Investigation of the Distribution of the Daytime Employed Population of Yangon, Myanmar, with and without the Impact of Work from Home

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1. INTRODUCTION

Yangon, having a population of over 5.2 million people and density of 5,500 persons/km², is the most densely populated city in Myanmar. Being the center for commerce or the highly industrialized city, at least 60% of the total population are employed in the different fields of zones. Due to this fact, the day-to-day travels of millions of people result, among other things, in traffic jams, lateness for work, and easy transmission of diseases in crowded areas. In particular, Yangon has been a severe victim of the local transmission of COVID-19, partially due to the ease of contact between people. Thus, in order to reduce crowdedness and maintain the sustainability of Yangon, the pattern of the daytime distribution of the general public has to be thoroughly analyzed and improved, with working from home being an option for workers.

Yangon has been in the status of work from home (WFH) since March of 2020. At the beginning, the entire city was transformed into “a vacant city,” with only a countable number of vehicles being seen on the streets. There were no traffic jams and the flow of vehicles was at its smoothest, free of hindrance. This situation was perfectly encapsulated by a local photographer from Frontier Myanmar, who observed, “Every street that I walked along was quiet and clean. It was a far cry from the crowded and polluted metropolis that I usually live in” (Lat 2020). Although the city had a sudden release from crowdedness for a while, people are now starting to come out into the streets and minor crowds can be seen all around township centers. This crowdedness is still comparatively smaller than before and improvement is deemed to have been made on the daytime distribution. Upon WFH, there were mixed opinions from the general public. Some people enjoyed working from home while others preferred the office environment shared with their colleagues. It is certainly hard to decide whether there is a future for this practice. From an affirmative point of view, WFH has a huge impact on discouraging crowdedness and commutations of millions on the streets, up until now. But in the long run, it must be optimized to find a balance between people working from home and working from their office. Therefore, for the sake of sustainable employed population distribution, in this research, a theoretical network model was built and the extent of impact of work from home on that network was analyzed.

General census data are available of the city of Yangon (Bhaduri 2008). However, these data alone of where people live is not able to forecast how dense the area can be during the daytime. Also, these data can show variance based on different days and times, and as such, a specific direction is needed to pin-point where it should be concentrated in building a new distribution model.

A general calculation of the daytime population of a township is suggested by adding the total residing population and total workers in the township minus the workers living in the area (US Census Bureau 2020). This method is
were identified for this distribution model, which had a ma-

According to the Yangon Regional Government, as cited by (Aung and Myint 2017), central areas of the city, such as business areas and tourist areas, tend to have higher agglomerations than the other areas during the daytime. In suburbs, the agglomerations are centered in the industrial zones. Therefore, when tackling data on the daytime population, township centers and industrial zones are areas to be focused upon. This generally gives data to forecast the trend of population agglom-
erations, from which future city implementations can be planned accordingly. Apart from being helpful in exacerbating townships’ developments, with daytime populations, it is possible to determine which areas have higher exposure to particular disasters and where evacuations would be ur-
gently needed. Hence, having daytime population data is imperative since it is beneficial for disaster recovery and ur-
ban re-vitality of the studied areas (Geoff 2018). Due to the above reasons, in this research, urban employment cores were identified for this distribution model, which had a ma-

2.2 City’s connectivity

In-land transportation, airlines, and water transportation are all available in Yangon. To maintain its workability, smoothness is to be ensured in both local and in-out trans-
port of passengers and cargos through the different modes of transportation. Currently, there are 102 public bus lines that are connected to the 33 townships of the city (Yangon Bus Directory 2019), and the township with the most bus line intersections is considered to have higher in-land bus connectivity. The existing central railway station in Mingalartaungnyunt township and international airport and Aungmingalar bus station in Mingalardon township create thousands of jobs for taxi drivers, restaurants, and stores by being the three main transport stations for passengers and cargo in Yangon. Townships like Seikkan not only have ferry connections to the neighboring islands or townships but also have several wharves for cargo, creating thousands of jobs. According to statistics, until 2019, Yangon Region had 41 wharves with imports and exports of over 1.1 million TEU every year (Aye 2019). The aforementioned townships were all considered to have a higher network distribution for employment in this research.

2.3 Job-creating areas

On a daily basis, people tend to travel more to the areas where jobs are created. Collective high-rise buildings and shopping centers in one township is a sign of high popula-
tion density in that township, for both daytime and night-
time. According to the statistics provided by CQHP (2020), most high-rise condominiums in Yangon are located near downtown centers or financial districts, accompanied by offices, underground parking, and major shopping centers, and thus create job opportunities for the general public. In addition, government offices are places for frequent visita-
tion, because of the fact that the general public has to go to these offices for various reasons, be it tax returns or pay-
ing municipal bills, etc. Meanwhile, nearly 4.5% of the to-
tal employed population within Yangon is composed of gov-
ernment employees working a 9–5 job every weekday (Min-
istry of Immigration and Population Myanmar 2015). Such a combination of both of the above factors creates crowded-
ness in proximity to government offices. On the other hand,
banks are catalysts for the majority of modern businesses. With at least 186 per 1000 adults of the total Myanmar population having one or more bank accounts (Trading Economics 2017), banks in Myanmar require high serviceability to adequately provide services to their customers. According to the Central Bank of Myanmar, there are 41 bank companies with 491 branches in summation, creating thousands of jobs for employment. Moreover, areas where agglomerations are formed include local markets, attractions, and restaurants. Thus, through preparation of a database on all of these areas, the precise daytime employment distribution is able to be calculated in this study.

3. METHODOLOGY AND RESULTS

With the ultimate purpose of adjusting the concentration of the employed population during the daytime distribution in Yangon, an implementation process diagram for the network distribution model was first created (Figure 1).

3.1 Identifying biases

Before building the network distribution model, distribution biases that could influence the composition of the distributions were identified. For this, an online survey was conducted. The survey was able to collect 421 samples from people who are working and living in Yangon. With these samples, we were able to identify that 55% of the correspondents agreed with the statement that companies should continue to provide a work from home option to their employees in the future (Figure 2). A minimum value of 50% (margin of error + or – 5%) was considered as Bias 1 in the network distribution model for the scenario that 50% of the employed population will remain within their own townships in the daytime, whereas others will continue to distribute around in Yangon.

A database for urban employment, which was defined earlier, was also built and analyzed. This database included employment at industrial zones; air, bus, and water connectivity; locations of government offices, restaurants, hospitals, shopping malls, and local markets; and major companies and bank branches per township. These data were thoroughly calculated for each township and the results were separated into two biases, Bias 2 and Bias 3.

Bias 2 resulted from the employment data of industrial zones, as shown in Figure 3. Eleven of the 33 townships in Yangon have industrial zones. A total of nearly five thousand industrial factories with over 1 million workers were assessed. Among these 11 townships, South Dagon and Hlaing Thar Yar were the most-employed townships, with each having over three thousand daytime workers, whereas Dagon Myothit (North) and Insein were the two lowest-employed townships (Figure 3). Two data were compared: one was the total number of employees residing in certain townships and the other was industrial employees working in industrial zones. This method is fairly similar to the one suggested by US Census Bureau (2020), with the resulting data instead generated into percentages. The comparison of these two data gave rise to employment percentage, meaning the percentage of employees who live and work within the same township while others have to travel to other townships for employment during the daytime. This percentage was separated into two ranks, namely high (above 50%) and low (below 50%). Those townships having higher (Dagon Myothit (Seikkan), Dagon Myothit (South), and Hlaing Thar Yar) retain a value of 75% of its total employed population within the township while only 25% average retention is held by those having lower ranks.

Unlike industrial zones, job-creating areas are spread everywhere within Yangon. No previous data were available for all the employment situations of each and every job center. Therefore, focuses were applied on urban employment cores, such as public centers, general offices, and connectivity of townships, to predict the possible distribution of these employed populations (Garb et al. 2007; Ma et al. 2017; Bhaduri 2008). Public centers where people visit frequently and thus create jobs included 491 bank branches, 6,977 restaurants, 35 attraction places, 72 hospitals/health care centers, 171 local markets, and 90 shopping centers, all of which were analyzed in this study. Additionally, 111 government offices, 214 high-rise office buildings, and 241 large capacity companies with more than 250 employees were also analyzed. Eleven industrial zones were reconsidered again here due to the fact that in Bias 2, it was only considered for employees not leaving the township and left the chance of employees entering from other townships to the industrial zones. On the other hand, Yangon is a

\[ \text{FIGURE 1. Implementation process diagram.} \]

\[ \text{FIGURE 2. Bias 1: work from home (agree or oppose) survey.} \]

\[ \text{FIGURE 3. Bias 2: industrial employment analysis.} \]
city where many low-income and medium-income workers have to rely upon public transportation when traveling for work. Therefore, townships having higher bus transits (102 bus lines) were considered, as well as townships having good air (one airport) and water (53 berths) connectivity, where many workers are in service for cargo and passenger carriage. All of these data were collected for 33 townships from Ministry of Immigration and Population Myanmar (2015), Yangon Bus Directory (2019), and Myanmar Marketing Research and Development (2020), along with many on-site survey data (Figure 4).

Bias 3 was identified by averaging the data described in Figure 4 and the average data were then categorized into three ranges: low, medium, and high. High represented 75% accepting rates of the employed population distributed from other townships to the current one. Meanwhile, medium and low each represented 50% and 25%, respectively, of accepting rates for the employed population into the townships.

3.2 Model for network distribution

The model for network distribution was created with the help of the Gephi software. Nodes were created for the 33 townships of Yangon, each township representing one node, and these nodes were directed with edges to the neighboring nodes so as to form a network for the employment distribution. With Gephi, it was able to identify a diameter of seven, meaning that after the seventh time of distribution, the partially employed population of the two farthest nodes in the network had reached from one node to the other for the first time. Nodes were coded with colors (red being the least and yellow being the most) according to the employed population in each township, and their sizes were adjusted according to the degree of the nodes. This network model is shown in Figure 5.

For achieving the ordinary daytime employed population, it was assumed that there was a decision tree of three nodes, namely X, Y, and Z, where node X was the main node or the distributor, and Y and Z were the sub-nodes or the receiver. In order to identify the distributed employed population from node X to node Y, Equation 1 was created utilizing Biases 2 and 3.

\[ y_1 = f(x) = x \times B_2 \times \frac{B_{3y}}{\sum B_3} \]  

(1)

where \( x \) and \( y_1 \) are the total employed population from node X and distributed employed population to node Y, and B2 and B3 represent Biases 2 and 3, respectively. Bias 2 is either 25% or 75% for townships having industrial zones and 100% for those that don’t. Bias 3 is 25%, 50%, or 75% depending on the respective township. This equation was applied to all 33 townships. After the first-time distribution was successful, the distributed values for the same sub-nodes were added together to be the total employed population of the node (Equation 2).

\[ \Sigma y = y_1 + y_2 + \ldots + y_n \]  

(2)

where, \( \Sigma y \) is the sum of all distributed employed populations to node Y during the first-time distribution. Starting from the second time distribution, only Bias 3 was involved in further calculations, since the industrial workers had been sieved out in first-time distribution. Equation 3 can thus be written as:

\[ y_1 = f(x) = x \times \frac{B_{3y}}{\sum B_3} \]  

(3)

Similarly, to find an improved daytime employed population (IDEP), Bias 1, 50% of the employed population, and Equation 1 were multiplied, as shown in Equation 4.

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Further processes of distributions were carried out using Equations 2 and 3. Both the ordinary daytime employed population (ODEP) and improved daytime employed population (IDEP) data were calculated for 10 times of distributions. The sieved-out data were added back again and were graphed as shown in Figures 6 and 7.

3.3 Comparison between ODEP and IDEP

The average employed population per each distribution time from the ordinary daytime employed population (ODEP) data was compared with the latest trip generation and attraction survey data prepared for YUTRA by JICA (2014). The data from YUTRA reveal the number of trips the general population made with the purpose of working during the daytime, the comparison of which is illustrated in Figure 8, wherein positive values indicated that the township gained the employed population for the network distribution model or the township had more attraction trips than the generation in YUTRA data.

From this comparison between the two models of work-related distribution across townships, we can see a significant correlation (CC = 0.57 > 0.5) in between. It can be said that even if the two surveys were taken six years apart, the pattern of distribution remained largely the same. The pattern of flow of people to each township in this model was similar to those who had traveled in 2014, despite being different in quantities. This proved that the network distribution created in this study is equated to the pattern of real distribution of the employed population in Yangon.

Correspondingly, from the survey of 421 samples, respondents’ addresses of the workplaces were found to be located within 14 townships. Within these townships, 12 have higher urban employment cores (using the ranges of Bias 3), whereas only six were within the medium range. In terms of neighboring linkage, half of the townships have high connectivity. By calculating the samples’ data, it was found that 78.86% of workplace addresses fell within the boundary of high urban employment cores and 57.9% of workplace addresses were from the townships having high connectivity. This showed that the majority of the respondents were working in the townships where there are high rates of urban employment cores and good connectivity. To prove if this hypothesis is true for this network distribution model, it was determined whether there was a correlation between the connectivity of a township, agglomerations at the urban employment cores, and employment distribution data of both IDEP and ODEP (Table 1).

In the case of ODEP, the correlation between the connectivity and distribution was (CC = 0.53 > 0.5), and that of urban employment cores and distribution was (CC = 0.63 > 0.5). Both cases showed that the employment distribution tended to be greater with a higher connectivity of the township and presence of higher urban job-creating areas in the townships. IDEP, conversely, had a slightly lower correlation than the previous results, (CC = 0.5) and (CC = 0.62 > 0.5). However, the correlations existed and they were still moderately impacting the distribution. Therefore, it can be said that connectivity of townships and presence of urban employment cores have more or less an impact on the employment distribution.

Again, the data of both ODEP and IDEP were calculated for the increment or decrement ratio using Equation 5.

\[
\text{Increment ratio} = \left( \frac{\text{DEP}}{\text{NEP}} - 1 \right)
\]

where DEP represents the daytime employed population and NEP represents the nighttime employed population (original census employed population). This is carried out in order to understand how many populations have improved in one township during the daytime because of the employed distribution. The positive signs in the results indicated an increment percent and another indicated a decrement percent in the employed population after the

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<th>TABLE 1. Correlations of ODEP and IDEP distributions to connectivity and urban employment areas (UEA).</th>
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distribution. Afterwards, on behalf of the 33 townships, the increment and decrement ratio of both ODEP and IDEP for Ahlone and Dagon Myothit (South) townships, where the former results in all increment percentage and the latter in a decrement percentage, were compared (Figure 9).

The results of the increment/decrement ratio of IDEP for both Ahlone and Dagon Myothit (South) appeared to be only half in values compared with those of ODEP. This is because WFH retained nearly half of the distributed population within the townships, the reasons for which may be that work from home lowered the amount of employment distribution. The distributed population data of both IDEP and ODEP were subsequently calculated for standard deviation (SD) and coefficient of variation (CV) to see the variation of changes for each township (Table 2). Two coefficients of variation were then tested for their p value to see whether the CV of IDEP was lower than that of ODEP. It was run with a t-test: paired two samples for means and the confidence level was considered as 95%.

Eighteen townships showed a decline in the mean population from ODEP to IDEP, while 15 showed the opposite. It was clear that the SD values from ODEP were much larger than those of IDEP; e.g., in Bahan, the SD of ODEP between each-time distribution was 16,209 people, which was then decreased to 7,338 people in IDEP. The other 32 townships showed similar results. Correspondingly, it could be seen that nearly all of the townships showed a certain decrease in CV between IDEP and ODEP, especially in two townships, Dala (from 56% to 10%) and Seikgyikanauunto (from 63% to 23%), where both showed a decrement in CV above 40%. Conversely, one township (Kamaryut) showed an increment in CV by 4%. Regardless, it can be said that the CV of the total employees during the ten times distribution of ODEP had almost three times more variation, with the highest occurring in Seikgyikanauunto (63%), whereas that of IDEP was only 23%. Then, the overall CV of IDEP (M = 7.96, SD = 13.59, n = 32) was hypothesized to be lower than the CV of ODEP (M = 15.12, SD = 6.52, n = 32) and the difference was significant with a t (31) = 2.039 and p = 0.00015 (one-tail). This shows that IDEP maintains its consistency with only a little-by-little employed distribution, unlike ODEP with its higher variation and thus, lesser conjunction during the distribution could be expected.

On the other hand, the amount of decrement percentage from ODEP to IDEP was carried out to test whether the percentile ratio of such decrements was consistent to the expected (true) value of 50% (Bias 1). Again, as shown in Table 2, the calculation revealed that except for five townships, Dagon Myothit (North; 43%), Dagon Myothit (East; 110%), Dagon Myothit (Seikkan; 39%), Kamaryut (42%), and Pazundaung (49%), other townships showed nearly 20% in difference from the expected value of 50% (Bias 1). Of the total townships, 60% were shown to have a maximum 10% in difference. This means that about 60% of the townships were consistent with a nearly 50% decrement from ODEP and IDEP, despite the complicated distribution. With this result, it was hypothesized whether the mean decrement percentage from ODEP to IDEP of all townships was equal to the expected value of 50%; this prediction came true with the t-test: one sample with a confidence level of 95%. The hypothesis showed that there is no significant variation between the mean decrement percentage from ODEP to IDEP of townships with p (0.12) > 0.05.

4. DISCUSSION AND CONCLUSION

Distribution does not occur by summing employed populations from 33 townships and each being distributed equally. In fact, distribution occurs by distributing a population from one township to its neighboring ones, from which it will be passed on gradually with the help of biases in each time of distribution. From the network distribution model, it was identified that higher connectivity (bigger degree of nodes in Figure 5) of a township contributes to higher employment distribution. Therefore, Mayangone and Mingalar taungnyunt, the two townships having the maximum number of connected neighbors, had the maximum amount of distribution occurring within them. Also, distribution biases ensure the precise values are given to the employed distribution. There were industrial zones and urban centers, which became Biases 2 and 3, to converge the employees having various directions into two. In this way, the distribution became systematic with the destinations being determined. Different townships have different bias values, and those that have higher clusters of urban centers, offices, connectivity, or industries will eventually have higher daytime employed populations. Such a hypothesis was been proven to be true by the survey, where 78.86% of the respondents’ workplace addresses were actually located within these high urban employment townships. This network distribution is overall genuine with respect to the real-life employed population distribution, as proven from the correlation test with the YUTRA data (0.57 > 0.5). However, since this study only utilized the average ranking values, it only resulted in an approximate or overall pattern of flow of employees in Yangon. For the most precise results, it is necessary to collect surveys of each individual, with one-to-one interviews conducted with each of the 5.2 million people in the city, because the data currently available in Myanmar are as yet unable to realize the full and adequate analysis related to the daytime population.

Based on the 421 survey samples, it was clarified that 55% of the population in Yangon were certainly in the favor of companies having WFH from home as an option in the future. This amount of surveys was able to represent the majorities’ opinions in Yangon by a 5% error. With this confirmation, the network distribution model in this study was able to give rise to two values, the ordinary daytime employed population (ODEP) and improved daytime employed population (IDEP), where only the latter included the work from home bias (Bias 1) during the calculations. There was a significant difference between ODEP and IDEP (as seen in Figures 6 and 7) in that, in ODEP, the distribution was
more turbulent every time and the amount of distribution was unstable. Crowdedness is caused by a large number of people from a geographically bigger township converging on the urban centers of smaller ones. Since the majority of employees were going out to work, their directions were facing everywhere and the capacity of roads and public transportation were fixed; therefore, there is the potential for crowdedness in township centers or traffic jams over the roads. However, with WFH, the amount of the first distribution was already reduced by 50% with Bias 1, and consequently, the amount of distribution was seen to be more stable and correspondingly might lower the amount of crowdedness and traffic jams. This scenario is clear where ODEP and IDEP were compared for the coefficient of variation and ODEP was higher than IDEP by almost three times. Therefore, with the work from home option, the movement of employees was more consistent and less various in the distribution of the employed population.

Since it was an interconnected network distribution, the distributions of employees were more or less different from one township to another. However, the research showed that 60% of the townships had a difference that was less than 10% from the expected value of 50% decrement between ODEP and IDEP. With the t-test, the mean value of the decrement for all the townships was also proven to be the same as 50%. Thus, the overall distribution was found to be very consistent, despite the individual townships having varied distribution amounts. This helps generally in predicting the future decrease in population of each township by simply multiplying with just one value (50% in the case of this research).

By providing a work from home option for employment, an overall 50% decrease in distribution could be expected. In other words, such change in working culture adjusts the over-crowdedness in one township or under-occupancy another. This brings the daytime and nighttime populations into nearer values. The distribution with work from home bias tended to create less fluctuation in distribution than the ordinary one. As a further consequence, traffic jams and the transmission of diseases might decrease correspondingly, since more people are working from home. Utilization of constraints such as Biases 1, 2, and 3 definitely gave rise to the more accurate results of the distribution. Survey data were in accordance with the results from the distribution model. Lastly, it is concluded that work from home defines a new normal for the working culture.
which brings nothing but positive impacts to our urban society in terms of employment distribution.

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AUTHORS’ CONTRIBUTIONS

YWA conceived the ideas, collected and interpreted the data, and wrote and edited the manuscript. SSM led the proofreading, commenting, and editing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

COMPETING INTERESTS

The authors declare no competing interest.

REFERENCES


