MAGAZINE INCAING
ISSN 2448 9131

Problem-based learning for the solution of a simulation model in a convenience store.

M.Sc.A Carlos Roberto Ibáñez Juárez[1], M.I. Nancy Roxana Ruiz Chavez[2],
Itzel Larissa Fernández Mijangos[3].

Research Professors *1,2; Students of program 3,*
From the Faculty of Engineering, Benemérita Universidad Autónoma de Puebla.

carlos.ibanez@correo.buap.mx; nroxana.ruiz@correo.buap.mx

SUMMARY

The present project shows a simulation model based on waiting lines of one and two servers in a convenience store, in order to be able to determine what the option is optimal for the company to decide if it is necessary to open ana second cash register inside of the establishment Taking how base Which one it the time of Hold on average y Yes is inside of the permissible limit of the company and for this to establish the average time of the service to a customer, the times between customer arrivals, the comparison of the simulation of a servidory Of servers, with the data obtained decide if with an servidor is able to cope with the establecimientono overtaking the Limits of time of Hold on o it necessary Of Servers for diminish the Times waiting. This project is carried out under the methodology of Problem-Based Learning, where a through of proyectos Practical herself search What the Students Put in practice their knowledge in class in one situation real y Seek Different Solutions for his analysis.

Keywords:

Simulation model of a server,

ABSTRACT

This project provide a simulation model based on waiting lines of one and two servers in an OXXO establishment, in order to determine which is the optimal option for the company to decide if it's necessary to open a second cash register within of the establishment based on the average waiting time and know if it's within the permissible limit time of the company and for this to establish the average time of service for a client, the times between the clients served, the comparison of the simulation of one server and two servers, with the data obtained, decide if a server is enough for the establishment without exceeding the waiting time limits or if two servers are necessary to reduce waiting times.

Keywords:

Simulation model, waiting time, servers, time between arrivals, service time.

1. INTRODUCCION

One of the Main Factors What Influence in the decision of one customer to the buy in one establishment is the time you have to wait to be taken care of, this happens in almost all establishment and can be decisive in whether or not it has customers, the position within the market and Including how one advantage Competitive with respect other companies; the present project herself Focus on a waiting line inside a convenience store to determine if it is convenient or noabrir the second cash register based on the permissible waiting time limits. Is important recalcar What to take one decision as this is required of one analysis that involve time taking, pilot tests and most importantly a simulation model that we will allow to see a panorama of how the behavior of a real situation is, for himor the shot of data shall be carried out one day in the shift covering the peak hours of the establishment, said schedule is from 7:00 A.M to 3:00 P.M. in which the times between arrivals of the clients will be taken, the time herself service average; is important recalcar What the taking of data it for the construction of our model of simulation by the What with base in it herself Determine the time of Hold on of the clients y decide Yes one box Register it enough o it necessary the aperture of one second box to reduce waiting times and be below the permissible limit of the criteria of the enterprise.

1.1 Location

The establishment of which the analysis will be done is the OXXO of lomas de Angelópolis located at the address Av. del Castillo 1, Lomas de Angelópolis, 72830 Acatepec, Puebla. Fig. 1

Fig. 1 Convenience *store location*

1.2 OBJECTIVES

1.2.1 General Objective

Design a simulation model of waiting lines to determine if one or two servers are necessary to be in the permissible limit of waiting time of a client in the OXXO establishment of Lomas de Angelópolis.

1.2.2 Specific Objectives

- Collect times between arrivals of customers in the establishment in the morning shift.
- Take service time from average customers at the property on the morning shift.
- Create two MM1 and MM2 simulation models of waiting lines.

2. PROBLEM

One of the concerns of commercial chains, especially convenience store chains, is the service they offer their customers, a service that is radically marked by the waiting time in them. For this reason, each establishment of this large chain determines its permissible waiting times according to its needs.

A convenience establishment is located in Lomas de Angelópolis that has 3 shifts, is currently working with a cashier, that is, under a model of simulation of waiting line with a server (MM1), it is also known that, the permissible waiting time established is 4 minutes, while the service time is 2 minutes and the time between llegacies are in a range of 0 to 4.5 minutes. The data obtained from time between arrivals and service times throughout the first shift, that is, from 7 to 15 hours, are also presented.

You want to know if the standby line simulation model of a server (MM1) with which you are is currently working is optimal or if necessary adopt a waiting line model with Of Servers (MM2), for power fulfill with the time of itpear permissible already established in the first shift What it where herself Find the hours pico y by end elder quantity of clients.

3. JUSTIFICATION OF THE MODEL TO BE USED

In the present project the waiting line models MM1 and MM2 are used, making a comparison to see if it is necessary to implement a waiting line model with two servers, since currently the establishment is working onlywith oneserver, for this reason a simulation model of a single server is first made, to see how it is currently working and then we made a model with 2 servers to see what benefits the implementation of a second box would bring to that establishment.

3.1 M/M/1 queuing system

In this model, the arrival process in many business situations follows a Poisson distribution. If, in addition, service times can be properly modeled with exponential distributionand there is only oneemployee, we speak of an M/M/1 queue system. Examples of queues modeled as M/M/1 systems include some small banks, rural post offices, and prepared food stores.

This model is based on the following assumptions:

- The arrival of each unit follows a Poisson probability distribution with rate of llegadas λ.
- Service times follow an exponential probability distribution, with service rate μ.
- The population of units seeking to be served is finite.

3.2 M/M/K queuing system

A multi-channel standby line is made up of two or more service channels that are assumed to be identical based on serviceability. Typical examples of M/M/K queuing systems include banks with multiple ATMs, post offices with multiple service windows, and fast food restaurants with multiple boxes.

In the multi-channel system, arriving units wait on a single line and then head to the first available channel to be served. This model presents the following characteristics:

- Arrivals follow a Poisson probability distribution.
- The service time of each channel follows an exponential probability distribution.
- The service rate μ is the same for each channel.

- Arrivals wait in a single waiting line and then head to the first open channel to be served.

Table 1 Analysis of the statistical distribution

No. Clientes	TIEMPO ENTRE LLEGADAS
1	7.449890861
2	7.376473412
3	2.093180169
4	5.995433573
5	5.51713683
6	6.432548006
7	6.50664818
8	2.141427355
9	5.528895869
10	4.38680861
11	4.505179987
12	2.132593848
13	5.697386176
14	2.842976639
15	3.937222664
16	3.135499124
17	3.328757852
18	4.334181236
19	6.793466379
20	6.835446064
21	2.335165771
22	6.036955235
23	6.058995665

PROMEDIO
4.50856875

DISTRIBUCIÓN:	Johnson Transformation

Session

Distribution	AD	P	LRT P
Normal	3.973	<0.005	
Box-Cox Transformation	4.341	<0.005	
Lognormal	6.149	<0.005	
3-Parameter Lognormal	4.050	*	0.000
Exponential	54.750	<0.003	
2-Parameter Exponential	14.967	<0.010	0.000
Weibull	3.728	<0.010	
3-Parameter Weibull	4.794	<0.005	0.011
Smallest Extreme Value	4.883	<0.010	
Largest Extreme Value	5.175	<0.010	
Gamma	4.804	<0.005	
3-Parameter Gamma	4.261	*	0.463
Logistic	4.269	<0.005	
Loglogistic	5.844	<0.005	
3-Parameter Loglogistic	4.299	*	0.002
Johnson Transformation	0.256	0.722	

Worksheet 1 ***

↓	C1	C2
	DATOS	
1	7.44989	
2	7.37647	
3	2.09318	

Rationale: It is known that when working with standby line simulation models, our data follows a normal distribution. In this case it can be observed that our data, with a sample size of 320, present a Johnson Transformationdistribution, given this situation it can be inferred that it is because the data were obtained in a atypical day (Monday), that is, a day where demand is not very high compared to other days of the week.

Table 2 Simulation of the MM1 *standby line model.*

TIEMPO ESPERA		<=	1	MIN						
										REPLICA 0
									PROMEDIO	3.019026676
									DESV. EST	0.310713333
LLEGADAS DE CLIENTES						CAPACIDAD SERVICIO AL CLIENTE				
NO. CLIENTE	ALEATORIO	T. ENTRE LLEGADAS (IAT)	T. LLEGADA (AT)	T. INICIO SERV. (TSB)	TIEMPO ESPERA (WT)	ALEATORIO 2	T SERVICIO (ST)	T. TERMINA SERV. (TSE)	T. DURACIÓN SIST. (TDS)	Tiempo Espera Promedio
1	0.218672383	0.984025722	0.984025722	0.984025722	0	0.061583185	1.229190839	2.213216561	1.229190839	0
2	0.869225884	3.911516477	4.895542199	4.895542199	0	0.909908418	2.670095642	7.565637841	2.670095642	0
3	0.453728606	2.041778728	6.937320927	7.565637841	0.628316914	0.383116079	1.851346513	9.416984354	2.479663427	0.209438971
4	0.521168968	2.345260357	9.282581284	9.416984354	0.13440307	0.343622615	1.798701848	11.2156862	1.933104918	0.190679996
5	0.068386784	0.307740527	9.590321811	11.2156862	1.625364391	0.6959597	2.256407598	13.4720938	3.881771989	0.477616875
6	0.420079444	1.890357496	11.48067931	13.4720938	1.991414493	0.819868116	2.457431299	15.9295251	4.448845792	0.729916478
7	0.237610472	1.069247125	12.54992643	15.9295251	3.379598666	0.207097301	1.591732839	17.52125794	4.971331505	1.108442505
8	0.719255173	3.236648277	15.78657471	17.52125794	1.734683228	0.979122135	3.017973242	20.53923118	4.75265647	1.186722595
9	0.46478579	2.091536057	17.87811077	20.53923118	2.661120414	0.672954265	2.224042766	22.76327394	4.885163179	1.350544575
10	0.353534911	1.590907097	19.46901786	22.76327394	3.294256082	0.821633507	2.460804094	25.22407804	5.755060176	1.544915726
11	0.205342291	0.924040312	20.39305817	25.22407804	4.831019864	0.278768187	1.706747628	26.93082567	6.537767493	1.843652466
12	0.82673165	3.720292426	24.1133506	26.93082567	2.817475067	0.367429906	1.830665975	28.76149164	4.648141042	1.924804349
13	0.117370016	0.52816507	24.64151567	28.76149164	4.119975972	0.592943626	2.117561835	30.87905348	6.237537807	2.093663705
14	0.834875175	3.756938286	28.39845396	30.87905348	2.480599521	0.77392878	2.375924027	33.2549775	4.856523548	2.121301977
15	0.033782989	0.152023451	28.55047741	33.2549775	4.704500097	0.654265879	2.198431669	35.45340917	6.902931766	2.293515185
16	0.535014956	2.4075673	30.95804471	35.45340917	4.495364466	0.441449239	1.926352057	37.37976123	6.421716522	2.431130765
17	0.634554291	2.855494311	33.81353902	37.37976123	3.566222211	0.505014135	2.006284452	39.38604568	5.572506663	2.49790085
18	0.271561655	1.222027449	35.03556647	39.38604568	4.350479214	0.403365872	1.877677775	41.26372346	6.228156989	2.600821871
19	0.937800039	4.220100175	39.25566664	41.26372346	2.008056814	0.995798531	3.317717759	44.58144121	5.325774573	2.56962371
20	0.405080849	1.822863821	41.07853046	44.58144121	3.502910752	0.698971633	2.260722555	46.84216377	5.763633307	2.616288062
21	0.145643825	0.655397211	41.73392767	46.84216377	5.108236096	0.200151886	1.579460583	48.42162435	6.687696678	2.734952254
22	0.194813382	0.876660217	42.61058789	48.42162435	5.811036461	0.786367071	2.396939515	50.81856387	8.207975976	2.874774263
23	0.016216613	0.072974758	42.68356265	50.81856387	8.135001218	0.544506095	2.055896328	52.8744602	10.19089755	3.103479783
24	0.928468751	4.178109381	46.86167203	52.8744602	6.012788165	0.632639496	2.169426144	55.04388634	8.182214309	3.224700966
25	0.056602492	0.254711213	47.11638324	55.04388634	7.927503096	0.200250561	1.579636705	56.62352305	9.507139801	3.412813051
26	0.59147225	2.661625124	49.77800837	56.62352305	6.845514677	0.813913501	2.446205201	59.06972825	9.291719878	3.544840036
27	0.511002731	2.29951229	52.07752066	59.06972825	6.992207587	0.301997435	1.740667856	60.8103961	8.732875443	3.672520316
28	0.829237909	3.731570589	55.80909125	60.8103961	5.001304855	0.562953903	2.07923136	62.88962746	7.080536214	3.719976907

Table 3 Replicas of the simulation

	REPLICA 1	REPLICA 2	REPLICA 3	REPLICA 4	REPLICA 5
PROMEDIO	2.604203317	4.327730504	4.221515164	2.704806736	2.471017931
DESV. EST	0.609249486	1.029381585	1.077627808	0.813298318	0.441177405
	Tiempo Espera Promedio	Tiempo Espera Promedio	Tiempo Espera Prom	Tiempo Espera Promedio	Tiempo Espera Promedio
	0	0	0	0	0
	0.009463962	0.462572917	1.008953297	0	0
	0.006309308	0.308381944	0.672635531	0.270657149	0.597675168
	0.130011833	0.680994742	1.002492418	0.910523707	1.153328757
	0.388446786	1.159968617	1.509518632	1.187770847	1.400578139
	0.862447751	1.495138374	1.97576867	1.446588368	1.498029954
	1.159610295	1.32126688	2.450182591	1.5512029	1.284025675
	1.315235077	1.404671905	2.715412438	1.52902985	1.131947194
	1.561150969	1.248597249	2.724518562	1.424941133	1.014853594
	1.643020731	1.229687019	2.663071546	1.28244702	0.913368234
	1.605846693	1.14740982	2.737237103	1.165860927	0.830334758
	1.472026135	1.051792335	2.721788159	1.06870585	0.849074627
	1.440353428	0.970885232	2.753015696	0.986497708	0.895607628
	1.376250831	0.981320517	2.850253167	0.916033586	0.967056511
	1.284500776	0.990276274	3.102156239	0.975906034	1.173899548
	1.204219477	1.096090579	3.436826791	0.954396598	1.418439183
	1.133383037	1.138192512	3.629183813	1.018486257	1.699363029
	1.070417313	1.095462239	3.918438514	1.226786418	1.844358476
	1.01551238	1.037806332	4.077306193	1.475386517	1.877340944
	0.964736761	0.985916015	4.233853437	1.711200672	1.894271085
	0.951752609	0.938967633	4.350877521	1.872500339	1.95005943
	0.908491126	0.896287286	4.378407794	2.000798198	2.079934414
	0.874174749	0.857318274	4.323816537	2.01961589	2.103965744
	0.837750801	0.821596679	4.344661945	2.096197082	2.100906106
	0.813495439	0.788732812	4.336766882	2.189516709	2.088935844
	0.782207153	0.758396935	4.346228873	2.314907037	2.094398688
	0.753236518	0.745634959	4.291311432	2.346374338	2.132974713

Table 4 Summary of *the statistical model*

No. De Clientes esperando	260
Probabilidad de Espera	10.94%
Tiempo de espera Promedio	5.308975922
Tiempo de Espera máximo	19.1809506

Through the graph it can be seen that the data do not present stability, the results do not follow a relationshiplines, the random part demands that over time it stabilizes for the creation of a more reliable model and that allows decisions to be made from that stability.

Therefore, it is necessary to perform a normality test to calculate a new sample size.

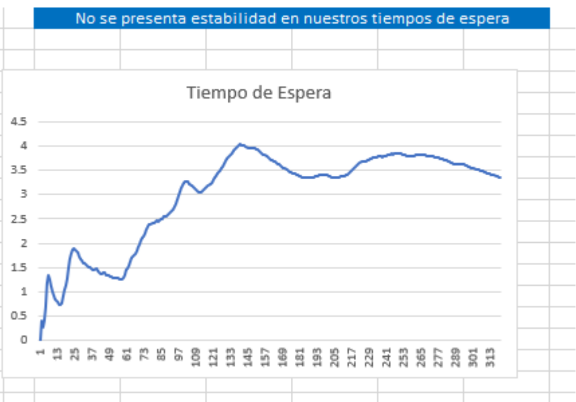


Fig. 2 Timeout stability graph.

The normality test is performed with a confidence level of 5%, for the development of a hypothesis test that allows us to verify the new values.

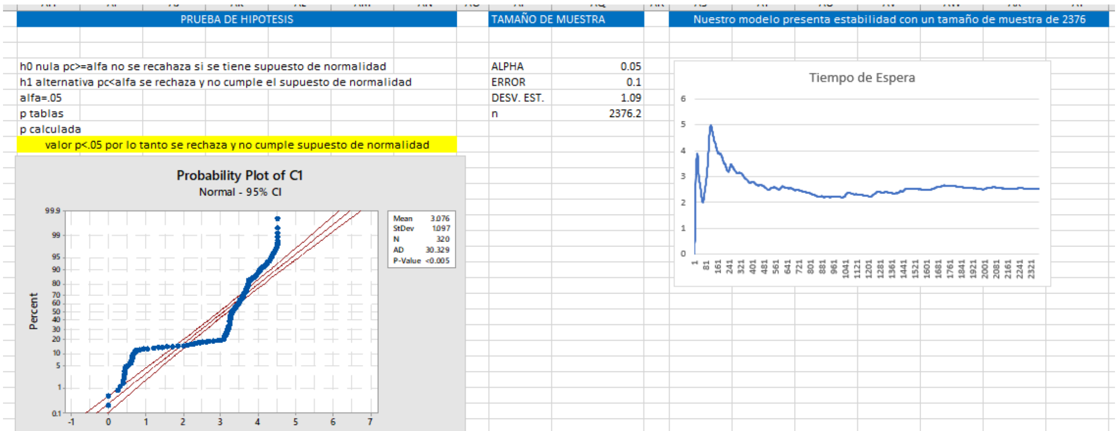


Fig. 3 Normality test

With this new normality test, the Ho is rejected and we accept the alternative, which allows us that with the new run an n = 2376.2 is considered and that with this size the normality is fulfilled according to the graph and its stability, so thatwe willalizaremos 5 replicas to evaluate the analysis of normality in a deeper way Fig. 4

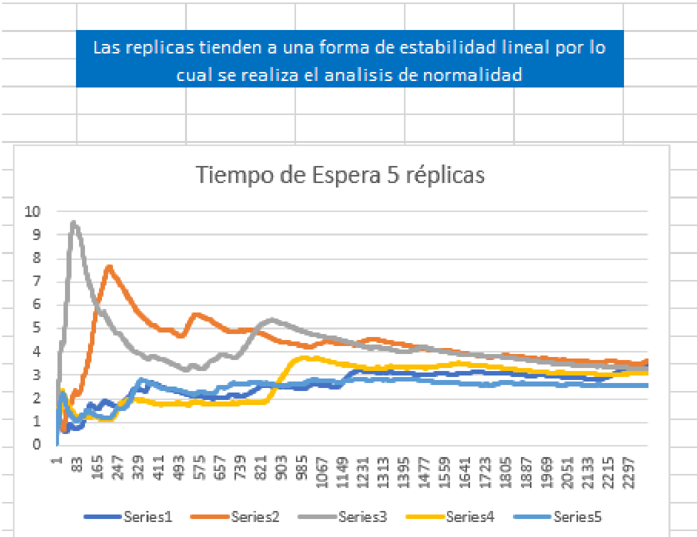


Fig. 4 Stability with 5 replicas.

Fig. 6 Stability model

With the above stability analysis, a stability model can be made to determine the behavior of the data referring to the 5 replicas and being in the confidence interval as seen, the model can be validated.

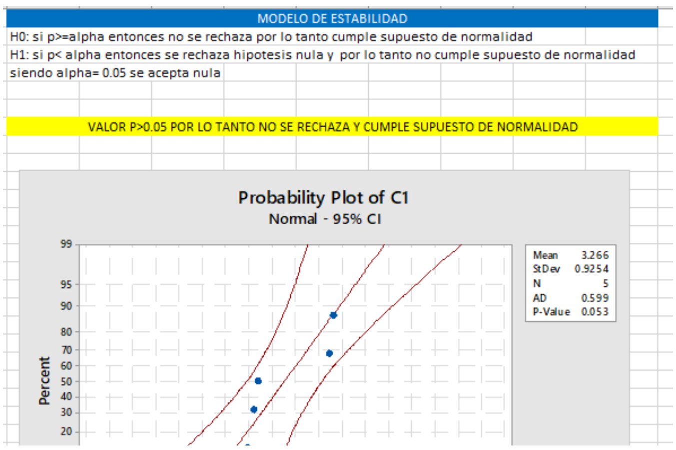


Fig. 5 Stability analysis

According to the established concepts and the stability test, it is concluded that with 95% confidence, you can have a waiting time for customers in the convenience store in an interval of 2.11 4.41 minutes with a single cash register.

INTERVALO DE CONFIANZA			
PROMEDIO	3.266		
DESV.EST	0.9254		
REPICAS	5		
ALPHA	0.05		
ALPHA/2	0.025		
T STUDENT	2.776	2.7764451	
R-1	4		
IC	2.1171483	-	4.4148517

Con un 95% de seguridad podemos decir que nuestro tiempo de espera para los clientes en el OXXO de Lomas de Angelopólis está en un intervalo de 2.11 a 4.41 minutos con una sola caja registradora.

Fig. 7 Confidence interval for a server

In the case of a model of two MM2 servers, a similar analysis is performed where the times per Waiting reasons are reduced by half, to create a shorter time effect of waiting under the consideration that customers arrive in the same random way as the previous model, giving as result the following times Fig. 8. As a justification it is known that, when working with models of simulOnline waiting, our data follows a normal distribution. In this case we can note that our data present a "Johnson" type distribution Transformation", before this It is inferred that this is debea that the data were obtained on a not very crowded day (Monday), in where the demand No esmuy high in comparison with other days of the week.

TIPO DE DISTRIBUCION DE LOS DATOS DE TIEMPO DE SERVICIO A LO LARGO DEL PRIMER TURNO (7-15 HRS)

No. Clientes	TIEMPO DE SERVICIO
1	1.718
2	2.845
3	1.647
4	1.719
5	2.988
6	2.467
7	2.643
8	2.527
9	1.244
10	1.725
11	1.935
12	2.181
13	2.250
14	1.931
15	2.298
16	2.183
17	1.510
18	2.149
19	1.046
20	1.907
21	2.520
22	2.628
23	2.129

PROMEDIO
2.012

DISTRIBUCION	Johnson Transformation

Session

Distribution	AD	P	LRT P
Normal	2.943	<0.005	
Box-Cox Transformation	2.943	<0.005	
Lognormal	5.930	<0.005	
3-Parameter Lognormal	2.977	*	0.000
Exponential	74.201	<0.003	
2-Parameter Exponential	21.819	<0.010	0.000
Weibull	2.635	<0.010	
3-Parameter Weibull	3.035	<0.005	0.334
Smallest Extreme Value	2.891	<0.010	
Largest Extreme Value	5.760	<0.010	
Gamma	4.557	<0.005	
3-Parameter Gamma	3.257	*	0.002
Logistic	3.249	<0.005	
Loglogistic	5.345	<0.005	
3-Parameter Loglogistic	3.253	*	0.000
Johnson Transformation	0.454	0.269	

↓	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
		T servicio								
1		1.718								
2		2.845								
3		1.647								

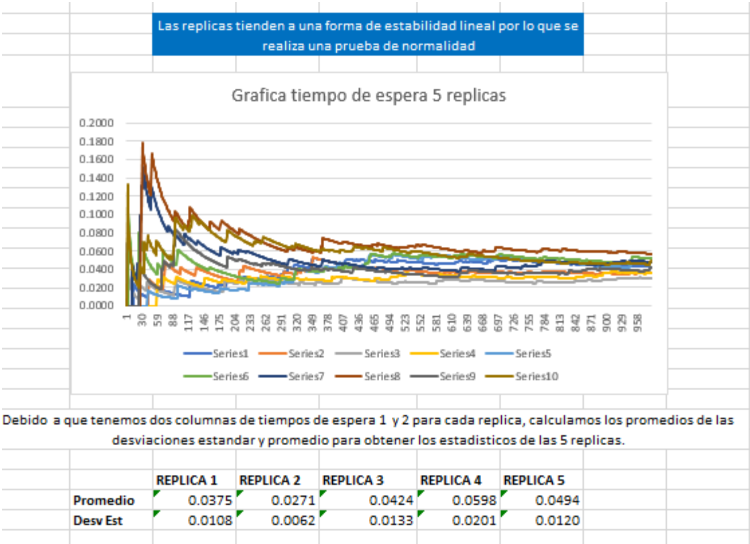
Fig. 8 Distribution of data during a shift with an MM2 model.

So the simulation model of 2 servers, shows us a small size and with short waiting times for the reason of the use of two servers.

Table 5 Statistics MM2

No. De Clientes esperando	87
Probabilidad de Espera	8.82%
Tiempo de espera Promedio	0.0422
Tiempo de Espera máximo	0.3919422

Through the graph of 5 replicas, it can be observed that the data does not present stability so it is necessary to perform a normality test to calculate a new size sample.



	REPLICA 1	REPLICA 2	REPLICA 3	REPLICA 4	REPLICA 5
Promedio	0.0375	0.0271	0.0424	0.0598	0.0494
Desv Est	0.0108	0.0062	0.0133	0.0201	0.0120

Fig. 9 Stability of 5 replicas

With the 5 replica model, the hypothesis test is performed to determine if it meets the assumption of normality

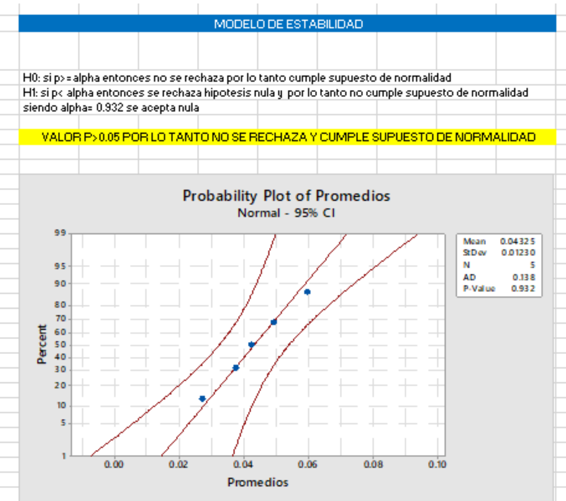


Fig. 10 Normality

Once the assumption of normality has been verified, and the hypothesis test, the model is already validated, so that the confidence interval determines the waiting time and if it is required that the convenience store propose a second server with a few waiting times, according to an alpha of 5% between 0.02 sec and 0.05 Fig. 11 . This time is very small almost negligible.

INTERVALO DE CONFIANZA			
PROMEDI	0.04325		
DESV.EST	0.0123		
REPICAS	5		
ALPHA	0.05		
ALPHA/2	0.025		
T STUDEN	2.776	2.776445	
R-1	4		
IC	0.02798	-	0.05852

Con un 95% de seguridad podemos decir que nuestro tiempo de espera para los clientes en el OXXO de Lomas de Angelopólis se encuentra dentro de un intervalo de 0.027 a 0.0585 minutos teniendo un modelo de 2 servidores. Lo cual nos indica que es totalmente factible la implementacion de un segundo servidor, pues de ésta manera los clientes estarian siendo atendidos al instante.

Fig. 11 Confidence interval for MM2

4. CONCLUSION

Based on the results of both models, it can be concluded that the use of a single cash register is not optimal for proper customer service because the confidence interval obtained indicates that customers would be speeding a time of between 2.11 and 4.41 minutes. does not comply with the parameter of the waiting time established by the store manager, which is 2 minutes, in addition to this model customers have a probability of 10.94% that they have to wait to be served. On the contrary, when performing the two-server model, we could observe that the waiting time is very small since it is in an interval of between 0.027 and 0.058 minutes, which indicates that customers would be being served immediately and would have a probability of waiting of 8.8%, which is reduced compared to the model of a server, for the aforementioned it is considered totally feasible to implement a second cash register in order to provide the best service to the customers of the convenience store.

Based on the data analyzed for the models this did not obtain a normal distribution because the data collected were not taken on a day of high or medium productivity puwas taken on a Monday where thereis no increase in sales, another factor is that the shift we analyzed does not cover most of the peak hours in which stable has an increase in customer service, finally that day was close to fortnight so it is stipulated it was not a day of high economic flow.

5. REFERENCES

[1] Google Maps. (n.d.). *Map of Oxxo* Lomas *de Angelopolis, Puebla*. Retrieved November 22, 2020, from https://www.google.com/maps/place/Oxxo+Lomas+Angelopolis/@19.005799,-98.2675945,17z/data=!3m1!4b1!4m5!3m4!1s0x85cfc7802bb591bb:0xd1c3b6aa90fa5bcd!8m2!3d19.005799!4d-98.2654058

[2] Anderson, David, Sweeney, D., Camm, J., & Williams, T. (2011). *Quantitative Methods for Business* (Onceava ed.). Mexico D.F, Mexico:Cengage Learning. Retrieved November 21, 2020

[3] Carro, R., & Gonzalez, D. (n.d.). *Models of Waiting Lines.* Retrieved November 21, 2020, from http://nulan.mdp.edu.ar/1622/1/17_modelos_lineas_espera.pdf

[4] Caballero, M. E. (2004). *Markov chains: an elementary approach.* Mexican Mathematical Society.

[5] Gómez R., J.M., & Jiménez M., J. A. (2020). Optimal portfolio selection based on first- and second-order Markov chains. *Readings from Economics, 92,* 33–66.

[6] Sanchez,R., & Barrera, P. (2018). Methodology based on Markov Chains for Demand Prediction and Decision Making in the short term. Case Study: Empresa Eléctrica Quito. (English). *Revista Técnica Energía, 15*(1), 44–50. https://doi-org.proxydgb.buap.mx/10.37116/revistaenergia.v15.n1.2018.322

[7] Ausín, C. (n.d.). *Bayesian analysis of queue systems.*

[8] Lorente Marín, A. (n.d.). *Discrete-time queuing systems with block inputs and services: theoretical study* and comparative *simulations.*

[9] *Discrete-time queuing systems with block inputs and services: theoretical study and comparative simulations.* (n.d.).

[10] Amador Pacheco, J. (n.d.). *Queuing systems with retry: analysis of blocked and successful* events [Universidad Complutense de Madrid, Servicio de Publicaciones.].