Concordia Institute for Information System Engineering
(CIISE)

Concordia University

INSE 691 – TOPICS IN INFORMATION SYSTEMS

Assignment -2:

Submitted to:

Professor Anjali Awasthi

Submitted By:

Student Name	**Student ID**
Keerthi Sanna Reddy	40159954
Nithish Reddy Yalaka	40164619
Sisinder Reddy Valmiki	40186128
Venu Podila	40159998
Chakri Gorantla	40165176

Faculty of Engineering and Computer Science
Expectations of Originality

This form sets out the requirements for originality for work submitted by students in the Faculty of Engineering and Computer Science. Submissions such as assignments, lab reports, project reports, computer programs and take-home exams must conform to the requirements stated on this form and to the Academic Code of Conduct. The course outline may stipulate additional requirements for the course.

1. Your submissions must be your own original work. Group submissions must be the original work of the students in the group.
2. Direct quotations must not exceed 5% of the content of a report, must be enclosed in quotation marks, and must be attributed to the source by a numerical reference citation[1]. Note that engineering reports rarely contain direct quotations.
3. Material paraphrased or taken from a source must be attributed to the source by a numerical reference citation.
4. Text that is inserted from a web site must be enclosed in quotation marks and attributed to the web site by numerical reference citation.
5. Drawings, diagrams, photos, maps or other visual material taken from a source must be attributed to that source by a numerical reference citation.
6. No part of any assignment, lab report or project report submitted for this course can be submitted for any other course.
7. In preparing your submissions, the work of other past or present students cannot be consulted, used, copied, paraphrased or relied upon in any manner whatsoever.
8. Your submissions must consist entirely of your own or your group's ideas, observations, calculations, information and conclusions, except for statements attributed to sources by numerical citation.
9. Your submissions cannot be edited or revised by any other student.
10. For lab reports, the data must be obtained from your own or your lab group's experimental work.
11. For software, the code must be composed by you or by the group submitting the work, except for code that is attributed to its sources by numerical reference.

You must write one of the following statements on each piece of work that you submit:
For individual work: **"I certify that this submission is my original work and meets the Faculty's Expectations of Originality",** with your signature, I.D. #, and the date.
For group work: **"We certify that this submission is the original work of members of the group and meets the Faculty's Expectations of Originality",** with the signatures and I.D. #s of all the team members and the date.

A signed copy of this form must be submitted to the instructor at the beginning of the semester in each course. I certify that I have read the requirements set out on this form, and that I am aware of these requirements. I certify that all the work I will submit for this course will comply with these requirements and with additional requirements stated [illegible] outline.

Course Number:	Inse 691	Instructor:	Dr.Anjali Awasthi
Name:		I.D. #	
Signature:		Date:	

[1] Rules for reference citation can be found in "Form and Style" by Patrich MacDonagh and Jack Bordan, fourth edition, May, 2000, available at http://www.encs.concordia.ca/scs/Forms/Form&Style.pdf.
Approved by the ENCS Faculty Council February 10, 2012

Keerthi Sanna Reddy	Chakri Gorantla	Nithish Reddy Yalaka	Sisinder Reddy Valmiki	Venu Babu Podila
40159954	40165176	40164619	40186128	40159998
Keerthi S.	G. Chakri			Venu Babu

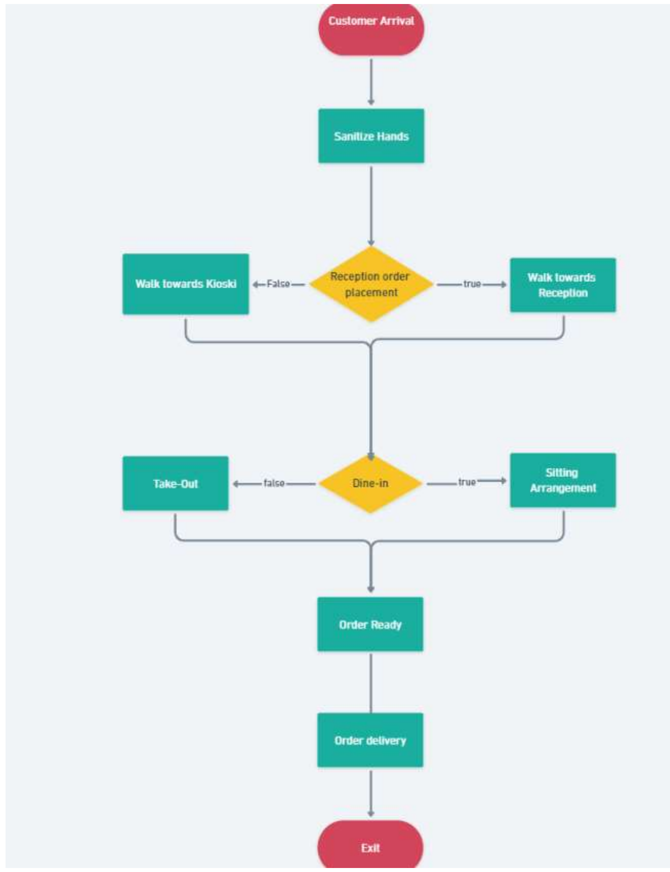
(Question 1)

Consider the following systems. Develop conceptual models using the following category of simulations.

A. Tim Hortons Restaurant - Discrete Event (Process Map)

Timhortons is one of the major franchise holders that deal with thousands of customers per day. For dealing with that they need to have a proper process of the delivery of their products to the customers. Here, we try to bring up a process map to ensure the smooth service for the customers.

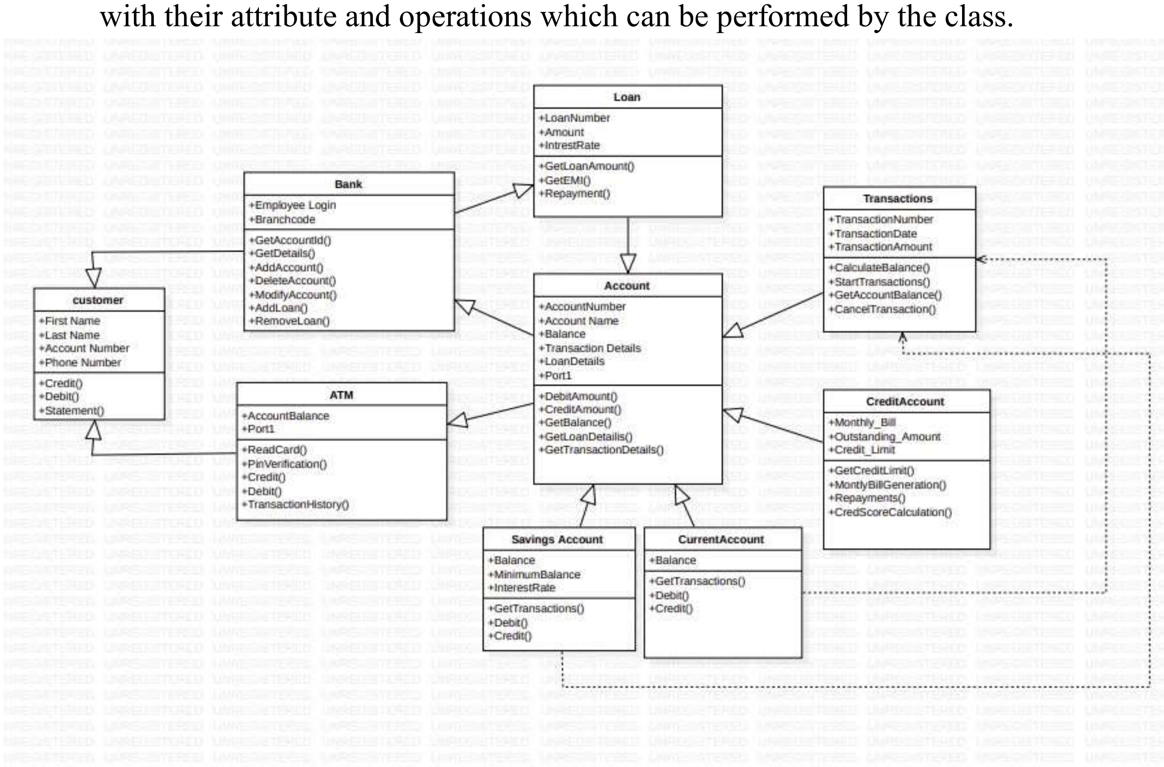
- The first in the process when the customer arrives into the store is to sanitize their hands, for that the store should provide a proper sanitization facility.
- The second step for the customer is to decide whether the order is from reception or from the kiosk. If it is from the reception, the customer should move towards the reception queue orelse he have to move towards the kiosk queue.
- Once the customer is done with the order placement, the customer should decide to either Dine-in or take-away.
- If it is take-away the customer just needs to wait for this turn for the packed order to get ready.
- For Dine-in the customer should make himself seated if the seats are available or wait for his/her turn to get seated.
- At last, the final step is to exit either for Dine-in or Take-away.



B. TD Canada Bank - Agent Based (Class diagram, state transition diagram, sequence diagram, use case diagram)

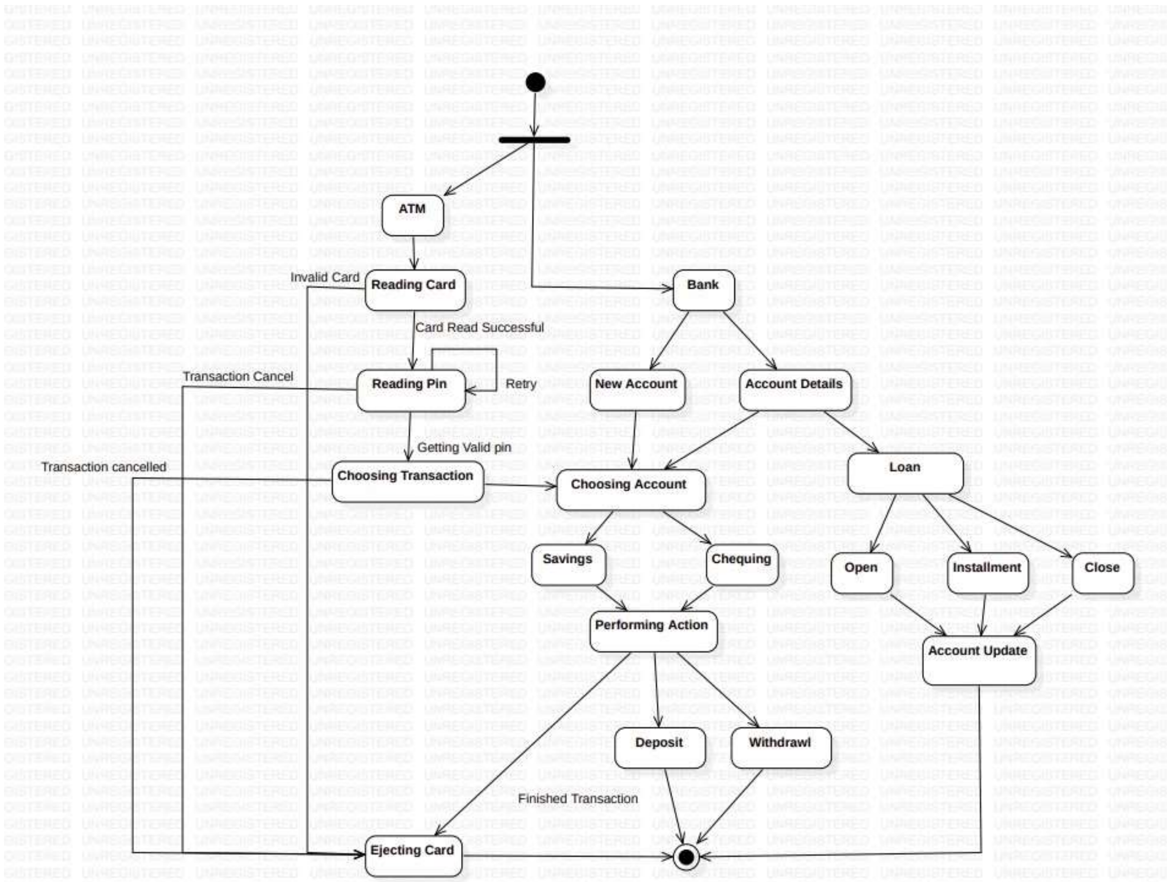
1. **Class diagram**

By using class diagram, we will be able to determine the class of each level with their attribute and operations which can be performed by the class.



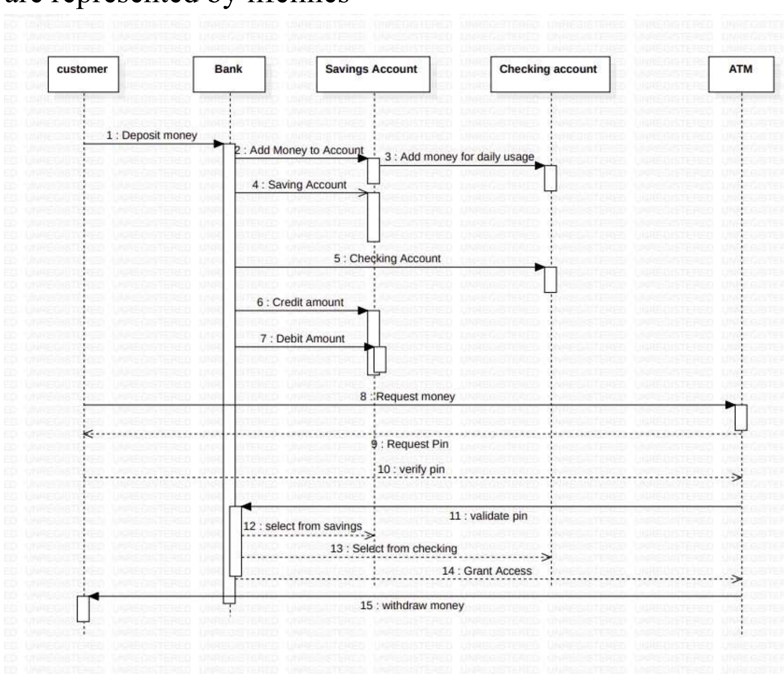
2. State Transition diagram

By using the state transition diagram, we will be able determine the behavior of the objects and flow of the system.



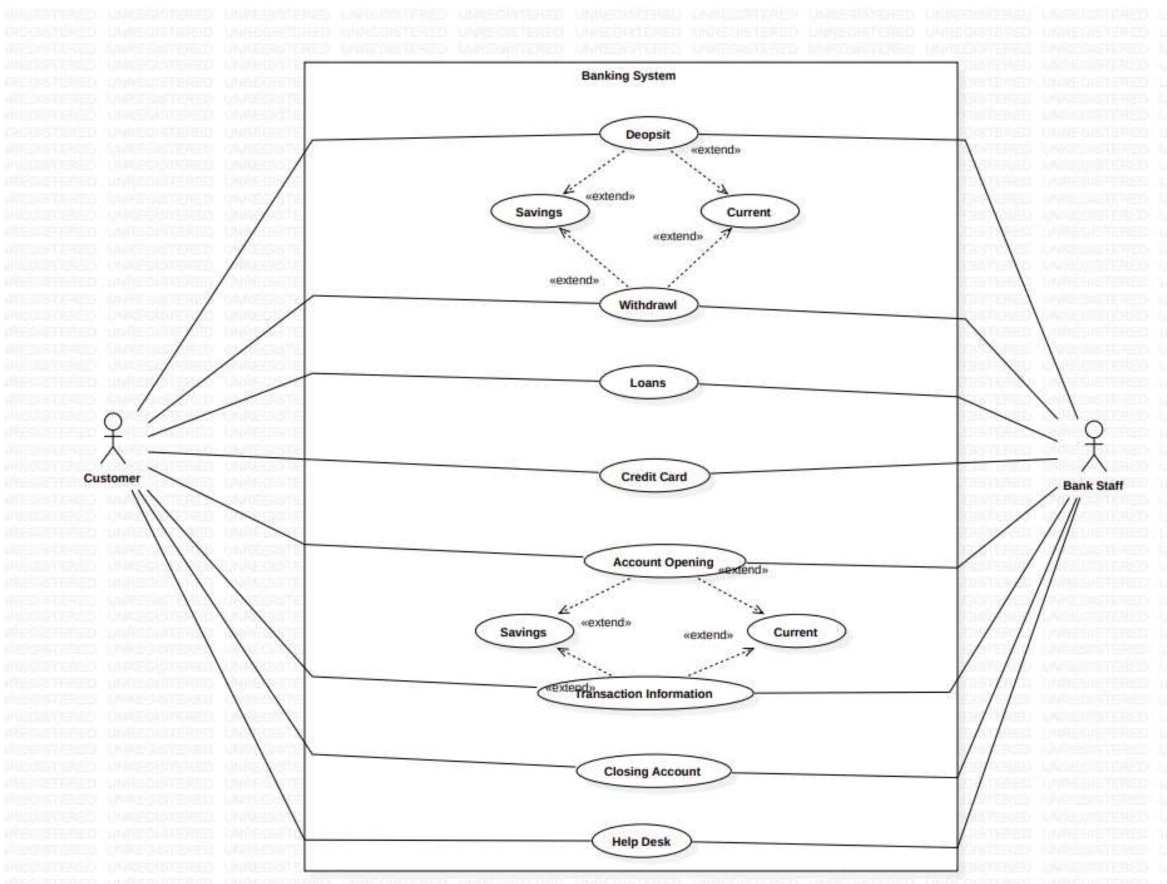
3. Sequence diagram

Sequence diagram helps in determining the interaction of the objects which are represented by lifelines



4 Use case diagram

Helps to determines interactions of the customer and bank staff with the system in different ways.



C. BIXI Bike sharing system - System Dynamics (Causal loop, Stock flow)

BIXI sharing system:

BIXI bicycle is also known as BIXI Montreal as it started in Montreal, it is also the north America's first large scale bike sharing system. Public bike system company was held in losses till 2013, soon Montreal city bought the shares and was serving the city of Montreal and Quebec without profits. This bike sharing system had started before four decades and became unsuccessful in the first two eras and then it began surging at which we are in the fourth decade.

The stand behind BIXI's successfully operation is due to advancement of technology, the process they follow is people will book a bixi bicycle through their mobile app and gets a unique access code so that the specified person will be responsible if the bike is stolen and can unlock the bicycle from the docker and may explore the places he likes, later on after using, it can be docked at his/her nearest dock station, as soon as he docks he gets an indication about the status of the bicycle.

Elements of BIXI bicycle sharing system:

Here we have used different functionalities like Person booking an electrical bicycle, Person booking a normal bicycle, Person coming near the bixi station to unlock the bicycle by using the passcode, income generated, bixi stand, functional cycles, nonfunctional cycles, available docks, normal functional cycles, electric functional cycles, solar power generated at stand, power consumed, remaining solar power in stand, bicycles not working properly, person no longer needed the bicycle, person with low battery with the electric cycle, nearest bike stand to dock the bicycle, no more battery left in the electric cycle to drive and person docking the bixi bike to the station are the variables used in implementing the casual loop, stock & flow diagrams of sharing system.

Causal loop diagram:

It is a Causal diagram that aids in visualizing how different variables in a system are causally interrelated. The diagram consists of a set of words and arrows. Causal loop diagrams are accompanied by a narrative that describes the causally closed situation the CLD describes. Closed loops, or causal feedback loops, in the diagram, are very important features of CLDs.

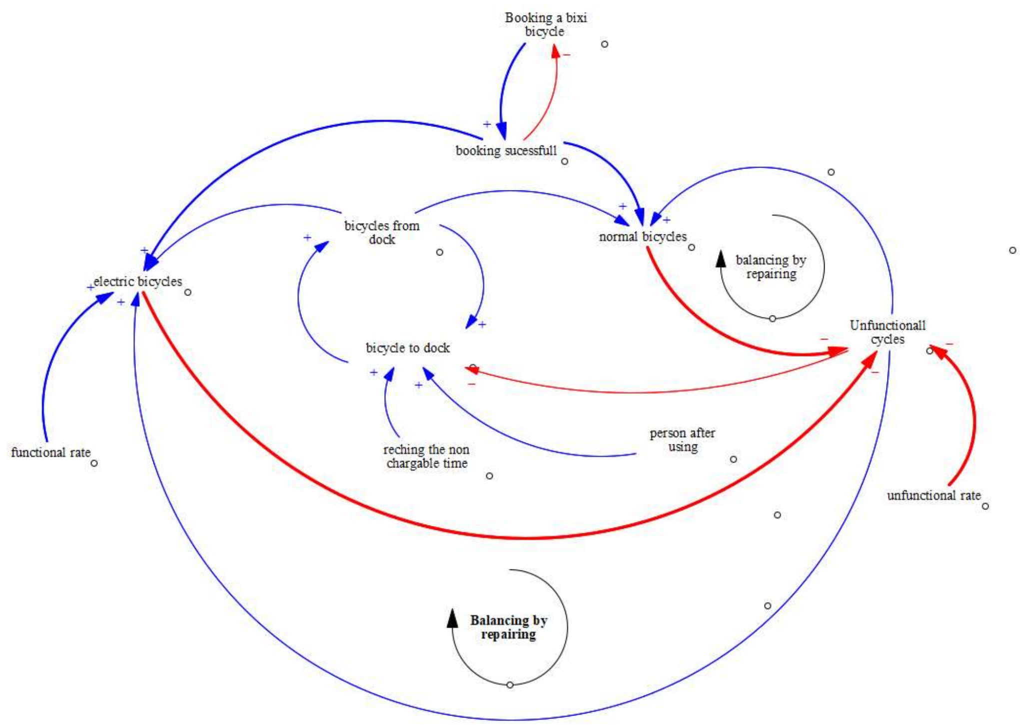


Fig 1.C.1 : casual loop diagram of bixi

Stock flow diagram:

Economics, business, accounting, and related fields often distinguish between quantities that are stocks and those that flow. These differ in their units of measurement. A stock is measured at one specific time and represents a quantity existing then (say, December 31, 2004), which may have accumulated in the past. A flow variable is measured over an interval of time. Therefore, a flow would be measured per unit of time (say a year). Flow is roughly analogous to rate or speed in this sense.

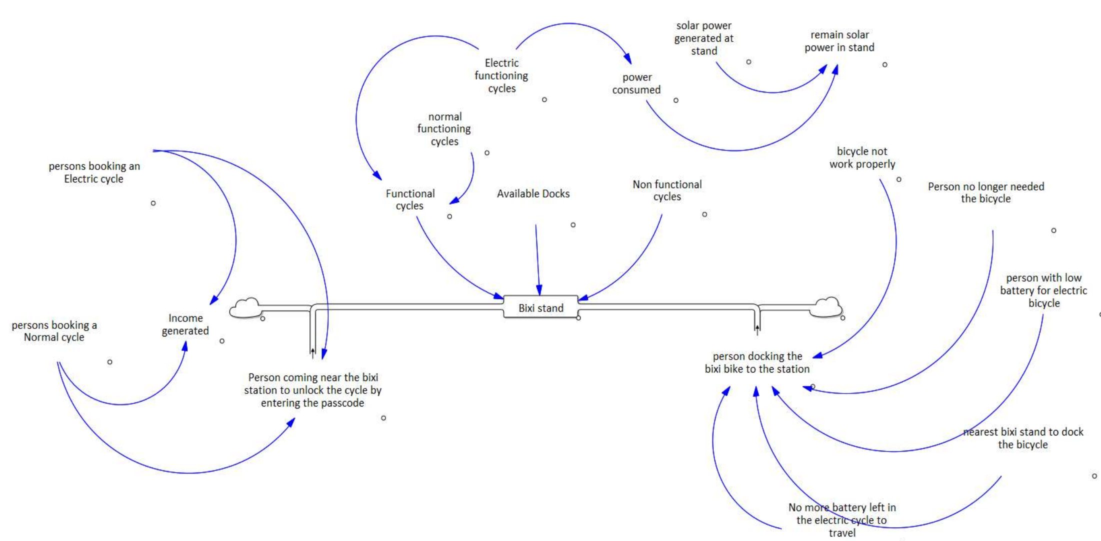


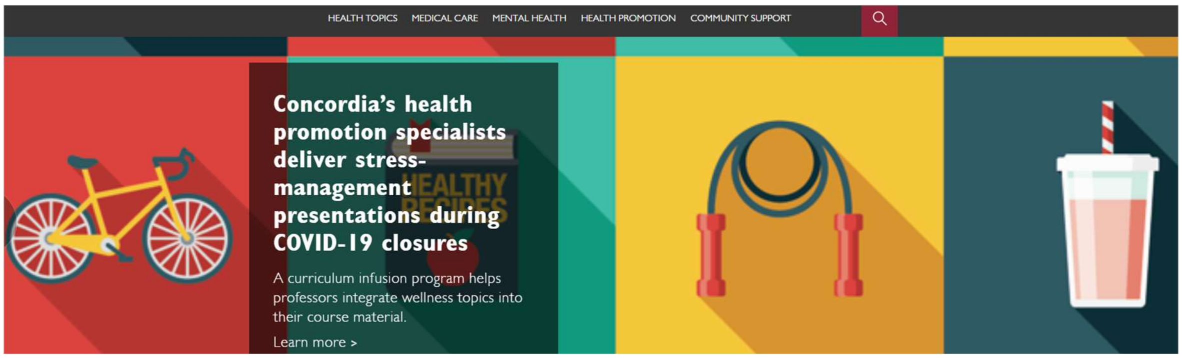
Fig 1.C.2 : Stock & Flow diagram of Bixi

D. Concordia Healthcare clinic - Monte Carlo (Sensitivity Analysis, Scenario Analysis)

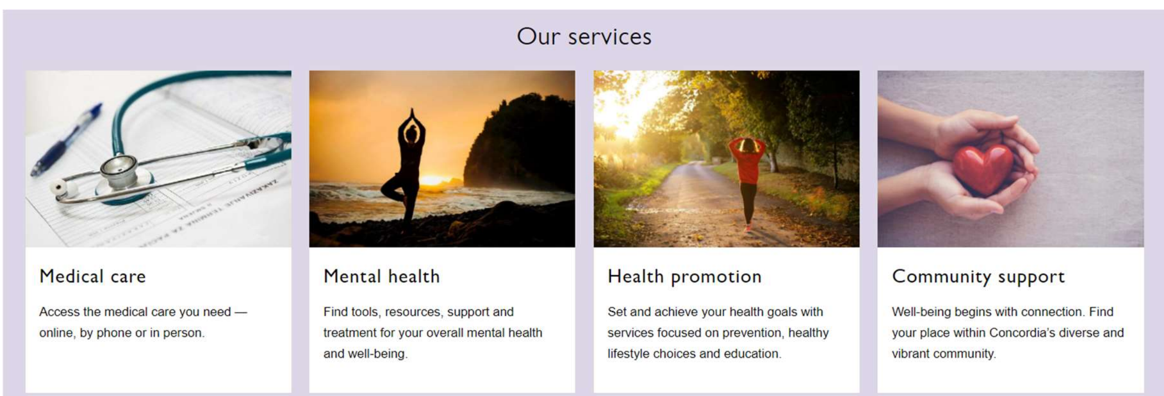
System: Concordia Healthcare Clinic

Health Services is your on-campus clinic staffed by nurses, family doctors, psychiatrists, and health promotion specialists. Services are free to access for all *Concordia students who pay student services fees* and *employees* who receive this benefit through their collective agreements.

Health Services offers confidential virtual appointments, available anywhere in Canada, as well as a limited number of in-person, pre-booked appointments.

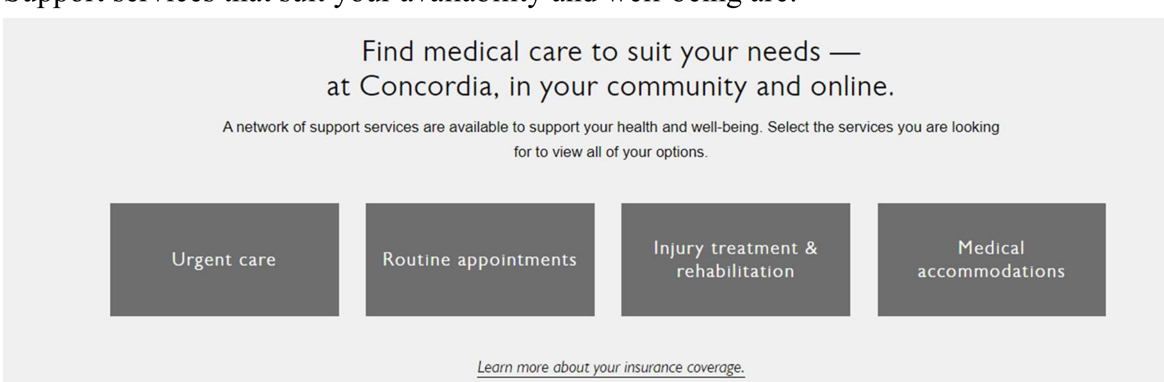


Services provided by healthcare clinic are:



Along with these major services, Concordia Healthcare clinic also provide services like **Academic Accommodations**, **Fitness & recreation**, and **financial wellness**.

Support services that suit your availability and well-being are:



Monte Carlo (Sensitivity Analysis, Scenario Analysis)

The objectives of Monte Carlo Simulation are:

1. Input Modelling
2. Random Number Generation
3. Process Mapping
4. Output Analysis
5. Design of experiments.

Sensitivity Analysis(Monte Carlo) of Concordia Healthcare Clinic:

Sensitivity analysis is a method that validates how target variables are being influenced based on transitions in other variables known as input variables. This model is also referred to as what-if or simulation analysis. It is an approach to predict the result of a decision given a certain range of variables.

The design and analysis of clinical trials often depends on assumptions that may have some effect, influence, or impact on the completion if they are not met. It is crucial to determine these effects through sensitivity analysis. Consistency between the results of primary analysis and the results of sensitivity analysis may enhance the outcome or integrity of the conclusion. However, it is necessary to mark that the significance of consistency may depend in part on the area of analysis, the conclusion of interest or even the conclusions of the discovery or results.

The Input modelling for sensitivity analysis-static is taken on hourly basis from 08:00 Am to 07:00 PM. In the data set we are assuming the values of two input values which are no. of patients(**λ**) and the no. of staff in the clinic(**μ**). The output elements based on these input feeds are Average number of patients in line denoted as '**Lq**', average number of patients in the system denoted as '**Ls**', waiting time(measured in minutes) of the patients denoted as '**Wq**' and the service time(measured in minutes, same as wait time) of the patients inside the clinic denoted as '**Ws**'.

Concordia Health Care Clinc - Monte Carlo

Sensitivity Analysis

Timeline	No. of patients per Day(λ)	No. of Staff in Clinic(μ)	Avg no of patients in waiting (Lq)	Avg no of patients in system (Ls)	Wait time (Wq)	Wq converted to min	Service time (Ws)	Ws in min	Wq in hrs
08:00-09:00	8	15	29.86666667	1.142857143	3.733333333	5376	0.142857143	205.714286	89.6
09:00-10:00	6	17	23.29411765	0.545454545	3.882352941	5590.588235	0.090909091	130.909091	93.17647059
10:00-11:00	11	20	54.45	1.222222222	4.95	7128	0.111111111	160	118.8
11:00-12:00	7	14	24.5	1	3.5	5040	0.142857143	205.714286	84
12:00-01:00	14	26	90.46153846	1.166666667	6.461538462	9304.615385	0.083333333	120	155.0769231
02:00-03:00	17	27	107.037037	1.7	6.296296296	9066.666667	0.1	144	151.1111111
03:00-04:00	19	29	124.4827586	1.9	6.551724138	9434.482759	0.1	144	157.2413793
04:00-05:00	9	19	42.63157895	0.9	4.736842105	6821.052632	0.1	144	113.6842105
05:00-06:00	12	25	74.88	0.923076923	6.24	8985.6	0.076923077	110.769231	149.76
06:00-07:00	4	9	8.888888889	0.8	2.222222222	3200	0.2	288	53.33333333

Fig1.D.1: Model designed for Sensitivity Analysis-static

The output values(Lq, Ls, Wq, and Ws) are calculated using the two input feeds with formula's given below. These formulas are taken from the class notes.

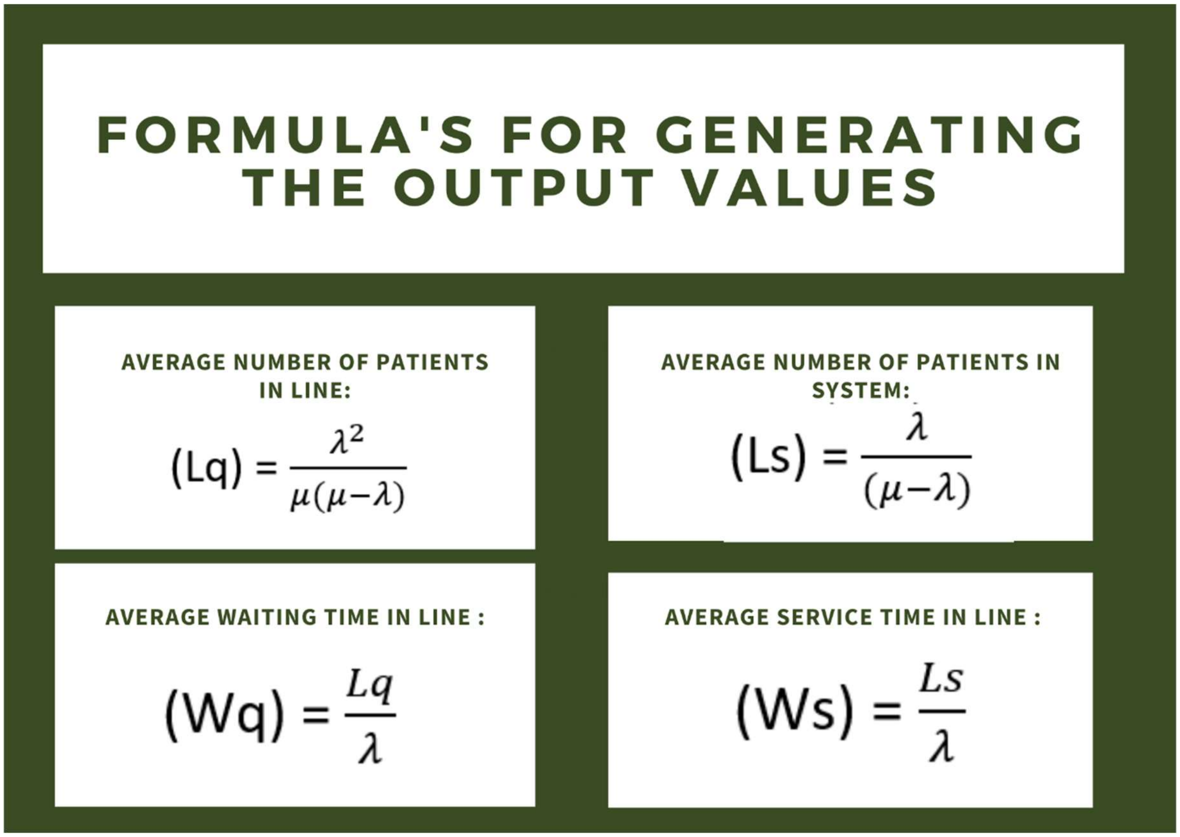


Fig1.D.2: Formula’s for calculating the outputs

With this data report, we have developed the conceptual model of Sensitivity Analysis of Monte Carlo Simulation. We have also simulated the model in excel and clearly stated with the representation.

Below graphical representation states the sensitivity analysis for static simulation of Monte Carlo Model

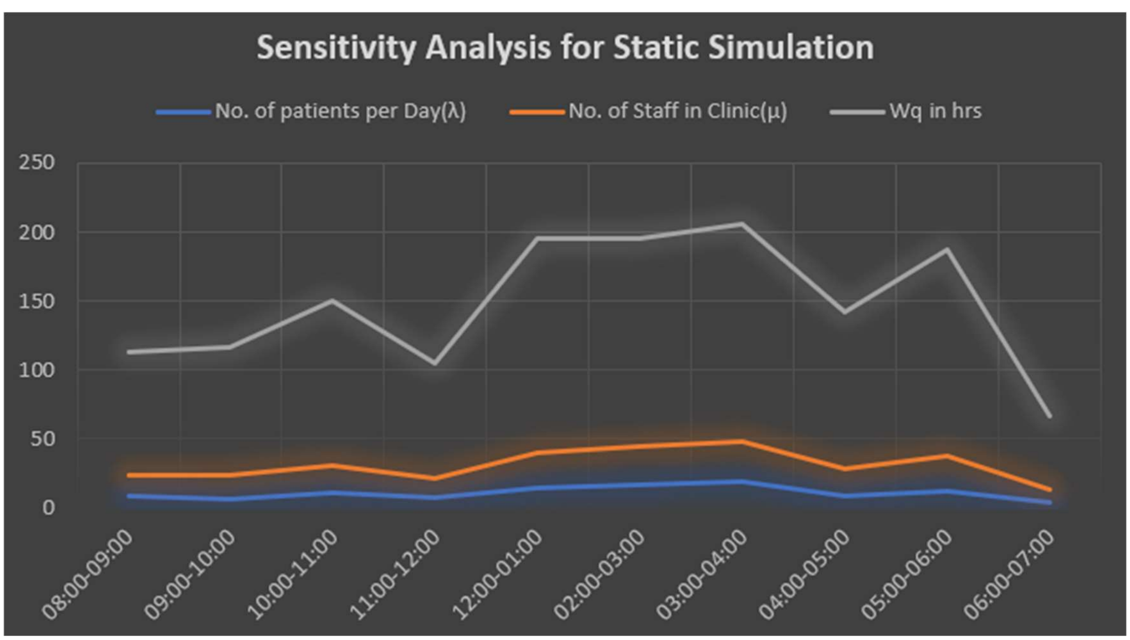


Fig1.D.3: Sensitivity Analysis for static simulation

Scenario Analysis(Monte Carlo) of Concordia Healthcare Clinic:

In deterministic models, it's very crucial to model different sequence of values for diverse inputs to see the effects of various outline scenarios. Using Monte Carlo simulation, we can analyze exactly which inputs had which values combinedly when certain results appear. This is helpful for ensuing further research.

The Input modelling for scenario analysis is taken on biweekly(14-day) basis from 08:00 Am to 07:00 PM. In the data set we are assuming the values of two input values which are no. of patients(**λ**) and the no. of staff in the clinic(**μ**). The output elements based on these input feeds are Average number of patients in line denoted as '**Lq**', average number of patients in the system denoted as '**Ls**', waiting time(measured in minutes) of the patients denoted as '**Wq**' and the service time(measured in minutes, same as wait time) of the patients inside the clinic denoted as '**Ws**'.

Concordia Health Care Clinc - Monte Carlo										
	Scenario Analysis									
Timeline	**No. of patients per Day(λ)**	**No. of Staff in Clinic(μ)**	**Avg no of patients in waiting (Lq)**	**Avg no of patients in system (Ls)**	**Wait time (Wq)**	**Wq converted to min**	**Service time (Ws)**	**Ws in min**	**Wq in hrs**
Day-1	107	120	1240.308333	8.230769231	11.59166667	16692	0.076923077	110.7692308	278.2
Day-2	91	104	1035.125	7	11.375	16380	0.076923077	110.7692308	273
Day-3	126	130	488.4923077	31.5	3.876923077	5582.769231	0.25	360	93.04615385
Day-4	87	97	780.3092784	8.7	8.969072165	12915.46392	0.1	144	215.257732
Day-5	115	121	655.785124	19.16666667	5.702479339	8211.570248	0.166666667	240	136.8595041
Day-6	123	128	590.9765625	24.6	4.8046875	6918.75	0.2	288	115.3125
Day-7	64	84	975.2380952	3.2	15.23809524	21942.85714	0.05	72	365.7142857
Day-8	96	110	1172.945455	6.857142857	12.21818182	17594.18182	0.071428571	102.8571429	293.2363636
Day-9	89	111	1569.927928	4.045454545	17.63963964	25401.08108	0.045454545	65.45454545	423.3513514
Day-10	117	126	977.7857143	13	8.357142857	12034.28571	0.111111111	160	200.5714286
Day-11	125	134	1049.440299	13.88888889	8.395522388	12089.55224	0.111111111	160	201.4925373
Day-12	119	125	679.728	19.83333333	5.712	8225.28	0.166666667	240	137.088
Day-13	96	102	542.1176471	16	5.647058824	8131.764706	0.166666667	240	135.5294118
Day-14	99	105	560.0571429	16.5	5.657142857	8146.285714	0.166666667	240	135.7714286

Fig1.D.4: Model designed for Sensitivity Analysis-static

The output values are calculated using the two input feeds with formula's provided in the fig1.D.2 above. These formulas are taken from the class notes.

With this data report, we have developed the conceptual model of Scenario Analysis of Monte Carlo Simulation. We have also simulated the model in excel and clearly stated with the representation.

Below graphical representation states the scenario analysis for static simulation of Monte Carlo Model

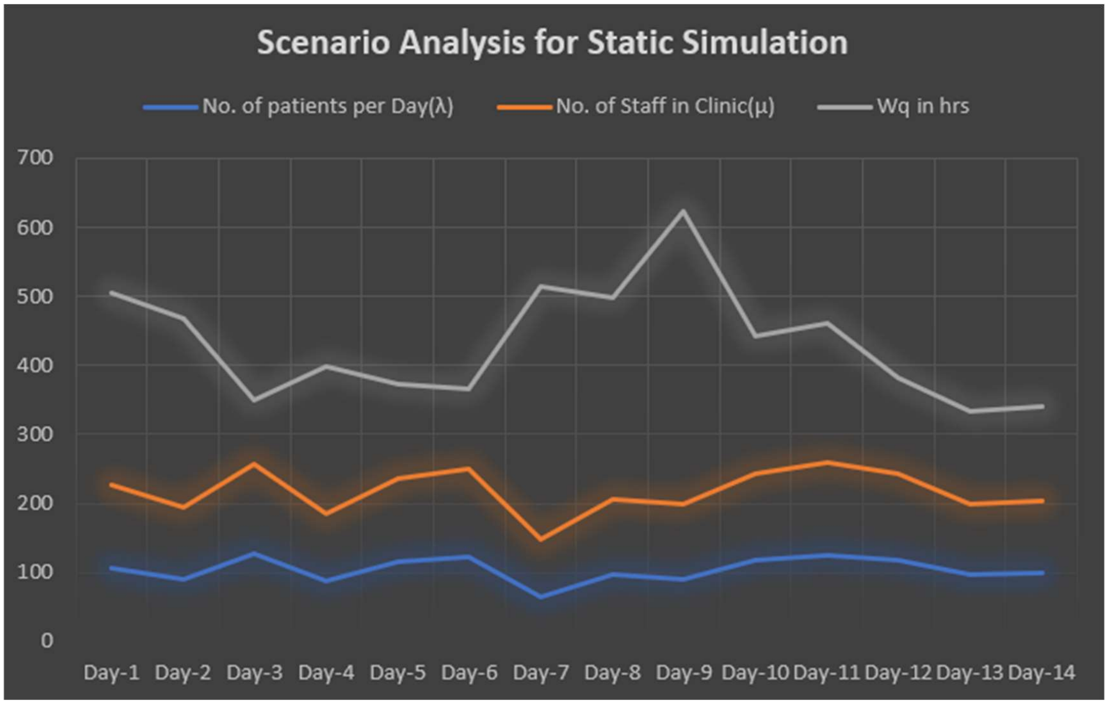


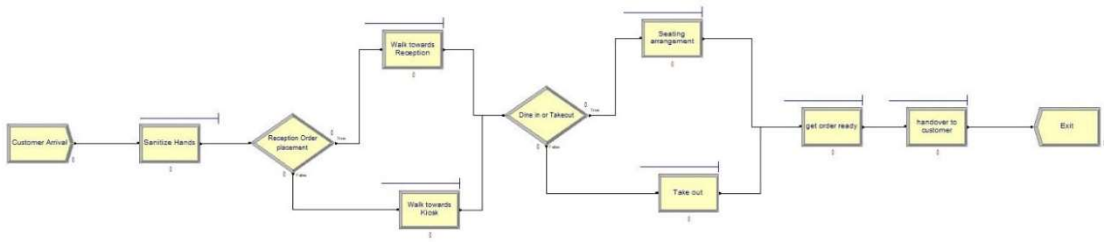
Fig1.D.5: Scenario Analysis for static simulation

(Question 2)

Execute the above four systems using the following tools.

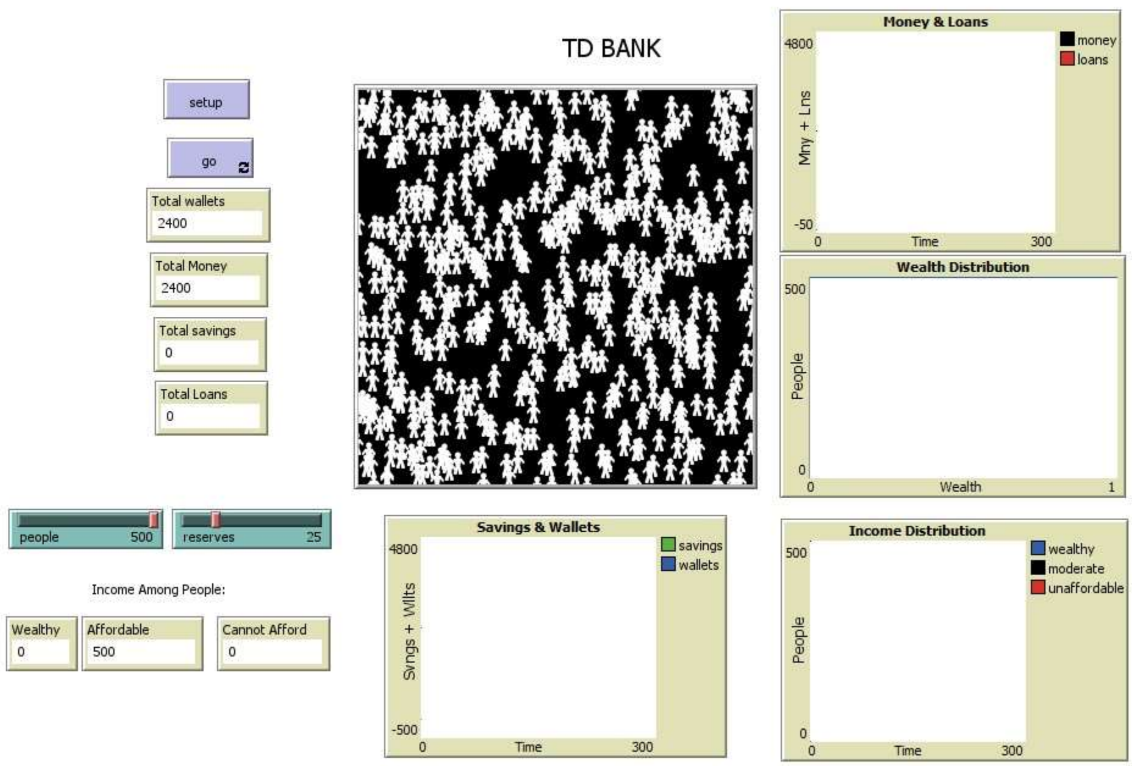
A. Tim Hortons Restaurant (Process Map) (Arena)

The arena simulation process map is shown below:

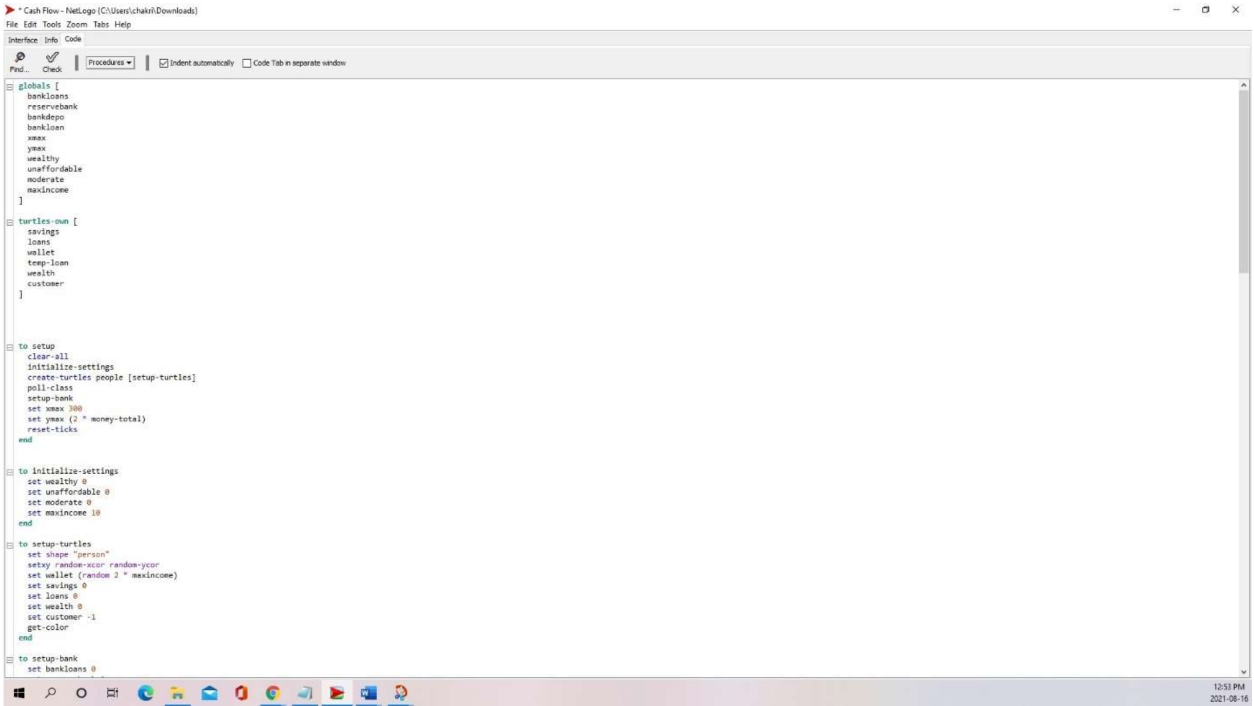


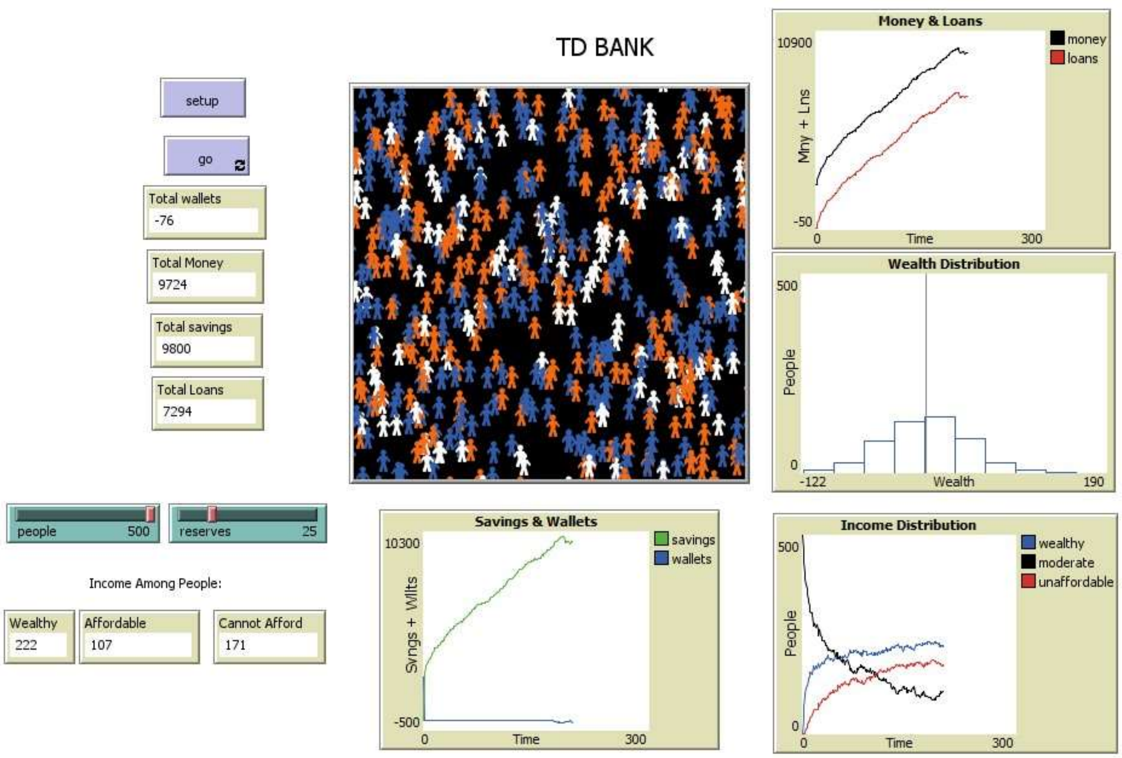
The simulation file is attached for the reports to be validated.

B. TD Canada Bank - Agent Based (Netlogo)

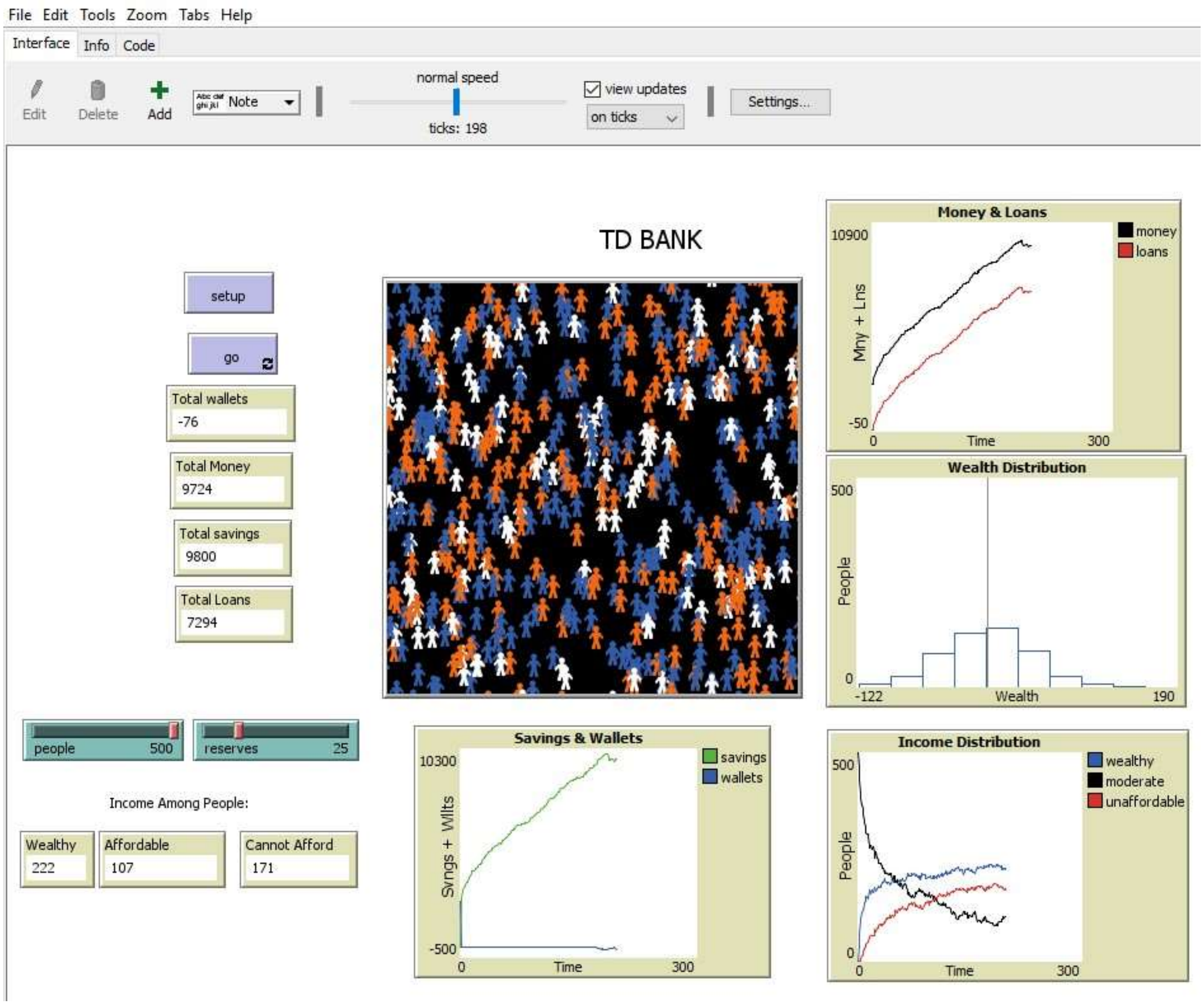


This model is used to describe the workflow of TD banking system. It is the complete representation of how the cash will be passed through all the stages and project every aspect of the transaction performed by the customer.





This model is very simple and easy to understand. It uses basic commands to run the model. It consists of a world and where all the persons and actions can be done. The above model consists of various buttons, sliders and display graphs. These display graphs show the results of the persons activity on how their money is being transferred and how well the customers maintain the bank balances. The SETUP button is used to reset. It returns to the starting state of the model. The GO button is used to start and stop the model and the plotter.



With slider bars we can set total number of people and reserves and compare the model with the other factors to check the income and wealth distribution among the customers with respect to the bank. All these can be done by predefining the commands on to the code and link them to the interface.

The code for the following output is:-

```
globals [
  bankmoney-requested
  reservebank
  bankdepo
  bankloan
  xmax
  ymax
  wealthy
  unaffordable
  moderate
  maxincome
]

turtles-own [
```

```
  currentlysaving
  money-requested
  amountinwallet
  temporaryloan
  wealth
  user
]



to setup
  clear-all
  initialize-settings
  create-turtles people [turtlessetup]
  classpoll
  banksetup
  set xmax 500
  set ymax (2 * totalmoney)
  reset-ticks
end


to initialize-settings
  set wealthy 0
  set unaffordable 0
  set moderate 0
  set maxincome 10
end

to turtlessetup
  set shape "person"
  setxy random-xcor random-ycor
  set amountinwallet (random 2 * maxincome)
  set currentlysaving 0
  set money-requested 0
  set wealth 0
  set user -1
  get-color
end

to banksetup
  set bankmoney-requested 0
  set reservebank 0
  set bankdepo 0
  set bankloan 0
end


to go
  ask turtles [runbusiness]
```

```
  ask turtles [
    remainingbalance-books
    get-color
  ]
  summarybalance
  classpoll
  tick
end

to classpoll
  set wealthy (countturtles with [currentlysaving > maxincome])
  set unaffordable (countturtles with [money-requested > maxincome])
  set moderate (countturtles) - (wealthy + unaffordable)
end

to runbusiness
  rt random 360
  fd 1



to remainingbalance-books
  ifelse (amountinwallet < 0)
   [ifelse (currentlysaving >= (- amountinwallet))
      [draw-money (- amountinwallet)]
      [if (currentlysaving > 0)
         [draw-money currentlysaving]
       set temporaryloan bankloan
       ifelse (temporaryloan >= (- amountinwallet))
         [takingloan(- amountinwallet)]
         [takingloantemporaryloan]
      ]
   ]
   [depositiinsavings amountinwallet]

  if (money-requested > 0) and (currentlysaving > 0) [
    ifelse (currentlysaving >= money-requested)
      [draw-money money-requested
       payloan money-requested]
      [draw-money currentlysaving
       payloan amountinwallet]
  ]
end



to summarybalance
  set bankdepo sum [currentlysaving] of turtles
  set bankloan sum [money-requested] of turtles
  set reservebank ((reserves / 100) * bankdepo)
  set bankloan (bankdepo - (reservebank + bankloan))
```

```
end


to depositiinsavings [totalamount]
  set amountinwallet (amountinwallet - totalamount)
  set currentlysaving (currentlysaving + totalamount)
end

to draw-money [totalamount]
  set amountinwallet (amountinwallet + totalamount)
  set currentlysaving (currentlysaving - totalamount)
end


to payloan [totalamount]
  set money-requested (money-requested - totalamount)
  set amountinwallet (amountinwallet - totalamount)
  set bankloan (bankloan + totalamount)
end

to takingloan[totalamount]
  set money-requested (money-requested + totalamount)
  set amountinwallet (amountinwallet + totalamount)
  set bankloan (bankloan - totalamount)
end


to get-color
  set color white
  if (currentlysaving > maxincome) [set color blue]
  if (money-requested > maxincome)  [set color orange]
  set wealth (currentlysaving - money-requested)
end


to-report currentlysaving-total
  report sum [currentlysaving] of turtles
end

to-report money-requested-total
  report sum [money-requested] of turtles
end

to-report totalamountinwallets
  report sum [amountinwallet] of turtles
end

to-report totalmoney
  report sum [amountinwallet + currentlysaving] of turtles
end
```

C. BIXI Bike sharing system - System Dynamics (Vensim)

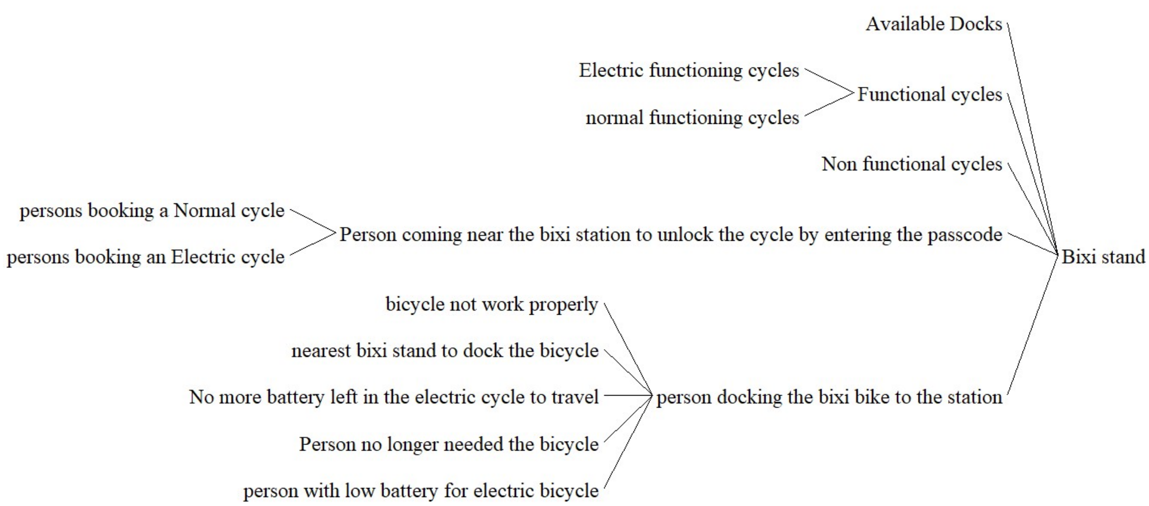
Execution of BIXI bike sharing system-Vensim:

Vensim:

Vensim is a simulation software developed by Ventana Systems. It primarily supports continuous simulation (system dynamics), with some discrete event and agent-based modeling capabilities and provides a graphical modeling interface with stock and flow and causal loop diagrams, on top of a text-based system of equations in a declarative programming language. Vensim can be used to solve a variety of problems. There are several example applications at our corporate website, in the resources, and of course in the models that come with Vensim. Still, that is only a small sample of things that can be done, and the applications of Vensim are as follows

- Work education mismatch.
- New C-roads and world climate simulators.
- Integrated sustainable development goals planning model.
- Energy policy simulator.
- Game change Rio.

<u>Tree diagram of BIXI :</u>



Causal loop diagram:

It is a Causal diagram that aids in visualizing how different variables in a system are causally interrelated. The diagram consists of a set of words and arrows. Causal loop diagrams are accompanied by a narrative that describes the causally closed situation the CLD describes. Closed loops, or causal feedback loops, in the diagram, are very important features of CLDs.

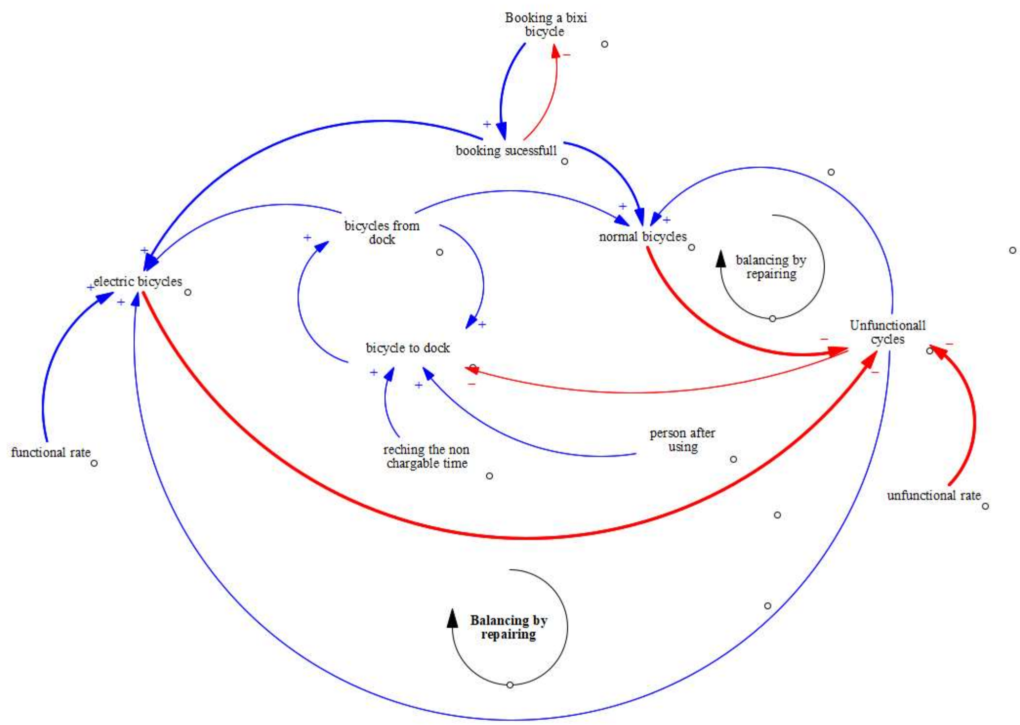


Fig: Casual loop diagram for BIXI bike sharing system

Stock flow diagram:

Economics, business, accounting, and related fields often distinguish between quantities that are stocks and those that flow. These differ in their units of measurement. A stock is measured at one specific time and represents a quantity existing then (say, December 31, 2004), which may have accumulated in the past. A flow variable is measured over an interval of time. Therefore, a flow would be measured per unit of time (say a year). Flow is roughly analogous to rate or speed in this sense.

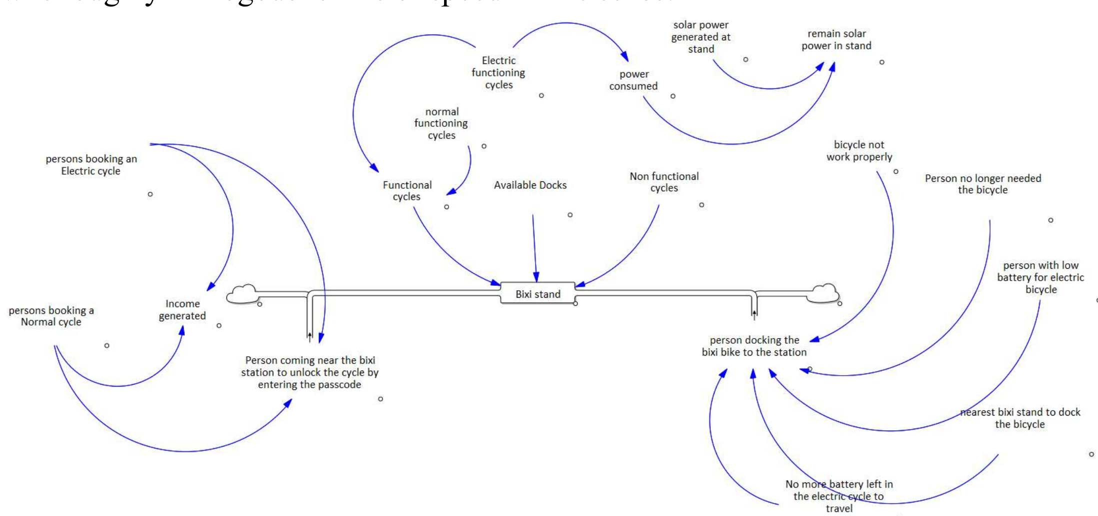


Fig: Stock & Flow diagram for BIXI bike sharing system

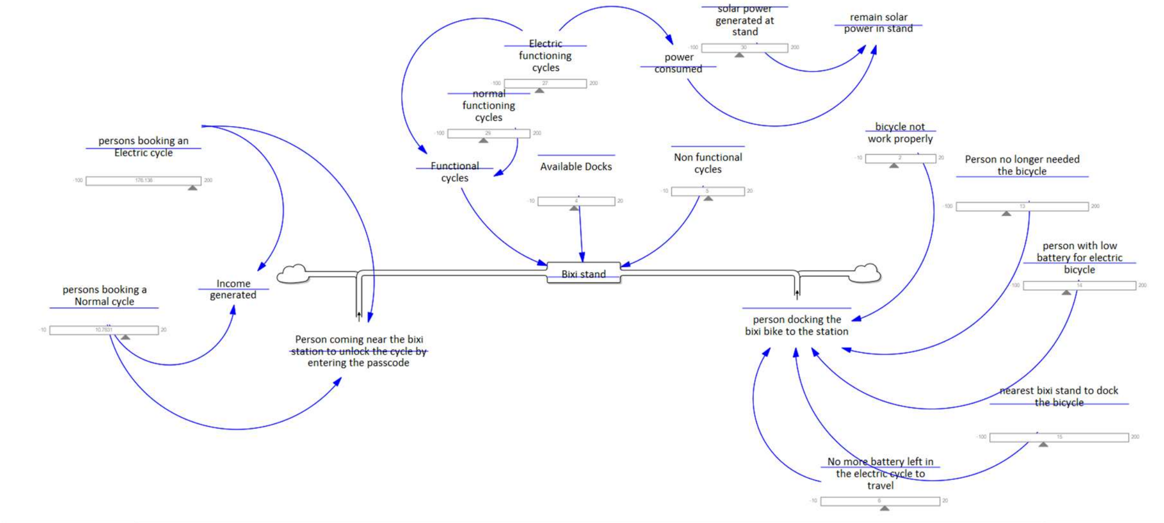
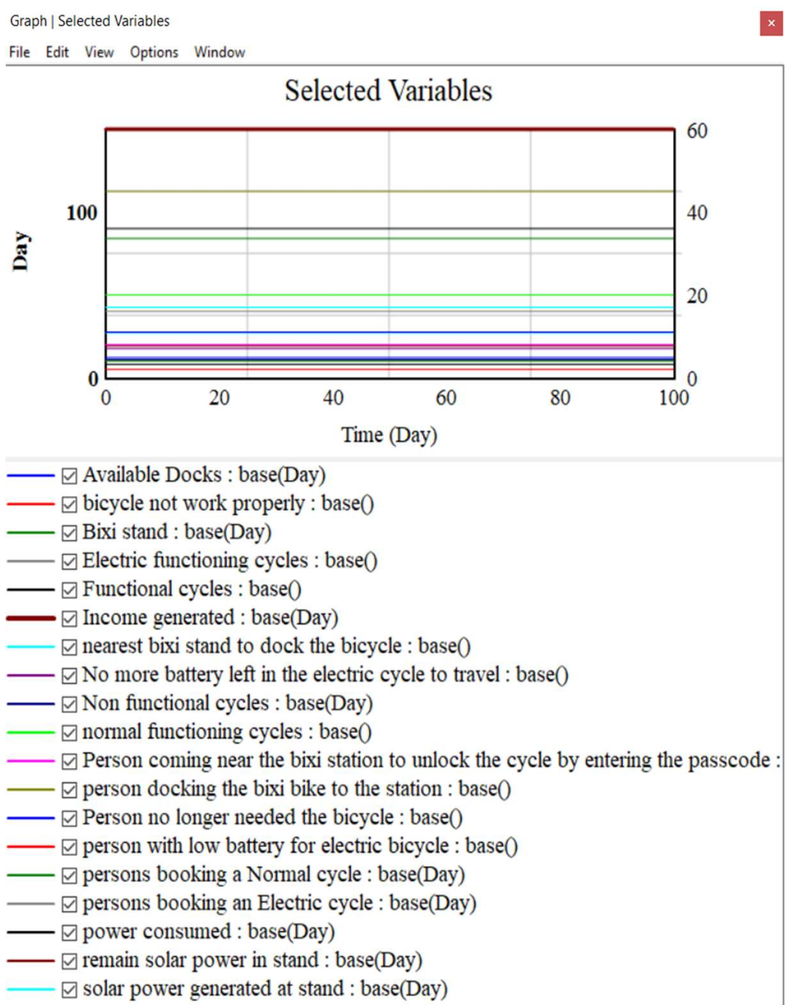


Fig: Execution of Stock & Flow diagram of BIXI bike sharing system

System dynamics output for Vensim:

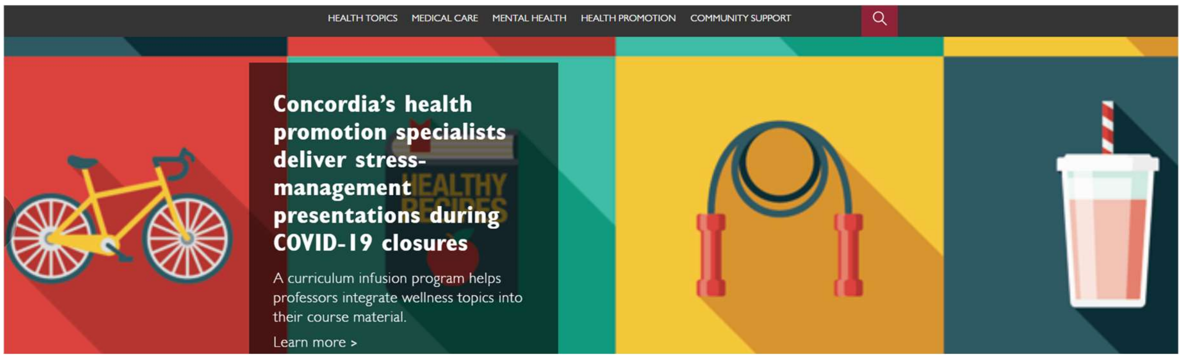


D. Concordia Healthcare Clinic – Monte Carlo (Sensitivity Analysis, Scenario Analysis) Excel Tool

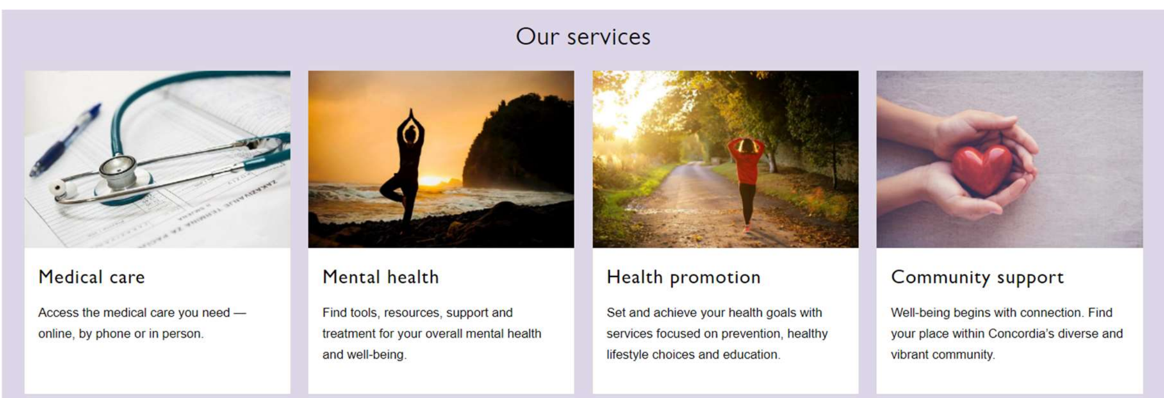
<u>System</u>: Concordia Healthcare Clinic

[Health Services](#) is your on-campus clinic staffed by nurses, family doctors, psychiatrists, and health promotion specialists. Services are free to access for all *Concordia students who pay student services fees* and *employees* who receive this benefit through their collective agreements.

Health Services offers confidential virtual appointments, available anywhere in Canada, as well as a limited number of in-person, pre-booked appointments.

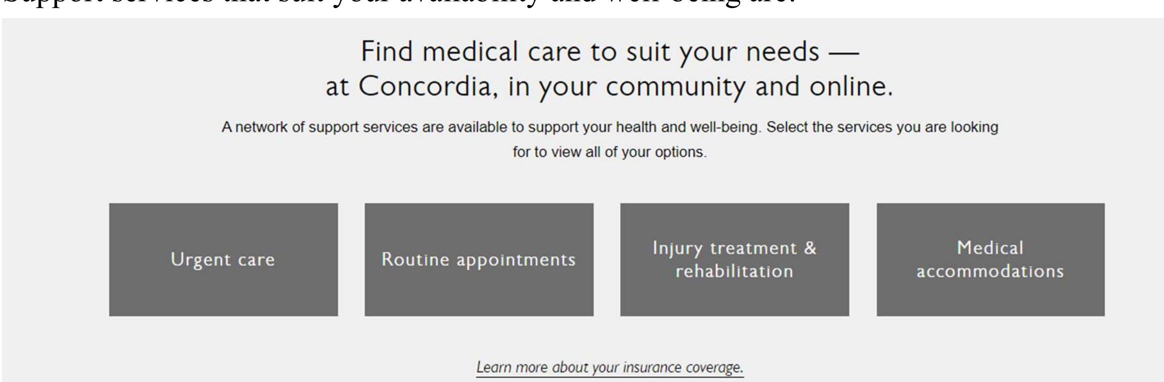


Services provided by healthcare clinic are:



Along with these major services, Concordia Healthcare clinic also provide services like **Academic Accommodations**, **Fitness & recreation**, and **financial wellness**.

Support services that suit your availability and well-being are:



Sensitivity Analysis(Monte Carlo) of Concordia Healthcare Clinic:

Sensitivity analysis is a method that validates how target variables are being influenced based on transitions in other variables known as input variables. This model is also referred to as what-if or simulation analysis. It is an approach to predict the result of a decision given a certain range of variables.

The design and analysis of clinical trials often depends on assumptions that may have some effect, influence, or impact on the completion if they are not met. It is crucial to determine these effects through sensitivity analysis. Consistency between the results of primary analysis and the results of sensitivity analysis may enhance the outcome or integrity of the conclusion. However, it is necessary to mark that the significance of consistency may depend in part on the area of analysis, the conclusion of interest or even the conclusions of the discovery or results.

The Input modelling for sensitivity analysis-dynamic is taken on hourly basis from 08:00 Am to 07:00 PM. In the data set we are **randomizing** the values of two input values which are no. of patients(**λ**) and the no. of staff in the clinic(**μ**) as the model is dynamic. The output elements based on these input feeds are Average number of patients in line denoted as '**Lq'**, average number of patients in the system denoted as '**Ls'**, waiting time(measured in minutes) of the patients denoted as '**Wq'** and the service time(measured in minutes, same as wait time) of the patients inside the clinic denoted as '**Ws'**.

Concordia Health Care Clinc - Monte Carlo									
Sensitivity Analysis - Dynamic									
Timeline	No. of patients per Day(λ)	No. of Staff in Clinic(μ)	Avg no of patients in waiting (Lq)	Avg no of patients in system (Ls)	Wait time (Wq)	Wq converted to min	Service time (Ws)	Ws in min	Wq in hrs
08:00-09:00	12	30	86.4	0.666666667	7.2	10368	0.055555556	80	172.8
09:00-10:00	16	30	119.4666667	1.142857143	7.466666667	10752	0.071428571	102.8571429	179.2
10:00-11:00	16	28	109.7142857	1.333333333	6.857142857	9874.285714	0.083333333	120	164.5714286
11:00-12:00	16	25	92.16	1.777777778	5.76	8294.4	0.111111111	160	138.24
12:00-01:00	11	30	76.63333333	0.578947368	6.966666667	10032	0.052631579	75.78947368	167.2
02:00-03:00	13	24	77.45833333	1.181818182	5.958333333	8580	0.090909091	130.9090909	143
03:00-04:00	15	28	104.4642857	1.153846154	6.964285714	10028.57143	0.076923077	110.7692308	167.1428571
04:00-05:00	10	22	54.54545455	0.833333333	5.454545455	7854.545455	0.083333333	120	130.9090909
05:00-06:00	18	20	32.4	9	1.8	2592	0.5	720	43.2
06:00-07:00	18	22	58.90909091	4.5	3.272727273	4712.727273	0.25	360	78.54545455

Fig2.D.1: Model designed for Sensitivity Analysis-Dynamic

The output values(Lq, Ls, Wq, and Ws) are calculated using the two input feeds with formula's given below. These formulas are taken from the class notes.

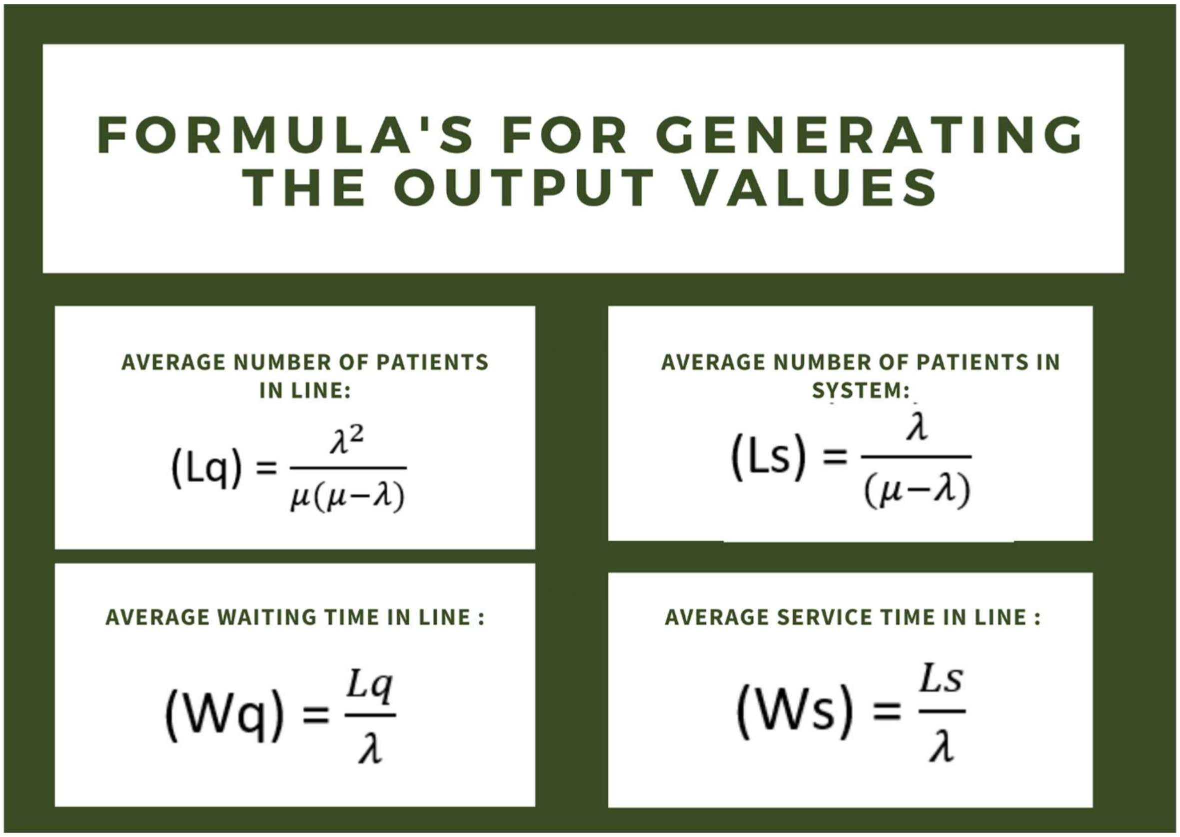


Fig2.D.2: Formula's for calculating the outputs

With this data report, we have developed the conceptual model of Sensitivity Analysis of Monte Carlo Simulation. We have also simulated the model in excel and clearly stated with the representation.

Below graphical representation states the sensitivity analysis for Dynamic simulation of Monte Carlo Model

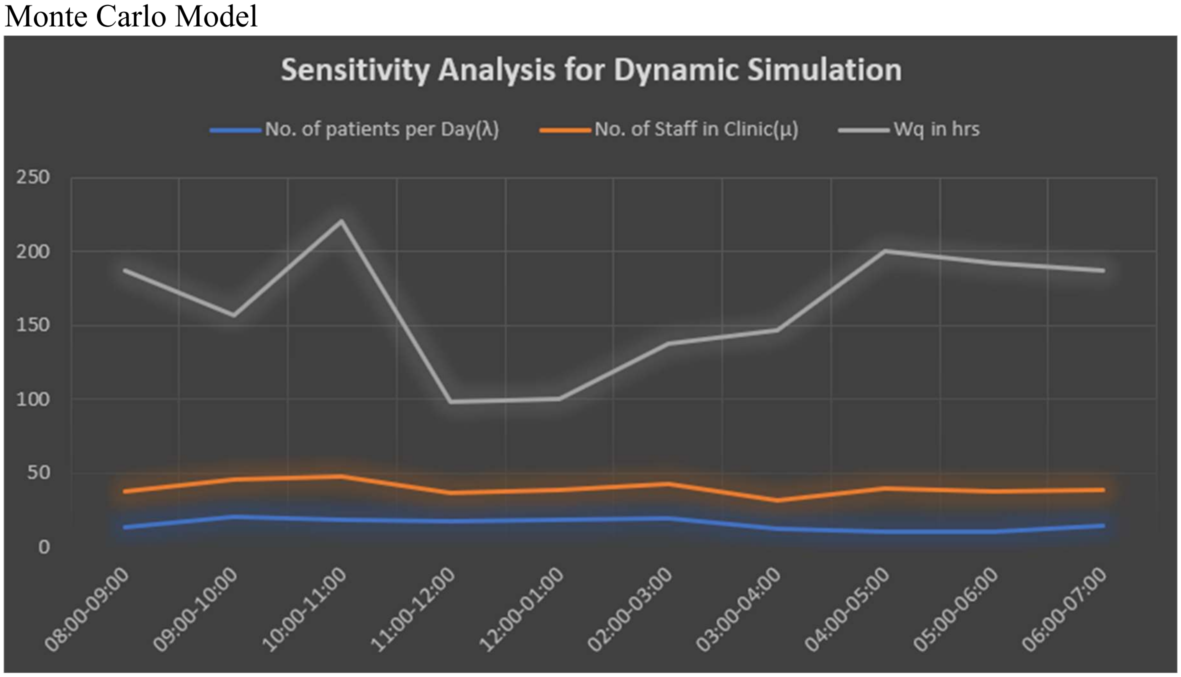


Fig2.D.3: Sensitivity Analysis for Dynamic simulation

Scenario Analysis(Monte Carlo) of Concordia Healthcare Clinic:

In deterministic models, it's very crucial to model different sequence of values for diverse inputs to see the effects of various outline scenarios. Using Monte Carlo simulation, we can analyze exactly which inputs had which values combinedly when certain results appear. This is helpful for ensuing further research.

The Input modelling for scenario analysis is taken on biweekly(14-day) basis from 08:00 Am to 07:00 PM. In the data set we are **randomizing** the values of two input values which are no. of patients(**λ**) and the no. of staff in the clinic(**μ**) as the system is **dynamic**. The output elements based on these input feeds are Average number of patients in line denoted as '**Lq**', average number of patients in the system denoted as '**Ls**', waiting time(measured in minutes) of the patients denoted as '**Wq**' and the service time(measured in minutes, same as wait time) of the patients inside the clinic denoted as '**Ws**'.

Concordia Health Care Clinc - Monte Carlo

Scenario Analysis - Dynamic

Timeline	No. of patients per Day(λ)	No. of Staff in Clinic(μ)	Avg no of patients in waiting (Lq)	Avg no of patients in system (Ls)	Wait time (Wq)	Wq converted to min	Service time (Ws)	Ws in min	Wq in hrs
Day-1	133	158	2798.892405	5.32	21.0443038	30303.79747	0.04	57.6	505.0632911
Day-2	135	156	2453.365385	6.428571429	18.17307692	26169.23077	0.047619048	68.57142857	436.1538462
Day-3	139	154	1881.915584	9.266666667	13.53896104	19496.1039	0.066666667	96	324.9350649
Day-4	139	151	1535.443709	11.58333333	11.04635762	15906.75497	0.083333333	120	265.1125828
Day-5	136	155	2267.251613	7.157894737	16.67096774	24006.19355	0.052631579	75.78947368	400.1032258
Day-6	135	161	2943.167702	5.192307692	21.80124224	31393.78882	0.038461538	55.38461538	523.2298137
Day-7	128	161	3358.21118	3.878787879	26.23602484	37779.87578	0.03030303	43.63636364	629.6645963
Day-8	139	152	1652.453947	10.69230769	11.88815789	17118.94737	0.076923077	110.7692308	285.3157895
Day-9	136	164	3157.853659	4.857142857	23.2195122	33436.09756	0.035714286	51.42857143	557.2682927
Day-10	122	156	3243.948718	3.588235294	26.58974359	38289.23077	0.029411765	42.35294118	638.1538462
Day-11	131	156	2750.160256	5.24	20.99358974	30230.76923	0.04	57.6	503.8461538
Day-12	127	151	2563.549669	5.291666667	20.18543046	29067.01987	0.041666667	60	484.4503311
Day-13	127	160	3326.60625	3.848484848	26.19375	37719	0.03030303	43.63636364	628.65
Day-14	123	159	3425.433962	3.416666667	27.8490566	40102.64151	0.027777778	40	668.3773585

Fig2.D.4: Model designed for Sensitivity Analysis-Dynamic

The output values are calculated using the two input feeds with formula's provided in the fig2.D.2 above. These formulas are taken from the class notes.

With this data report, we have developed the conceptual model of Scenario Analysis of Monte Carlo Simulation-Dynamic. We have also simulated the model in excel and clearly stated with the representation.

Below graphical representation states the scenario analysis for Dynamic simulation of Monte Carlo Model

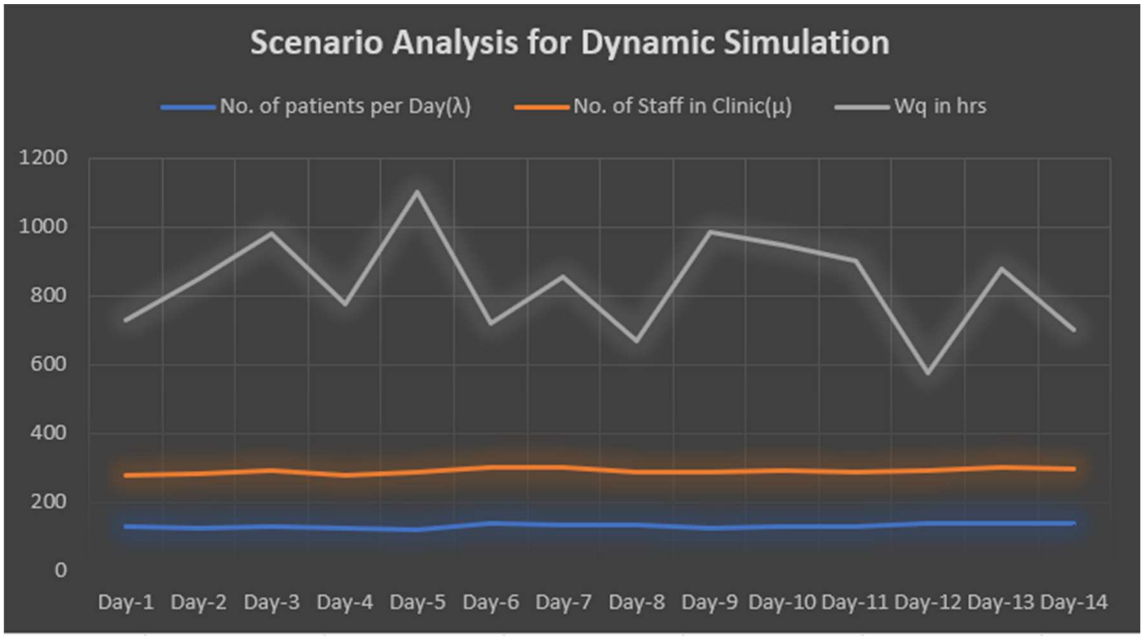


Fig2.D.5: Scenario Analysis for Dynamic simulation

(Question 3)

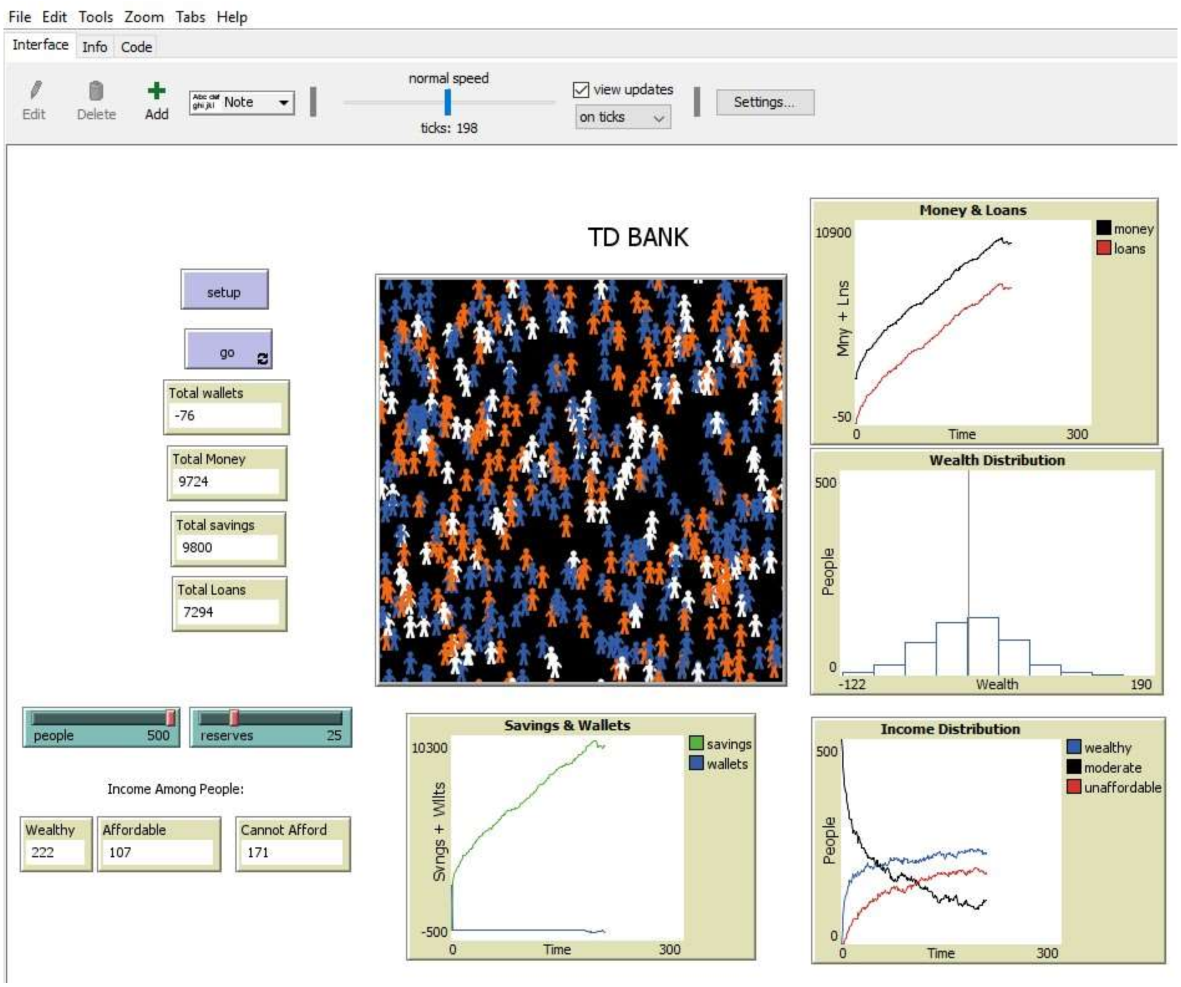
Verify and validate the simulation models developed for the above four systems.

A. verification and validation of Tim Hortons.

All the data and simulation used in the process are validated and verified using reports generated. All the results and the reports are attached in the folder for the conclusion.

B. Verification and validation for TD bank.

Verification is based on the output



C. Verification & Validation of BIXI:

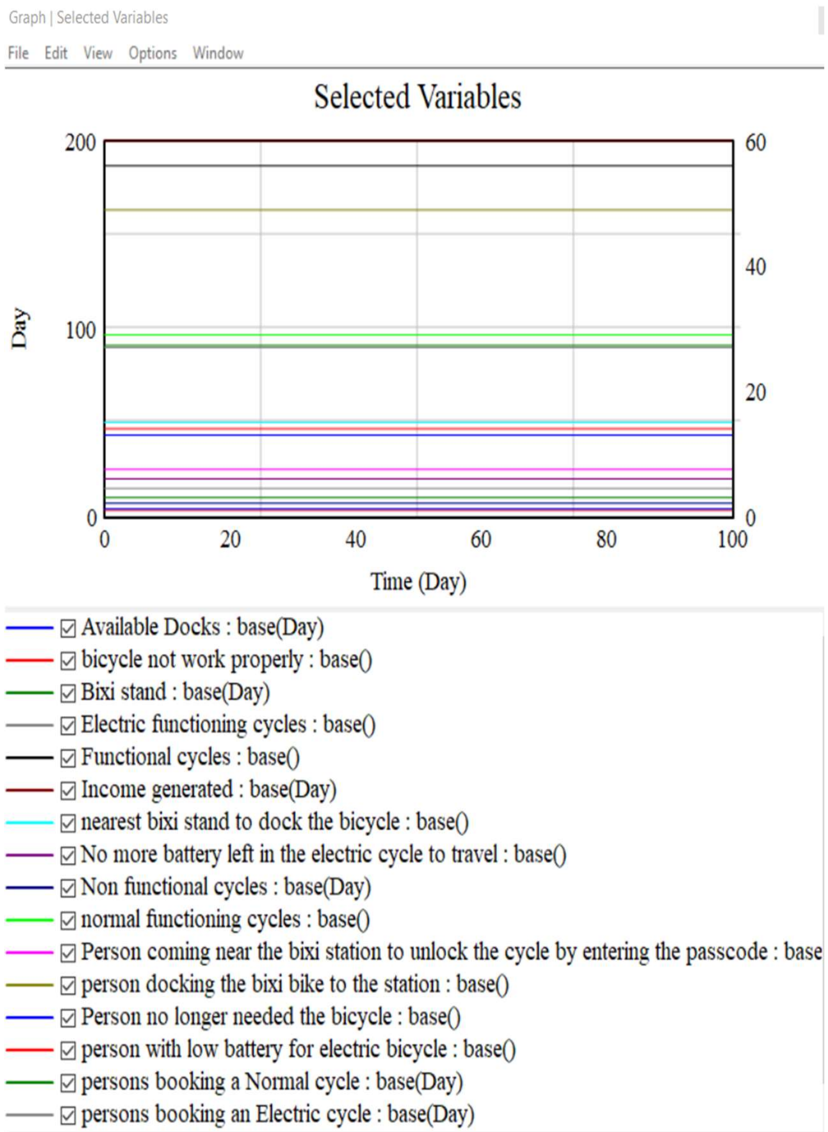
Verification:

Verification is the method of identifying the truth, correctness, and a process of validating the output two or more times to see whether we get the same result after many trails. If we get the same outcome after multiple attempts, we can say that it is running efficiently and as verified.

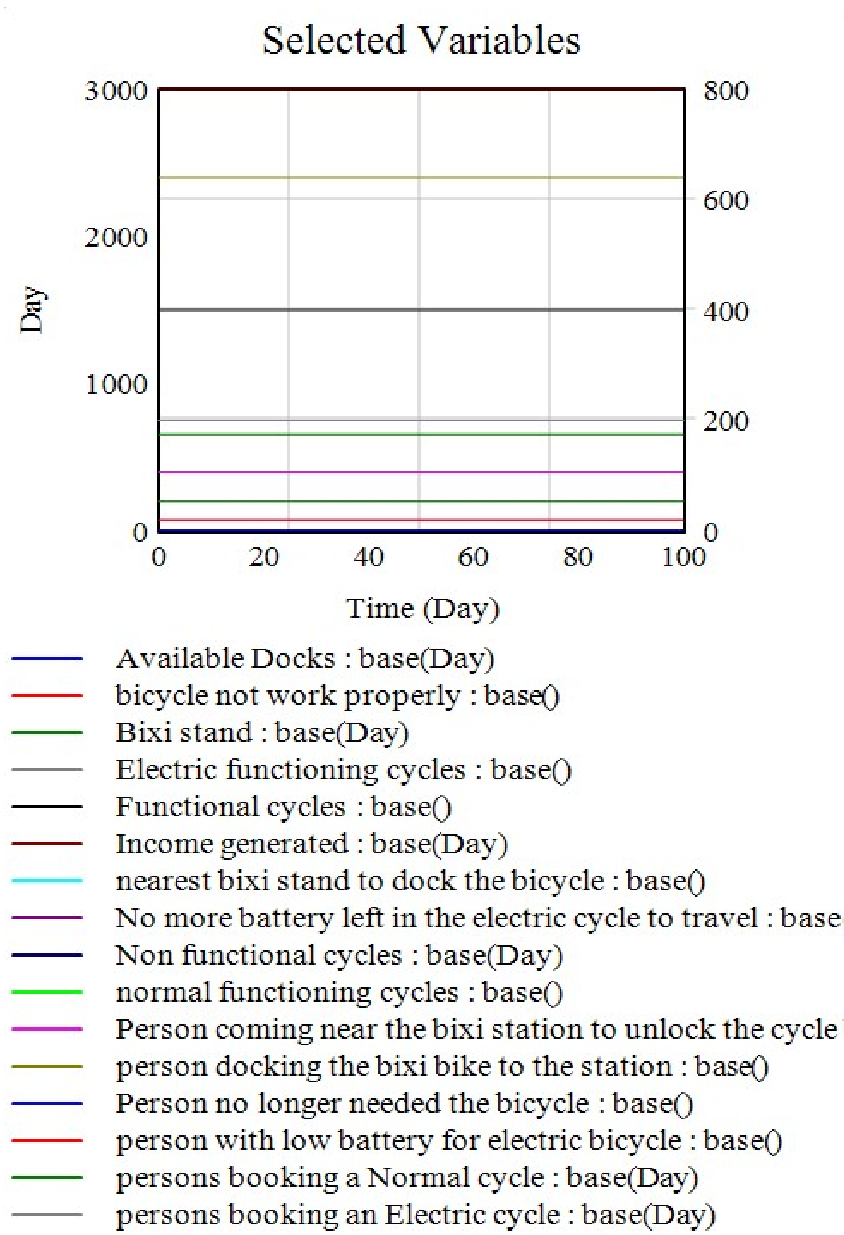
Validation:

Validation is the approach of fulfilling requirements of the system by meeting predefined format quality attributes with other input criteria and evaluating whether the outputs of a statistical model are sufficient with meeting the user's expectations by effectively structuring it.

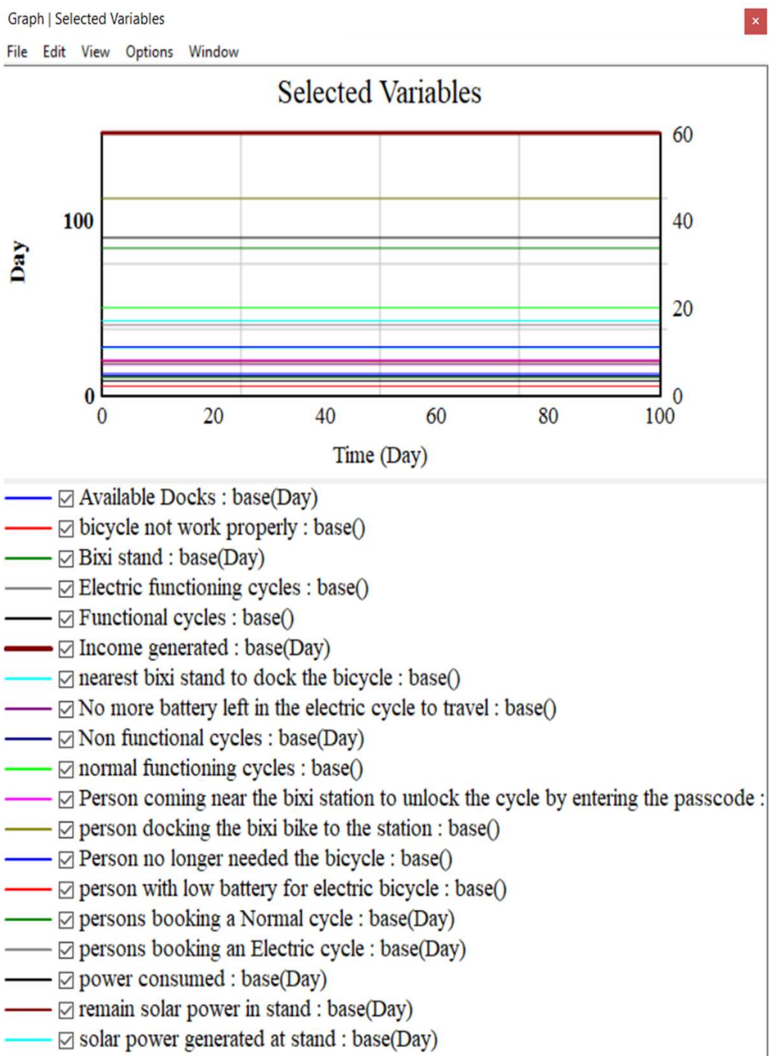
Attempt 1:



Attempt 2:


Selected Variables
3000
2000
1000
0
800
600
400
200
0
Day
0
20
40
60
80
100
Time (Day)
Available Docks : base(Day)
bicycle not work properly : base()
Bixi stand : base(Day)
Electric functioning cycles : base()
Functional cycles : base()
Income generated : base(Day)
nearest bixi stand to dock the bicycle : base()
No more battery left in the electric cycle to travel : base(
Non functional cycles : base(Day)
normal functioning cycles : base()
Person coming near the bixi station to unlock the cycle
person docking the bixi bike to the station : base()
Person no longer needed the bicycle : base()
person with low battery for electric bicycle : base()
persons booking a Normal cycle : base(Day)
persons booking an Electric cycle : base(Day)

Attempt 3:



Documentation for the executed flow: -

(01) Available Docks=

4

Units: Day

(02) bicycle not work properly=

2

Units: **undefined**

(03) Bixi stand= INITIAL(

Available Docks+Functional cycles+Non functional cycles+person docking the bixi bike to the station

-Person coming near the bixi station to unlock the cycle by entering the passcode

)

Units: Day

(04) Electric functioning cycles=

27

Units: **undefined**

(05) FINAL TIME = 100

Units: Day

The final time for the simulation.

(06) Functional cycles=

Electric functioning cycles+normal functioning cycles

Units: **undefined**

(07) Income generated=

(persons booking a Normal cycle*5)+(persons booking an Electric cycle*10)

Units: Day [0,?]

(08) INITIAL TIME = 0

Units: Day

The initial time for the simulation.

(09) nearest bixi stand to dock the bicycle=

15

Units: **undefined**

(10) No more battery left in the electric cycle to travel=

6

Units: **undefined**

(11) Non functional cycles=

5

Units: Day

(12) normal functioning cycles=

29

Units: **undefined**

(13) Person coming near the bixi station to unlock the cycle by entering the passcode

=

persons booking a Normal cycle+persons booking an Electric cycle

Units: Day [0,?]

(14) person docking the bixi bike to the station=

bicycle not work properly+nearest bixi

stand to dock the bicycle+Person no longer needed the bicycle

+No more battery left in the electric cycle to travel+person with low battery for electric bicycle

Units: **undefined**

(15) Person no longer needed the bicycle=

13

Units: **undefined**

(16) person with low battery for electric bicycle=

14

Units: **undefined**

(17) persons booking a Normal cycle=

10

Units: Day

(18) persons booking an Electric cycle=

15

Units: Day

(19) power consumed=

(0.5*Electric functioning cycles)

Units: Day

(20) remain solar power in stand=

solar power generated at stand-power consumed

Units: Day

(21) SAVEPER =

TIME STEP

Units: Day [0,?]

The frequency with which output is stored.

(22) solar power generated at stand=

30

Units: Day

(23) TIME STEP = 1

Units: Day [0,?]

The time step for the simulation.

D. Verification and Validation Monte Carlo Simulation:

Verification: Verification is the method of identifying the truth, correctness, and a process of validating the output two or more times to see whether we get the same result after many trails. If we get the same outcome after multiple attempts, we can say that it is running efficiently and as verified.

- In our simulation model, we have taken input parameters as no of patients, no of staff based on hourly basis per day and biweekly.
- We have started developing the simulation model with moderate details in the beginning and then added extra details after confirming the model we developed was accurate.
- We did an analysis by collecting the intermediate test results obtained by the simulation model and compare both the outputs obtained with real-time handy calculations.
- In our Static Testing, wait time increases with the decrease in staff members or increase in patients and wait time decreases with decrease in patients or increase in staff.
- In Dynamic Testing, we have used the Random function in order randomize and vary the input data in real-time. We have verified the relation between input and output validations.
- Simulation model is executed with variety of input scenarios and understood if the change in the output is reasonable.

Validation:

Validation is the approach of fulfilling requirements of the system by meeting predefined format quality attributes with other input criteria and evaluating whether the outputs of a statistical model are sufficient with meeting the user's expectations by effectively structuring it.

- Sensitivity Analysis was performed on the model by changing and inputs and observed the parameters that are affected because of the input change.
- We have followed the real-time approach and calculated the margin of error and obtain the accurate results.

For every random value, the total number of inputs is equal to the output generated in the handmade calculations. Hence, it can be said that the model developed using Monte-Carlo is verified and validated