# Optimizing Human Resources Capacity and Performance of Newroz Telecom Company by Proposing Queuing Theory

Ahmet Demir[1] & Cumhur Aydinli[2] & Karwan Talaat[3]

[1] Department of Business and Administration, Ishik University, Sulaimania, Iraq
[2] Department of Business and Administration Ipek University, Ankara, Turkey
[3] Department of Business and Administration Ishik University, Erbil, Iraq
Correspondence: Ahmet Demir, Ishik University, Sulaimania, Iraq. E-mail: ahmet.demir@ishik.edu.iq

Received: June 12, 2015 Accepted: August 24, 2015 Online Published: September 1, 2015

**Abstract:** Human resources capacity is one of the very important decision points of a management. In this case efficiency plays a strategic role. On the other hand, customer satisfaction also must be considered when optimizing the human resources capacity. In this research, human resources capacity of a call center was calculated regarding to arrival of calls to the center and optimized by using waiting lines method. As a result it was seen that queuing theory worked and efficiency of the call center was increased.

**Keywords:** Queuing Theory, Waiting Lines, M/M/S/∞, Human Resources Capacity, Performance Optimization, Increasing Efficiency

## 1. Introduction and Literature Review

Anyone may see people on a queue waiting to buy a hamburger, cars waiting to be washed or fuel filled, customers waiting on the phone for a call center representative…etc. the reason why people or customers are waiting to be served is because the servers are less than the customers at that moment. From this point of view, waiting is a natural behavior of some companies like shopping centers, malls, car washing centers, restaurants, call centers,…etc. However, waiting is not a desirable time from the customers' side. On the other hand, company cannot hire more employees than required. At this point a question occurs such as what is the optimum level of employees to be hired in order to optimize the waiting time of the customers?

There are many researches done to solve this problem like; Gowrishankar and Bhaskar (2013) have used queuing theory to analyze performance measures with and without feedback as two individual cases. Ban, Hao, and Sun (2011) has proposed this theory to estimate real time queue lengths at signalized intersections using intersection travel times collected from mobile traffic sensors. Marsudi (2011) has proposed queuing theory for achieving an appropriate queuing analytical model and determine its performance measures by analyzing the capacity requirements and estimating manufacturing cycle times. Haviv (2014) has used waiting lines method in order to show how queuing systems can be regulated by imposing an entry fee, a holding fee (based on time in the system), or a service fee (based on the required service time) when customers know their service requirements. Boucher and Couture-Piche (2015) performed a research to estimate four parameters of the car insurance services such as; rate new car signing a contract with an insurance company, secondly rate of cars those remove the contract, thirdly the cars those cancel their contract with insurance company, and finally the cars those renew the contract with the insurance company. Babicheva (2015) has a research about optimizing the number of cars waiting on the road intersections. The researcher also used queuing theory in that paper. Singer and Donoso (2008) have proposed this model for assessing the performance of ambulance service in Chile. Kozlowski and Worthington (2015) have estimated the maximum times at healthcare services to guarantee the waiting time accuracy in Denmark.

We can easily see that there are many implementations of queuing theory in different countries on different topics. Furthermore, if anyone wants to see more researches about the queuing theory, many more papers are available at different databases (Ashton, 2009; Taufemback & Da Silva, 2012; Hanning, 1996; Karlberg & Brinkmo, 2009; Siciliani & Hurst, 2005; Belciug & Gorunescu, 2015; Vrangbæk, et. al., 2007; Wiley, 2005; Hanning & Spångberg, 2000; Johannesson, Johansson, & Söderqvist, 1998; Zavanella, et. al., 2015).

Queuing theory includes some terminological abbreviations and signs those needs to be defined such as (Hiao & Zhang, 2010);

$Pn$: the probability of exactly n customers in the queue systems in the statistic equilibrium.

$L_s$: The number of the customers in the queue system in equilibrium state. The mean number/expectation of the customers is $L_s$

$Lq$: The number of the customers in queuing in equilibrium state. That is the expected queuing length (excludes customers being served). The mean number/expectation of the customers in a queue is $Lq$

$W_s$: The staying time of customers (including service time), as the queue system is in the equilibrium state; the mean number of the staying time for each individual customer in the queuing system is $W_s$

$Wq$: The waiting time of customers (excluding service time), as the queue system is in the equilibrium state; the mean number of the waiting time for each individual customer in the queue system is $Wq$ .

λ: The mean arrival rate (expected number of arrivals per unit time) of new customers when $n$ customers are in systems.

μ: The mean service rate for overall systems (expected number of customers completing service per unit time)

## 2. Methodology

In this paper, multiple server and infinite queue (M/M/C: GD/∞/∞) model was proposed as customers are arriving into the system randomly based on the assumption of Poisson distribution and departure based on the Exponential Distribution. Below on the Figure 1 multiple server system is shown as;

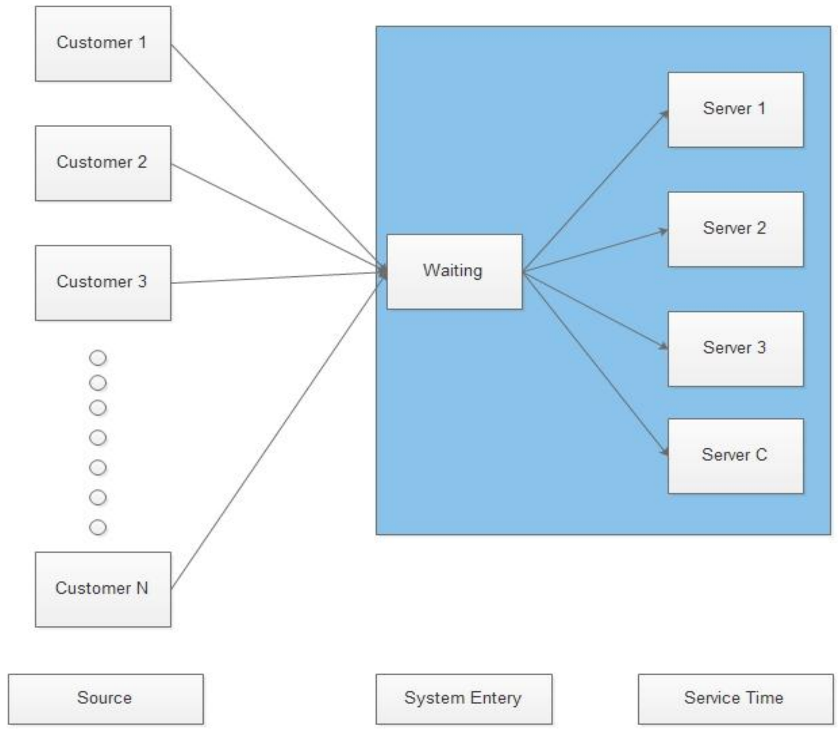



Figure 1: A simple "multiple server" service model

For this concept, the formulas of the system can be determined as;

$$\left.\begin{aligned} P_n &= \left\{\frac{\rho^n}{n!} * P_0\right\}, \qquad n < C \\ P_n &= \left\{\frac{\rho^n}{c!c^{n-c}} * P_0\right\}, \qquad n \geq C \end{aligned}\right\} \tag{1}$$

Formula (1) shows the probability that there is n customer(s) in the system. There are two formulas can be used according to number of customer(s) are more and less or equal to the number of server in the system.

$$P_0 = \left\{\sum_{n=0}^{C=1} \frac{\rho^n}{n!} + \frac{\rho^c}{C!}\left(\frac{1}{1-\frac{\rho}{C}}\right)\right\}^{-1}, \frac{\rho}{C} < 1 \tag{2}$$

$P_0$ formula outputs determine the probability that there is no customer in the system or there is no arrival to the system. Remaining $L_s$, $L_q$, $W_s$, and $W_q$ formulas are such;

$$\left.\begin{aligned} L_s &= L_q + \rho \\ L_q &= \frac{\rho^{c+1}}{(c=1)! * (c-\rho)^2} * P_0 \end{aligned}\right\} \quad (3)$$

$$\left.\begin{aligned} W_s &= \frac{L_s}{\lambda} \\ W_q &= \frac{L_q}{\lambda} \end{aligned}\right\} \quad (4)$$

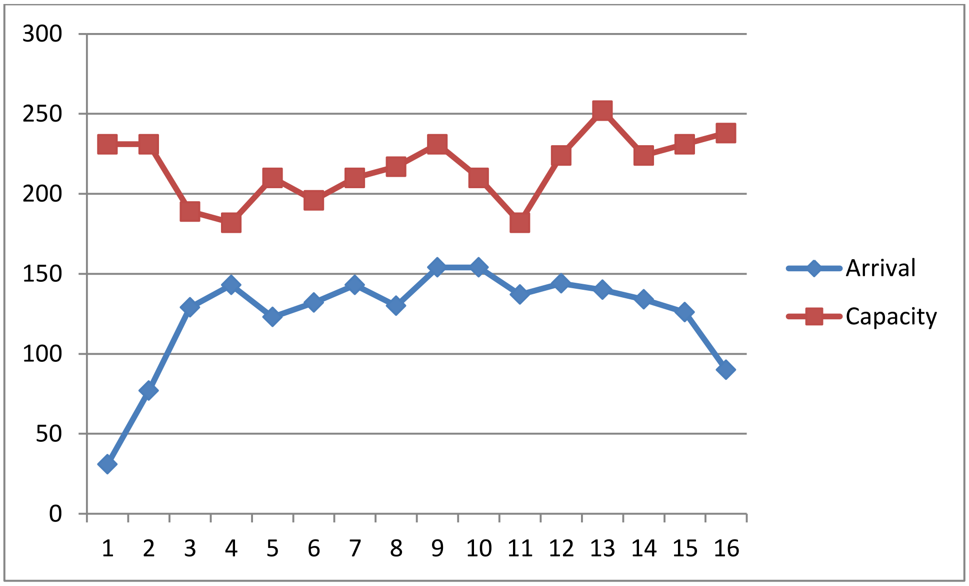
In this research, call center of Newroz Telecom Company was taken as case and data that was used in this research belongs to call center of that company. Allai Newroz Telecom is a joint venture established in mid-2007 between Newroz Tel (previously a PSTN operator in Erbil and Dohuk) and VTEL Holdings to build and operate landline phone, fixed wireless, advanced ADSL, and EV-DO internet networks in addition to transmission backbone networks in the region and international Gate-Way. Call center of the company has structure of multiple server and infinite queue attribute where the population also is infinite. The data was chosen random two months. Observed raw data was prepared for the model by calculating λ and μ for each hour. That call center starts working from 8:00 and working time ends by the time 00:00. From this point, we wanted to evaluate the arrivals and departures hourly average arrival and service such as;

Table 1: Arrival and Service table of the call center

| **Morning Shift** | | | | **Evening Shift** | | | |
|---|---|---|---|---|---|---|---|
| Hour | Server | λ | μ | Hour | Server | λ | μ |
| 08:00-08:59 | 7 | 31 | 33 | 16:00-16:59 | 7 | 154 | 33 |
| 09:00-09:59 | 7 | 77 | 33 | 17:00-17:59 | 7 | 154 | 30 |
| 10:00-10:59 | 7 | 129 | 27 | 18:00-18:59 | 7 | 137 | 26 |
| 11:00-11:59 | 7 | 143 | 26 | 19:00-19:59 | 7 | 144 | 32 |
| 12:00-12:59 | 7 | 123 | 30 | 20:00-20:59 | 7 | 140 | 36 |
| 13:00-13:59 | 7 | 132 | 28 | 21:00-21:59 | 7 | 134 | 32 |
| 14:00-14:59 | 7 | 143 | 30 | 22:00-22:59 | 7 | 126 | 33 |
| 15:00-15:59 | 7 | 130 | 31 | 23:00-23:59 | 7 | 90 | 34 |

It seems on table 1 that in the morning time and the night times number of customers decreasing. Furthermore, number of calls is increasing in the mid-times of days. This expression can be shown on Graph 1 as;

Graph 1: Arrival and Capacity graph of the call center




On the graph it can be seen more easily that capacity of call center is always more than the arrivals. On the other hand, in the morning times and night times capacity is much higher than the sufficient one. By other words, how much the capacity is above the arrival that much the efficiency or utilization decreases or waste of time and cost increases. Of course, the utilization shouldn't exceed 80-85% because in this case waiting time will increase and customer satisfaction will decrease. Within this information the capacity can be optimized by using queuing theory. Before optimizing the capacity, it is better to see the recent utilization of the call center hourly. Formula of the efficiency is;

$$Efficiency = \lambda/(Server * \mu) \quad (5)$$

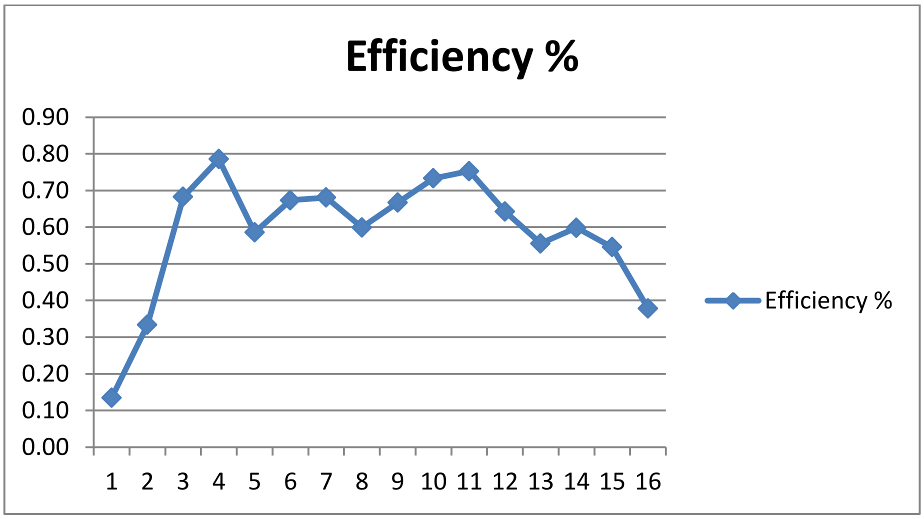
Table 2: Current efficiency level of the call center

| Efficiency | | | |
|---|---|---|---|
| Morning Shift | | Evening Shift | |
| 08:00-08:59 | **0.134** | 16:00-16:59 | **0.667** |
| 09:00-09:59 | **0.333** | 17:00-17:59 | **0.733** |
| 10:00-10:59 | **0.683** | 18:00-18:59 | **0.753** |
| 11:00-11:59 | **0.786** | 19:00-19:59 | **0.643** |
| 12:00-12:59 | **0.586** | 20:00-20:59 | **0.556** |
| 13:00-13:59 | **0.673** | 21:00-21:59 | **0.598** |

| | | | |
|---|---|---|---|
| 14:00-14:59 | **0.681** | 22:00-22:59 | **0.545** |
| 15:00-15:59 | **0.599** | 23:00-23:59 | **0.378** |

Table 2 shows that the efficiency of the call center is very low in the early morning times and late evening times. This table can be graphed as;

Graph 2: Graph of the current efficiency of the call center




At this utilization rate waiting time on the system (queue + service), waiting time on queue, number of customers on the system (queue + served), and number of customers waiting to be served are calculated hourly below by using formulas given above;

Table 3: Current Ls, Lq, Ws, and Wq levels of the call center

| Morning Shift | | | | | Evening Shift | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hour | Ls | Lq | Ws/min | Wq/min | Hour | Ls | Lq | Ws/min | Wq/min |
| 08:00-08:59 | 0.94 | 0.000 | 1.8 | 0 | 16:00-16:59 | 5.16 | 0.50 | 2.01 | 0.19 |
| 09:00-09:59 | 2.33 | 0.005 | 1.8 | 0 | 17:00-17:59 | 6.11 | 0.98 | 2.38 | 0.38 |
| 10:00-10:59 | 5.36 | 0.588 | 2.4 | 0.27 | 18:00-18:59 | 6.46 | 1.19 | 2.83 | 0.52 |
| 11:00-11:59 | 7.17 | 1.670 | 3 | 0.6 | 19:00-19:59 | 4.89 | 0.39 | 2.04 | 0.16 |
| 12:00-12:59 | 4.31 | 0.210 | 2.1 | 0.06 | 20:00-20:59 | 4.43 | 0.24 | 1.98 | 0.10 |
| 13:00-13:59 | 5.25 | 0.530 | 2.3 | 0.24 | 21:00-21:59 | 4.43 | 0.24 | 1.98 | 0.10 |
| 14:00-14:59 | 5.35 | 0.578 | 2.2 | 0.24 | 22:00-22:59 | 3.95 | 0.13 | 1.88 | 0.06 |
| 15:00-15:59 | 4.43 | 0.245 | 2.0 | 0.06 | 23:00-23:59 | 2.65 | 0.01 | 1.77 | 0.00 |

We can see that in the morning times from 08:00 until 10:00 customer doesn't wait to be answered or served. On one hand this might be considered good but on the other hand it means that efficiency of the system is very low, too. In this case, it is needed to decrease the number of servers gradually in order to increase the efficiency to the reasonable levels. There is new table below shows the results of gradually decreased level of capacity and efficiency. It is also compared with the old system.

Table 4: Comparison of efficiency between the current capacity and calculated capacity

| Efficiency | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Morning Shift | | | | | Evening Shift | | | |
| Hour | Servers | Old Eff. | Servers | New Eff. | Hour | Servers | Old Eff. | New Eff. |
| 08:00-08:59 | 7 | 0.134 | 2 | 0.46 | 16:00-16:59 | 6 | 0.667 | 0.78 |
| 09:00-09:59 | 7 | 0.333 | 3 | 0.78 | 17:00-17:59 | 6 | 0.733 | 0.86 |
| 10:00-10:59 | 7 | 0.683 | 6 | 0.79 | 18:00-18:59 | 6 | 0.753 | 0.88 |
| 11:00-11:59 | 7 | 0.786 | 7 | 0.79 | 19:00-19:59 | 6 | 0.643 | 0.75 |
| 12:00-12:59 | 7 | 0.586 | 5 | 0.82 | 20:00-20:59 | 5 | 0.556 | 0.78 |
| 13:00-13:59 | 7 | 0.673 | 6 | 0.79 | 21:00-21:59 | 5 | 0.598 | 0.84 |
| 14:00-14:59 | 7 | 0.681 | 6 | 0.79 | 22:00-22:59 | 5 | 0.545 | 0.76 |
| 15:00-15:59 | 7 | 0.599 | 6 | 0.70 | 23:00-23:59 | 3 | 0.378 | 0.88 |

On the comparison with the old system one can easily see the new calculations have shown that efficiency of the system has increased significantly. Independent Samples T-Test results show the significance of the difference below;

**Table 5: Group Statistics**

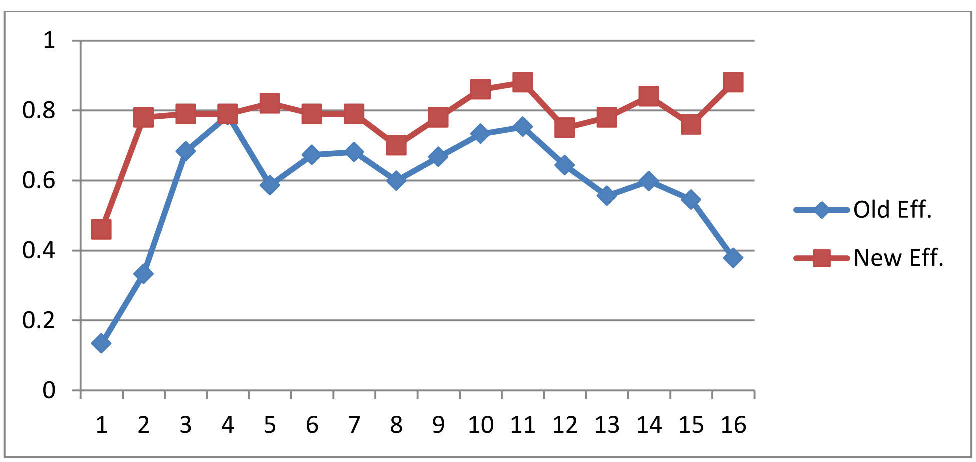
| | Old_New | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Efficiency | Old Efficiency | 16 | .5843 | .17122 | .04280 |
| | New Efficiency | 16 | .7781 | .09731 | .02433 |

Table 6: Independent Samples Test

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Efficiency | Equal variances assumed | 3.607 | .067 | -3.938 | 30 | .000 | -.19388 | .04923 | -.29443 | -.09332 |
| | Equal variances not assumed | | | -3.938 | 23.775 | .001 | -.19388 | .04923 | -.29554 | -.09221 |

Shortly, group statistics show that mean of efficiency has increased from 0.58 up to 0.78 overall. However, this increase is significant based on sig. (2-tailed) is less than 0.05 (in this case 0.000) and this proves that the increase is not a coincidental outcome but it is significant. Furthermore, efficiency comparison results can be seen on graph 3 also.

Graph 3: Comparison of current efficiency and calculated efficiency graphically




Graph 3 also shows increase of efficiency on the system has increased every hour. However, it was expressed that the efficiency shouldn't exceed 80-85%. If it exceeds, this time waiting time on the queue will increase and satisfaction as fact will decrease. The table 7 below shows new Ls, Lq, Ws, and Wq for the new calculations;

Table 7: Calculated Ls, Lq, Ws, and Wq of the call center

| Morning Shift | | | | | Evening Shift | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hour | Ls | Lq | Ws/min | Wq/min | Hour | Ls | Lq | Ws/min | Wq/min |
| 08:00-08:59 | 1.20 | 0.26 | 2.33 | 0.52 | 16:00-16:59 | 6.32 | 1.65 | 2.47 | 0.65 |
| 09:00-09:59 | 4.47 | 2.13 | 3.49 | 1.67 | 17:00-17:59 | 8.90 | 3.77 | 3.47 | 1.47 |
| 10:00-10:59 | 6.77 | 1.99 | 3.15 | 0.93 | 18:00-18:59 | 10.23 | 4.96 | 4.48 | 2.17 |
| 11:00-11:59 | 7.17 | 1.67 | 3.01 | 0.70 | 19:00-19:59 | 5.76 | 1.27 | 2.40 | 0.53 |
| 12:00-12:59 | 6.80 | 2.70 | 3.32 | 1.32 | 20:00-20:59 | 5.68 | 1.79 | 2.44 | 0.77 |
| 13:00-13:59 | 6.50 | 1.79 | 2.96 | 0.82 | 21:00-21:59 | 7.42 | 3.24 | 3.32 | 1.45 |
| 14:00-14:59 | 6.72 | 1.95 | 2.82 | 0.82 | 22:00-22:59 | 5.39 | 1.57 | 2.57 | 0.75 |
| 15:00-15:59 | 4.96 | 0.77 | 2.29 | 0.36 | 23:00-23:59 | 8.54 | 5.90 | 5.69 | 3.93 |

New calculations show that naturally waiting time on queue has increased regarding to decrease on number of server hourly. Though, there is not very much increase that dissatisfies customers. But only between 18:00-18:59 and 23:00-23:59 there is a need for managerial decision about increasing servers one in order to decrease waiting time on queue. Because waiting more than around one minute may dissatisfy customers. However, by increasing servers one the waiting time on queue will decrease but on the other hand efficiency also will decrease below 80%. So this is a managerial decision that should be considered.

## 3. Discussions and Recommendations

The calculations show that the efficiency of the call center has increased by decreasing number of severs gradually. This decrease has also will decrease the total cost of the call center service naturally. The management may recalculate the total cost of the call center service and regarding to the new picture they may decide to use optimized human resources capacity of the call center or not. Furthermore, the efficiency shows the success of management. Because management should increase the efficiency to the optimal numbers and use the capacity sufficiently. This decision will affect both efficiency and cost positively.

According to the calculations and results, it was seen that in the morning times (08:00-10:00) the company doesn't need 7 servers but less. However, night times (23:00-00:00) also the call center needs very less than 7 servers on average. Furthermore, the company needs 7 servers only at 11:00 o'clock. On other times they need to decrease the human resources capacity based on the directions given on this paper.

Final recommendation might be calculation of the new cost and seeing how these calculations will affect overall cost. In this research we couldn't calculate the cost because of the privacy of the company. As a conclusion, queuing theory has worked for optimizing the human resources capacity of the call center and waiting time of customers on queue.

## References

Ashton, T. (2009, October). Increased use of private hospitals. *Health Policy Monitor*.

Babicheva, T. S. (2015). The Use of Queuing Theory at Research and Optimization of Traffic on the Signal-controlled Road Intersections. *Procedia Computer Science*, *55*, 469-478.

Ban, X. J., Hao, P., & Sun, Z. (2011). Real time queue length estimation for signalized intersections using travel times from mobile sensors. *Transportation Research Part C: Emerging Technologies*, *19*(6), 1133-1156.

Boucher, J. P., & Couture-Piché, G. (2015). Modeling the number of insured cars using queuing theory. *Insurance: Mathematics and Economics*.

Gowrishankar, L., & Bhaskar, V. (2013). Performance evaluation of a single queue capable of handling two like jobs as a single entity. *Applied Mathematical Modeling*, *37*(4), 2562-2573.

Hanning, M.(1996). Maximum waiting- time guarantee An attempt to reduce waiting lists in Sweden. *Health Policy*, *36*(1),17–35.

Hanning, M.,& Spangberg, U.W.(2000). Maximum waiting time A threattoclinical freedom? Implementation of a policy to reduce waiting times. *Health Policy*, *52*(1), 15–32.

Haviv, M. (2014). Regulating an M/G/1 queue when customers know their demand. *Performance Evaluation*, *77*, 57-71.

Johannesson, M., Johansson, P.O., & Söderqvist,T. (1998).Time spent on waiting lists for medical care: An insurance approach. *Journal of health economics*, *17*(5), 627–644.

Karlberg, H.I.,& Brinkmo, B.M. (2009). The unethical focus on access: A study of medical ethics and the waiting-time guarantee. *Scandinavian Journal of Public Health*, *37*(2), 117–121.

Kozlowski, D., & Worthington, D. (2015). Use of queue modelling in the analysis of elective patient treatment governed by a maximum waiting time policy. *European Journal of Operational Research*, *244*(1), 331-338.

Marsudi, M. (2011). Application of queuing theory in analyzing the use of production capacity. *International Journal of Integrated Engineering*, *2*(1).

Singer, M., & Donoso, P. (2008). Assessing an ambulance service with queuing theory. *Computers & operations research*, *35*(8), 2549-2560.

Siciliani, L., & Hurst, J. (2005). Tackling excessive waiting times for elective surgery: A comparative analysis of policies in12 OECD countries. *Health Policy*, *72*(2), 201–215.

Taufemback, C., & Da Silva, S. (2012). Queuing theory applied to the optimal management of bank excess reserves. *Physica A: Statistical Mechanics and its Applications*, *391*(4), 1381-1387.

Vrangbæk, K., Ostergren, K., Birk, H. O.,& Winblad, U. (2007). Patient reactions to hospital choice in norway, denmark, and sweden. *Health Economics, Policy and Law*, *2*,125–152.

Wiley, M.M. (2005). The irish health system: Developments in strategy, structure, funding and deli very since 1980. *Health Economics*, *14*(S1), 169–S186.

Xiao, H., & Zhang, G. (2010, January). The queuing theory application in bank service optimization. In *Logistics Systems and Intelligent Management, 2010 International Conference on* (Vol. 2, pp. 1097-1100). IEEE.

Zavanella, L., Zanoni, S., Ferretti, I., & Mazzoldi, L. (2015). Energy demand in production systems: A Queuing Theory perspective. *International Journal of Production Economics*.