

Simulation Modelling and Analysis – AY 2022/23

Default Simulation Project

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DESCRIPTION OF PROBLEM SITUATION

Every morning, on your way to University, you visit your local coffee shop, a place known by the name of “STJ Coffee Shop” (STJ). This is a nice lovely little shop very close to your place, run by Samantha (Sam), Tom and Jane, who are close friends and business partners. The shop is quite small, but conveniently located in the centre of Edinburgh, in the vicinity of the main University of Edinburgh Campus, and open 8am-8pm on Mondays, Tuesdays, Wednesdays, Thursdays and Fridays. They are also open on 9am-6pm on Saturdays and 9am-4pm on Sundays.

During the normal working week (Monday to Friday), the flow of customers into the shop tends to increase in the afternoon hours, particularly around canonical ‘tea-time’. The shop owners are joined then by David, a PhD Student in his writing-up phase, who needs to work as his scholarship has run out and he is late on submitting his work. David works 12noon-8pm (Monday to Friday) and has a 12-month fixed contract with STJ, which is the time he expects to have to wait until he can submit his PhD Dissertation to the Moray House School of Education of the University of Edinburgh. The job is reasonably well paid and David feels happy and well-integrated with the rest of the team at the shop. Also, David has worked in coffee shops in the past and he is known to be quite efficient at both serving customers at the till as well as preparing drinks and food. On the same days (Monday to Friday) and for the same reasons, an additional member of staff joins the team at STJ specifically for the 4-6pm slot. The turnover on this role tends to be quite high, so that different people will be covering it, typically for just a few weeks, over the year - they tend to leave STJ as soon as they find another more stable job opportunity in Edinburgh.

Two out of the three shop owners guarantee to be working in the coffee shop during any weekday, but they also take time off work, of course. In fact, each one of the owners takes one day off during the normal working week time (Monday to Friday). Also, two of them work in the shop every weekend, on both Saturday and Sunday of the same weekend, and the remaining one takes the whole weekend off. All this happens on the basis of an agreed rota.

David does not work weekends (no need for him to), as the shop tends to be less busy at this time of the week. In fact, recently, students have started to use the University Library somewhat less frequently over weekends, plus all Schools and Departments have just moved to a “100% doors-shut over weekends” policy, so the main university campus tends to be not as busy on Saturdays and Sundays.

Any of the people running the shop (part-time staff included) can, at any time, perform any of the usual tasks involved with running a coffee shop: till operations (taking orders and collecting payments); preparations of drinks and/or food; delivery of orders to tables for sit-in customers, cleaning of tables; cleaning of toilets; etc.

Prices at the coffee shop are not too bad, actually! STJ charges £2 for any coffee, £1 for any tea and £1.5 for any soft drink. Also, they charge food at the following rates: £2.50 for a slice of any homemade cake, £2.80 for any slice of cake purchased by the local bakery shop; £1 for every piece of fruit; and an average price of £1.50 apiece for anything else purchased on the premises. No wonder Sam, Tom and Jane tend to be so popular amongst university students!

There are two 2-seater tables and one 4-seater table at STJ. An additional 2-seater table could be “squeezed-in” if necessary, but table and chairs would need to be purchased if that’s the case. Other than that, internal space capacity is pretty much all used at the present time. However, external space immediately to the front of the shop could be rented by Sam, Tom and Jane, directly by the managers of the “QRmile Estate” where the shop is located, in which case the monthly fee to be paid for this additional space would have to be agreed with them. The additional space would guarantee the presence of up to four 2-seater tables, as well as two long tables with wooden benches on both sides, each long table capable of sitting up to ten customers. All of these additional tables, benches and chairs would need to be procured, in which case the shop owners are thinking about purchasing them from the local branch of IKEA, exploiting the fact that Tom has an IKEA family (loyalty) card.

The behaviour of the shop’s customers tends to be very consistent over time:

- They arrive either alone or in a group of up to four people. Sometimes there are bigger groups turning up at STJ, but these occasions are not so frequent and the owners say this could happen approximately five times per week, at maximum. The shop is typically seen as a quiet nice place where to study/write/work, so it is not too popular with bigger groups anyway...
- Each customer tends to order one drink (never more than one, if they indeed order a drink). The drinks menu includes varieties of teas and coffees, as well as the most popular soft drinks (in bottles and cans). In addition to the drink, about 25% of customers order a piece of fruit, while about 37% of customers order either a slice of cake - homemade cakes are particularly popular (Jane and Tom are terrific bakers!), and about 28% of customers order either one or two pieces of some other kind of food.
- Both individuals and two-person groups only seat at 2-seater tables; groups of three or four only sit at the bigger table (4-seater). While this behaviour is fairly obvious to assume and has long been observed by the owners anyway – without necessarily having to enforce it, it is not known what different configuration choices, such as the presence of long tables with benches, may have on the seating behaviour, although sharing of a long table/bench amongst groups of varied size is fairly likely to be the case.

On arrival, customers go directly to the till to place their order. For every pair or groups of three or four turning up at STJ, all individuals from the pair/group tend to join the queue (but only one of them places the order). The owners think this is because customers like to keep chatting with one another as they are waiting to place their orders. However, there seems to be quite a few cases when one or more members of a group go to grab existing free space on one of the tables while the rest of the group are remaining in queue to place their orders.

Experience has shown Sam, Tom and Jane that If there are more than 10 customers queueing at the till, excluding the individual currently placing an order, customers leave the shop straight away – competition on the main university campus in Edinburgh is fierce! If they join the queue (or access directly the till when there is no queue, any one of the baristas (based on availability, over time, during the day) takes orders using the machine at the till. Again, experience says the order-taking process at the till never takes less than 30 seconds (best case scenario) but also that it never goes beyond 3 minutes (worst case).

Take-away customers pay for the order directly at the till, and then move on to the end of the bar, joining another queue (like at most Starbucks shops), where they collect their orders, before proceeding to the shop's door and leaving the premises. Sit-in customers have an additional habit of checking, just before joining this second queue, whether there is a table available or not. In case no table is available by the time they collect their order at the end of the second queue, they may, or may not, 'switch to take-away customer behaviour' and leave the shop as well. During the normal working week, there is probably some space available in the various departments located around campus, e.g. a sofa or a chair or a bench or whatever, for them to go enjoy their coffees/teas and cakes! Experience says that only about one in five customers are happy at that point to wait for a table to become available. If they are indeed wanting to wait, they obviously need to start sipping their drink while standing somewhere between the till/bar and the tables/seating area. No premium is paid at the shop for sitting in and enjoying the drink in total relax. Plus – there are only paper cups available at the shop anyway, hence any customer can quickly change their mind and decide to have their drinks somewhere else.

All drinks for the same order are placed on a single tray at the end of the bar, for customers to collect and take to their tables, if sitting in. Four trays are available at STJ, and STJ staff never have to go around the tables to find unused trays to be taken back behind the bar for the next use. Recent repeated observations from Jane seem to demonstrate that customers/groups sitting in, generally take between 30 seconds and 1 minute to reach and seize their table, from the moment a table is made available for reuse. Sit-in customers stay in the coffee shop and chat/read/study at their table for some time. Upon customers leaving a table, one member of staff comes to clean the table and clear it of all remaining items, including trays, which are put back to their storage position just behind the bar, or other forms of refuse. Only when a table is fully cleaned and cleared of any materials, other customers can seize it and start their 'sojourn' at STJ.

Recently, Sam, Tom and Jane have noticed long queues at their till, lots of customers leaving the queues and even, at times, have seen customers entering the shop, just observing the queue and then leaving impatiently. Certain days, their impression was that of an unbelievable overcrowding of their shop, which would ultimately deter new customers from starting to visit, or put off habitual customers from returning in the future. Customer satisfaction seems to have fallen (based on broader direct conversations to customers), and daily revenues with it as well (although figures/estimates on customer retention are not known or easy to figure out).

You have started visiting STJ a few times recently, and know Sam well by now. Last week, she overheard you and your classmates, while you were sitting in at one of the tables in the shop, talking of your BA programme and your simulation course, and how you are looking for a local shop to be working with, within the context of your simulation project, the aim of which is to help local business managers to improve their businesses by using 'simulation techniques'. Before approaching you to let you know she happened to pick up your conversation and to double check whether you may want to collaborate with STJ to look after their recently identified problems, she had a feeling that these simulation techniques you kept mentioning at your table, whatever they may be, could help them three 'desperados' to improve the situation at STJ, before problems escalate too quickly, too much, and hence before word of mouth in Edinburgh starts to spread around the idea that their coffee shop is too inefficient and people should go somewhere else, where spaces are copious and times in queue reasonable. Upon your next visit, this time alone, you ended up discussing with Sam about the possibility to help them and they agree. The course lecturer also reckons that STJ is a very good case study for your own coursework project for the Simulation Modelling and Analysis (SMA) course.

You then accepted to help the owners of STJ, for a reasonable reward: one free coffee of your choice every day until the date of your graduation ceremony. After that, you started talking to the staff in the shop, as well as a few of their customers, for a period of a few weeks, and also went to visit the shop on a few different dates, observing what was happening each time and collecting 'data' on how long each bit of the overall 'process' takes. The shop owners were all happy (and desperate - at the same time!) to share their data and problems with you, as long as you helped them shed some light on what's wrong with the shop's operation. The present document is the first version of the 'Problem Description' document that your simulation course lecturer discussed in one of his lectures.

Your observational experience told you that order preparation takes:

- for a cup of coffee: no less than 2 minutes but no longer than 4 minutes;
- for a cup of tea: no less than 1 minute and no longer than 3 minutes, and that most times it takes 2 minutes;
- for a soft drink: around 30 seconds each drink, on average.

You also measured the following typical customer arrivals patterns over the day:

8am-10am	10am-12pm	12pm-4pm	4pm-6pm	6pm-8pm
10/hour	8/hour	12/hour	15/hour	12/hour

The above observations on arrival patterns were collected by you directly, from a series of 5 consecutive days of observations, over one single week (w/c 3 January 2023).

Of all of the customers you had the chance to observe over a few days period, 30% were individual customers, 40% were pairs/couples, and the remaining were groups of three (15%) or four.

Ordering behaviour as measured by you says one in two customers order coffee, one in five order a soft drink and the remaining order tea.

Only 40% of customers seem to walk into the shop with the intention of sitting in.

You also noticed table occupancy time can be conveniently represented by an exponential distribution with mean 30 minutes, whatever the size of the group.

More in general, all aspects of the problem as detailed in previous paragraphs were raised by lengthy conversations between you and the staff at STJ.

On second reading of the problem description you just put together (i.e. this section), you have the impression that some other pieces of data should probably be collected, if at all possible, but are unsure what/how to collect, in practice. You also reckon that at this stage your extracted everything that could possibly be extracted by the team at STJ, and that visits to the shop would not add much. In addition, you wouldn't want to upset STJ staff by imposing your presence in their shop any more than you have already done so far (they are busy people, in the end!)

You finally agree with Sam, Tom and Jane for a date/time to meet with them in their coffee shop, during closing time, to present in just ten minutes your modelling and analysis work and related recommendations for improvement of the situation at STJ. You also agree with them to submit a written report.

PROJECT CONTEXT AND GOAL

Back at STJ Coffee, they agreed with you to meet for your final presentation of your results and recommendations to the business only after your Semester 2 exam/assessment diet will be over. They want a short report of up to 2 pages about a week before the presentation date. They will also want the slides used by you in your presentation, immediately after it.

Having acknowledged all the above, you feel extremely happy 😊 as this Semester you have your Simulation Modelling and Analysis (SMA) individual coursework to submit (around Easter time), way earlier than the due dates agreed with the STJ owners. In the coursework for that particular course, the course organiser asked students to work with a local business on a specific simulation project of their choice. You have chosen STJ Coffee's case and proposed it to the course organiser, who signed off your project proposal.

The reason why you are so happy about this opportunity can be explained as follows. Whilst confident in your sales skills (you are not too concerned at all about your two-pager report for the STJ owners, nor about your slides and presentation performance), this is the first 'proper' simulation project for you, and given all the learning from the SMA course, you feel perhaps less confident on the credibility and precision of your results (from the perspective of a simulation expert, not the client), on the validity of your model(s), and on the exact level of rigour you may put through the various phases and activities of the simulation project (again, from the perspective of a simulation expert). Fortunately, these aspects are exactly what gets assessed through the SMA coursework! The higher the mark you'll receive in SMA, the more confident you shall be about the prescriptive analytics work you can deliver to the STJ folks!