties level, respectively. The formula for the solver objective takes the summation of the ratio of time needed divided by the time available for each month for the months of i=1 to N, and divides it by N, which is the total number of months in this duration. Furthermore, the objective is set to value of 100%, as it would indicate the CSO is overworked in some months while underworked in other months (Table 6).

$$Objective\ (O) = \frac{\sum_{i=1}^{i=N} \frac{Ratio\ of\ time\ needed_i}{Time\ Available_i}}{N} \qquad (1)$$

Table 6. Solver parameters for finding case distribution

| **Solver for Case Distribution** | |
|---|---|
| **Set Objective** | Set the value of O = 100% |
| **By Changing Variables** | $W_1$, $W_2$, $W_3$ (Distribution of Cases) |
| **Constraint 1** | $W_1 + W_2 + W_3 = 100\%$ |
| **Constraints 2 to 5** | $0\% <= W_1, W_2, W_3 <= 100\%$<br>$50\% <= W_1 <= 70\%$,<br>$10\% <= W_2 <= 30\%$,<br>$5\% <= W_3 <= 25\%$, |

The company doesn't have a clear answer regarding the distribution of case difficulty and the time taken for each of them. However, they gave us a few possible scenarios to help us identify the distribution of case difficulty.

Let $D_{a,b}$ be the duration for Case difficulty level a at stage b.

Table 7. Final solver output for optimal duration and difficulty distribution

| **Case Difficulty** | $D_{a,2}$ | $D_{a,3}$ | **Difficulty Distribution** |
|---|---|---|---|
| C1 | 0.50 | 0.75 | 61% |
| C2 | 0.91 | 1.37 | 26% |
| C3 | 1.41 | 2.11 | 13% |

We also used Solver to determine the case duration. After running the Solver, the following results given in Table 7. After finalising on the output from solver, we can create the model which tells the user if the department can clear the forecasted demand with their current number of CSOs. Like before, we derive the total number of working hours available and the number of hours needed to clear the demand to see if the department is able to meet the demand. If they cannot clear the demand within the available working hours, the model would provide the user with the total number of overtime hours the department has to do to meet demand.

Model 1 Resource Planning for a one-month time window (Model 1)
The manpower model is used to derive the amount of demand the sales department can clear within the available working hours or the number of overtime hours the sales department has to take to clear the demand in a month. This model assumes that CSOs need to clear all T2 cases before spending their remaining time to clear T3 cases. This ensures that when the demand for T2 turns into T3 in the following month, they can start on the processes for the T3 phase and not be working on the T2 processes. This method also tries to replicate how the company calculates its service level. Currently, the service level of the month is determined by calculating the number of cases completed within their eight-week time limit. To replicate this, the model will view service level as a percentage of T3 demand the sales team is able to or has to clear. To ensure calculations aren't complicated, we ensure all T2 demand is cleared before moving on to T3 demand. Additionally, if there are leftover T3 cases from the previous month, those cases would take precedence over both T2 and T3 demand when using the time available. The Table 8. below is a sample of our model 1.

Table 8. Output1 from model 1

| **Manpower Planning Model 1** | |
|---|---|
| % of T3 Demand to be Cleared | **80%** |
| T2 Demand | **2500** |
| T3 Demand | **2500** |
| No of CSO | **35** |
| % of T2 being cleared | 100.00% |
| % of T3 able to clear | 69.32% |
| Too much Work? | Y |
| Demand To be Cleared | 80.00% |
| Total Hours Needed to meet 80% of T3 | 3986.95 |
| Need to OT? | Y |
| OT hours needed | 290.95 |
| OT Per CSO | 8.31 |
| Man Days needed to clear OT | 1.73 |
| Hours Leftover for Next month | 543.68 |
| Derive # of extra CSO if No OT | 3 |

Table 8 shows the model for a single month. Users can adjust the values in the input cells, such as T2 demand, T3 demand, and CSOs' number and percentage of T3 demands to be cleared, to derive the total working hours they have to overwork to meet demand. When T2 and T3 demand are placed into the parameters, the model would inform the user if they can clear the entire demand with the available working hours.

Table 8 above, when both T2 and T3 demands are set at 2,500, the department of 35 CSOs can only clear 69.32% of T3 demand. CSOs need to work OT, and the total OT hours needed to clear 80% of T3 is 290.9, it is translated to 8.31 per CSO. Therefore, each CSO must work an additional 8.31 hours of overtime to meet 80% of T3 and 100% of T2 demand. 543.68 hours' worth of T3 cases would be left to exceed it's 8-week time limit and be rolled over to the next month. Alternatively, the company should hire three additional CSOs for the month if they do not wish to have any CSO working overtime.

Model 1 starts by ensuring that all T2 demands are cleared. Any remaining time can then be spent on T3 demand. With the remaining time, the model derives the amount of T3 demand the department can clear. If the available time cannot hit a certain percentage of T3's demand, which is 80% for this case, then it would state the additional hours the department must take to meet demand. If the available time can meet the required demand of 80%, then any left-over cases would be left for the next month.

Table 9. Output2 from model 1

| **Manpower Planning Model 1** | |
|---|---|
| % of T3 Demand to be Cleared | **80%** |
| T2 Demand | **1500** |
| T3 Demand | **1500** |
| No of CSO | **35** |
| Total time available per month | 3696.00 |
| Total time required to clear T2 | 1087.59 |
| Total time required to clear T3 | 1631.39 |
| Total time needed (T2+T3) | 2718.98 |
| % of T2 being cleared | 100.00% |
| % of T3 able to clear | 100.00% |
| Too much Work? | N |
| % of T2 being cleared | 100.00% |
| % of T3 being cleared | 100.00% |
| Total demand cleared | 3000 |
| % of demand cleared (T2+T3) | 100.00% |
| Extra time needed to clear 80% | 0.00 |
| Number of man days required per CRM | 0.00 |
| Number of man weeks required per CRM | 0.00 |
| Hours Left Over for Next Month | 0.00 |

Table 9 shows another scenario where the demand for T2 and T3 is set to 1500, respectively. The sales department still has 35 CSOs. Based on the 8-hour working week, 60% utilization rate, and 22 days in a month, the total number of hours available is 3696. It can clear 100% of T2 and T3 demand. The total number of demand cleared is 3000. No CSOs need to work OT, and the number of hours left over for the next month is Zero.

Model 2 Resource Planning for a two-months time window (Model 2)

This second model moves further back to view the case in two months. This reduces the complexity of needing to clear T2 or T3 cases first but rather views the case in its entirety of eight weeks. With this model, we can accurately derive the number of cases the department can clear within the two-month period without the need to break it down into two phases.

Model 2 used the same input as model 1, but instead of 22 working days, the working days are set to 44. The user inputs the forecasted amount of demand with the number of CSOs working to derive the percentage of cases the department can clear within the available working hours and the amount of overtime the department has to work if it wishes to meet 80% of the demand.

Table 10. Output1 from model 2

| Manpower Planning Model 2 | |
|---|---|
| Total number of working days | **44** |
| Total demand | **5000** |
| No of CSO | **35** |
| Total time required to clear demands | 9063.28 |
| Total time available in 8 weeks | 7392.00 |
| Too much Work? | Y |
| Total cases cleared within 8 weeks | 4078 |
| % of cases cleared within 8 weeks | 81.56% |
| Need to OT? | Y |
| OT hours needed to clear 100% | 1671.28 |
| Man days needed to clear OT | 9.95 |
| # of cases carried forward to next month | 922 |

In Table 10 when we set the demand for both months to be 5000, the department of 35 CSOs can only have 81.56% of the cases. CSOs need to work OT, and the total OT hours needed for 100% of the demand is 1671.28, equivalent to 9.95 man-days per CSO. The total number of cases carried forward to next month will be 922.

## 6. Computational Results

A simple model is created for sensitivity analysis to derive the number of CSOs required to meet a certain demand. Figure 6 below shows that the number of CSOs required increases as demand increases. Using this, we can derive that when demand increases by 58.72, the number of CSOs required increases by 1. Therefore, we can conclude that each CSO can take a maximum of 2.67 cases daily. According to this model, every CSO will work on an average of 29 to 58 cases per month or between 1.32 to 2.67 cases per day. We also use the TRENDLINE to get the line y = 0.6952 + 0.01754x equation, where y is the number of CSOs required, and x is the number of sale applications. Using this formula, we can estimate the number of CSO required to meet the SLA.

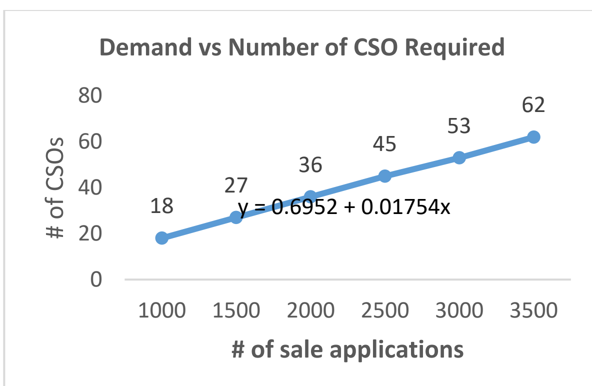


Figure 6. Graphical Representation of several demands versus the number of CSOs required.

Currently, the model uses inputs that were derived from the available data and the company's feedback. However, these inputs can be adjusted after the management did more in-depth research into how long a CSO takes to clear each type of case. We have used four months of new operational data to validate our model. After model completion, the company provided an extra four months for a number of cases and several cases completed within their 8-week time limit. The duration spans over four months, and the KPIs the sales team meets each month are shown. Applying the demand values to our model, we found the mean absolute percentage error (MAPE) for the 1-month resource planning model to be 2.29%.

$$\text{MAPE} = (\text{Actual} - \text{Predicted})/(\text{Actual}) * 100\%$$

Alternatively, the mean absolute difference increases to 3.29% when we apply the same demand to the 2-month resource planning model. Based on the model performance, we have recommended that the company to deploy Model 1, which is a one-month time window model for manpower planning.

## 7. Conclusion

In this paper, the authors have discussed macro-level manpower planning for the sale application process via the online portal in one of the service companies in Asia. The authors first performed the exploratory data analysis and created four additional columns, namely T1, T2, T3, and T4, to record the durations of each application to the nearest week. The service time at each phase is further analyzed and used as input in the mathematical model. The sale applications are further categorized into three difficulty levels, C1, C2, and C3, and the respective service time for T2 and T3 are derived.

The authors developed two mathematical models: Model 1 is based on one month time frame and model 2 is based on two-months duration. The aims of the two mathematical models are similar. We wanted to identify the total number of cases completed given the number of CSOs and the additional hours the sales department has to work overtime to meet all or, if not, a certain amount of demand. The generated model tries to maximise its dependency on the data provided by the company. Although resource utilisation is used to reflect the productivity level of the employees, it can also be adjusted when other factors are considered. The utilisation rate can be adjusted after the company adjusts the CSO workload, such as reducing the time they need to handle emails, calls, and appeals.

The macro-level manpower planning model was further validated using the new four-month data, and the one-month model has been recommended as it yields better results and is easy to implement. It that we have developed has a mean absolute error rate of less than 5% , which is very favorable. The model that we developed has given the management a way to compute the time required systematically and has been deployed to use it in their planning. It can be further expanded to allow for other inputs such as the cost of current workers working overtime, or cost of hiring new employees to meet demand. The model should ultimately serve as a guide for the sales application team as it does not fully encompass the real situations on the ground level. Therefore, users should only refer to the model for determining a rough gauge on the required number of CSO for a certain amount of demand. Expanding the model can help the sales application team better understand the possible range of solutions for tackling their ever-changing environment.

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