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Statistical analysis of e-commerce delivery demand modeling framework

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Abstract---The e-commerce delivery demand has developed quickly in the past two decades and such trend has intensified tremendously due to the continuing coronavirus pandemic. Given the situation, the requirement for forecasting e-commerce delivery demand and evaluating applicable logistics solutions is expanding. However, the present simulation models for e-commerce delivery demand are still limited and do not address the delivery alternatives and their properties that customers experience on ecommerce order placements. The inability to construct and monitor agent systems that have been deployed throughout a network is one of the primary challenges, along with ensuring that software agents are installed in a manner that is both secure and efficient. The field of multi-agent technology is one of the areas of information and communication technology that is advancing at one of the quickest rates. Virtually every day, new agent-based services, products, and applications are being developed. The coordination, control, and simulation of the architecture of decision support systems that are used in e-commerce are all performed with the use of an agent-based simulation model. The design that was recommended improves the decision support systems that are already in place and achieves a competitive advantage.

Keywords---e-commerce, software agent, architecture, simulation.

Introduction

To build new applications for specialized fields like electronic commerce, software developers have been studying the applicability of distributed, cooperative

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software entities rather than developing single, monolithic programs. This is done in order to reduce the amount of time and resources needed to build new applications. One example of a subject where concepts of this sort are now being discussed upon is the industry of electronic commerce; however, this is only one example. Examples of intelligent agent-based electronic commerce applications include check systems, brokerage agents, applications that link customers and vendors over the World Wide Web, and programmes that facilitate competitive contracting. The two most recent methods divide the necessary intelligent agents into two different categories, namely, those agents that represent the buyer and those agents who represent the seller. In general, the agent-based strategy provides the benefit of issue separation in addition to the possibility of scalability for application use. However, in order to properly deploy distributed systems, particularly in the field of electronic commerce, a number of essential prerequisites must first be satisfied. Among these are the secure installation of components, the communication of protected agents, and the efficient administration of system optimization. The following is a list of some of the potential advantages that mobile agent technology or distributed object technology may offer to other businesses in addition to e-commerce, specifically:

- Decrease the quantity of traffic on the network by carrying out processing that calls for a significant amount of computing resources as close as possible to the server that supplies the source of the information.
- Greater degrees of autonomy as a direct outcome of an agent's ability to carry out its tasks in an asynchronous fashion.
- Make it easier to switch between multiple service providers by providing the option to do so.
- Increase the network's availability by utilizing activities that are both independent and asynchronously carried out by the agents.
- Reduce the amount of time that is spent in addition to the amount of labor that is necessary for the installation, operation, and administration of the system.
- Facilitate the delivery of specialist services "on demand" by creating the necessary infrastructure.
- Make possible a larger degree of decentralization in management and service control; as a consequence, this will minimize the dependence that is placed on the availability of the network, which will lead to a system that is more dependable.

Any sort of commercial or financial transaction that takes place via the Internet and involves the exchange of information is referred to as "electronic commerce," which is sometimes shortened as "e-commerce." It encompasses a wide range of businesses, from consumer-focused retail sites to sites that specialize in auctions or music to commercial exchanges that facilitate the purchase and sale of products and services between firms. Some examples of these businesses include auction sites, music sites, and retail sites. It is now one of the most significant new aspects of the Internet that has developed at this moment in time. E-commerce has the potential to provide a number of advantages that are not accessible with more conventional types of company structures. By reducing the number of employees, it has to pay, the company is able to bring down its overall cost. The use of e-commerce results in a reduction in the number of errors that occur during the data entry process, a shorter amount of time spent on paper work, and a decrease in the costs connected with the delivery of shipments. One further advantage that results from this is a reduction in the amount of time wasted. As a consequence, this leads in shorter lead times for payment, a greater return on investment in advertising, and speedier product delivery. Flexibility and responsiveness have both increased thanks to the rapid dissemination of information, the digitization of record keeping, and the networking potential offered by the internet. Additionally, new intermediates that are more efficient have been developed as a result of these advancements. It has improved internal coordination, led to a rise in the utilization of outsourcing, enlarged access to markets, cut the time it takes to get items to market by connecting orders to production, and extended market access.

Objectives

1. Study on Statistical analysis of E-commerce.
2. Study on Delivery Demand Modeling Framework.

Model parameter assumptions and sensitivity analysis

"In this section, rather of employing data from the real world for the full model estimate, we create assumptions about the model parameters based on past research and/or synthetic data. We then apply those assumptions for the demonstration sensitivity analysis. Even though we make an attempt to use realistic model parameters, we do not claim that the results of the simulation "or the model parameters themselves are indicative of any real-world situations. This is because we make an effort to use realistic model parameters. The one and only conceptual contribution that we assert to have made to research is outlined in this section. The objective of "this section is to demonstrate how applicable the proposed framework is" in practice. Before the models can be utilized to forecast the actual shipping need for e-commerce in the real world, more calibration is required.

Assumptions

Data collected from a wide variety of different sources are used in the process of determining the model's parameters. The parameters that are predicted to be a component of the model are outlined in Table 1, which offers an overview of the parameters.

Table 1
Summary of the Model Parameters that were Assumed

Parameter	Value	Parameter	Value
Delivery option choice		**Order value choice**	
β_i^{speed}		$\beta_{logsumdo}$	1.05
- same day	0.177	$\beta_{interval}$	-0.111
- next day	0.082	$\beta_{storage}$	-0.0183
- 2-5 business days	-0.259	**Total value choice**	
β_j^{slot}		$\beta_{logsumov}$	0.0597
- no time slot	-0.157	β_{hhs}	-0.000175
- 2 hr	0.113	α	12.3
- 4 hr	0.040		
β_k^{time}			
- daytime	-0.090		
- daytime & evening	0.090		
β_l^{date}			
- weekday	-0.063		
- weekday & Saturday	0.054		
- all days	0.009		
β_{fee}(fee, US$)	-1.377		

Sensitivity Analysis

A sensitivity analysis is performed by us, with the parameters of the model that are expected to be listed in Table 1 serving as the basis for the analysis. As was mentioned earlier, the sole objective of this analysis is to demonstrate how "the proposed model specification can make the demand characteristics, which include e-commerce order size, order frequency, and delivery option choice, sensitive to the delivery options and, more specifically, delivery fees that are offered by e-commerce vendors. We" make use of the statistics that were created on the basis of the information supplied by households in the "2019 Puget Sound Regional Travel Study about the average size of households. These statistics were developed based on the information provided by households (933 households that received packages at least once during the survey period). It" is vital to note that the only item of information that was utilized was the household size, which acts as an independent variable. This means that the number of people living in each family was the only piece of information that was used.

Table 2 displays the four distinct delivery choice scenarios that we developed. It is assumed that every single household has access to the same variety of possible methods of delivery in every single circumstance. If the total value of the order is at least $25, the payment for the DO1 (2-5 day) delivery service will be waived. The S1 scenario refers to the situation in which the shipping service is supplied at no cost. In scenario S2, there is no such thing as a free shipping service; in this situation, a shopper is compelled to pay a delivery fee even if the total value of their purchase is higher than $25. This is because there is no such thing as a free shipping service in this scenario. Free delivery is included in both Scenario 3 and Scenario 4, but only in Scenario 3 will you also receive free shipment. Scenario 4 will not include free shipping. The delivery fee for express deliveries, which includes deliveries made within one day and deliveries made the same day, is what differentiates S1 and S2 from S3 and S4. It is anticipated that S3 and S4 will have a delivery fee for express deliveries that is 30 percent lower than S1 and S2, respectively.

Table 2
Delivery Option Scenarios

Scenario	Delivery option (do)	Speed	Fee (US$) Order size: $0-25	$25-50	$50-100	$100-
S1: Free shipping	1	2-5 days	6	0	0	0
	2	One day	12	15	17	20
	3	Same day	18	20	22	27
S2: No free shipping	1	2-5 days	6	7	8	10
	2	One day	12	15	17	20
	3	Same day	18	20	22	27
S3: Free shipping & 70% delivery fee for express deliveries	1	2-5 days	6	0	0	0
	2	One day	8.4	10.5	11.9	14
	3	Same day	12.6	14.0	15.4	18.9
S4: No free shipping & 70% delivery fee for express deliveries	1	2-5 days	6	7	8	10
	2	One day	8.4	10.5	11.9	14
	3	Same day	12.6	14.0	15.4	18.9

Note: The following is a list of characteristics that are present across the board in terms of both the outcomes and the delivery methods: There are no time slots, and deliveries are done at all times during the day, as well as each day (i.e. both weekday & weekend). Figures 1 and 2 as well as Table 3 include the outcomes of the simulation, which may be found here. Figure 2 presents a visual representation of the "cumulative density distribution of total value over the course of each week. The fact that the differences between S1 and S3 and between S2 and S4 are quite small suggests that the effect of the reduction in the cost of express delivery is also relatively small in the environment that is being considered. This is the case because of the fact that the disparities between S1 and S3 and between S2 and S4 are" quite small. When placed side by side, S1 and S2 are able to be differentiated from one another more easily (or S3 and S4). It is estimated that the overall value has decreased by approximately 6% as a direct result of the removal of the previously provided free delivery service. Figure 5, which illustrates the cumulative density distribution of the order value, is where this may be viewed for yourself. As seen in the picture, there is a stark contrast between the scenarios that contain free shipping and those that do not include free shipping. The delivery frequency in scenario S2 is approximately 36 percent lower than in scenario S1. The model demonstrates how consumers attempt to reduce the overall cost of delivery by either increasing the quantity of their purchases or lowering the frequency with which they place orders.

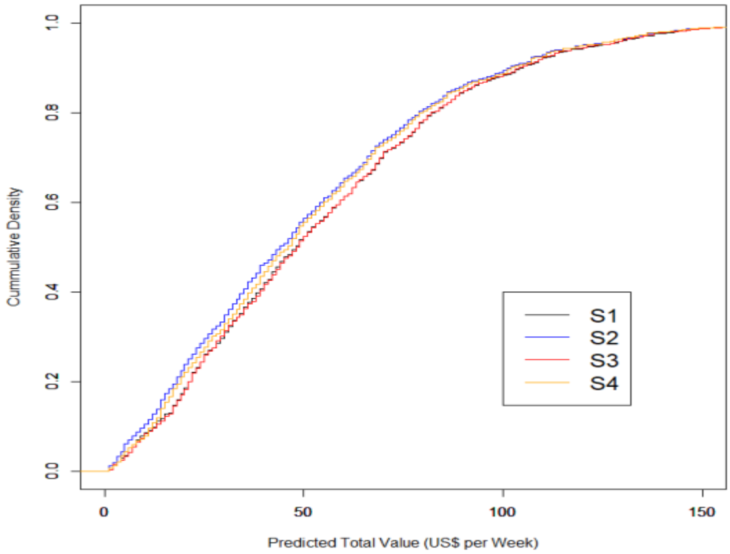

Figure 1. Analysis of differences between totals

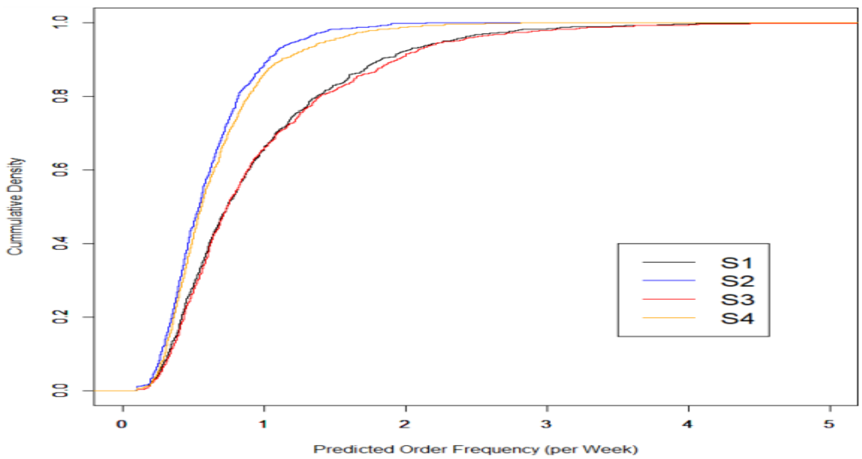

Figure 2. "Comparison of order frequencies"

Table 3
Summary Statistics of Sensitivity Analysis

	Total Value: Mean	Order Frequency: Mean	Share of 2-5 days delivery (%)	Share of one day delivery (%)	Share of same day delivery (%)
S1	54.2	0.944	93.3	3.9	2.8
S2	50.8	0.607	50.8	28.1	21.1
S3	54.2	0.971	89.8	5.9	4.3
S4	52.0	0.659	39.6	34.3	26.0

Request to be considered for auto-innovative city

Figure 4 provides an overview of the development of the e-commerce demand simulation. This figure is titled "The Flow Simulation." The homes are the most important contributor to the simulation's data, which is collected from them. Taking into account the data collected from a variety of sources (for example, Etumnu and Widmar (2020)), the adoption rates of e-commerce were calculated to be 0.12, 0.30, and 0.50 respectively for grocery, home products and medications, and other packages, respectively. Etumnu and Widmar (2020) was one of the sources that was used. The term "adoption" is used in this discussion to refer to the process of placing at least one order within a month that is selected at random. Following the calibration method, which will be covered in more detail later on, it was found that these adoption rates are final. After selecting the homes at random based on the adoption rate for each item category, the household-based e-commerce demand model was applied to the homes that had been randomly selected earlier in the process. After the e-commerce orders have been transformed into packages, a discrete choice model is applied in order to decide which distribution centre should be utilized to fulfil each unique e-commerce package. The "Supplier Selection Module of Sim Mobility Freight employs this very same model, so you can be sure that it is accurate (Sakai et al., 2020). The output, which included both B-to-B shipments and e-commerce shipments, was integrated with the former and utilized as an input for Pre-day Logistics Planning in Sim Mobility Freight. The latter were also included in the output".

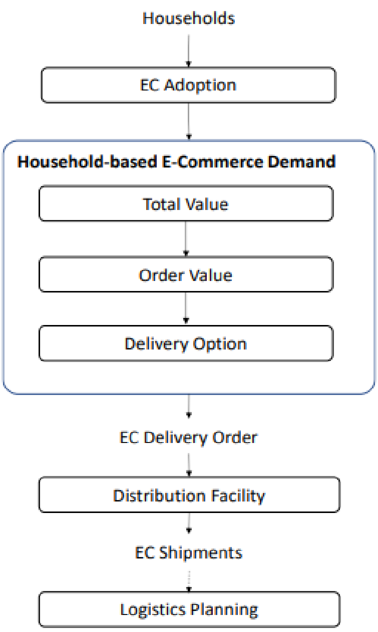

Figure 3. Simulation of the flow and demand of e-commerce

The initial model parameters are comprised of those described in the section that came before this one when it comes to orders done through online shops. In addition, we modified the parameters in a few additional ways. These modifications included those that pertained to Equation (3) (the scales of per-HH member e-commerce purchase demand), interval in Equation (2), and storage in Equation (2) for each of the item categories. This adjustment was made in order to bring the number of deliveries and the typical monthly expenditures for e-commerce into alignment with the reference values that were computed on the basis of the data that were readily accessible Figures that served as a point of reference are presented in Table 4, which contains those figures.

Table 4
References for Calibration

Reference for calibration	Groceries	Household goods and medicines	Other packages
No of deliveries (pre-Pandemic)[a)]	0.6/person-month *(exclude <15 yrs old)*	1.2/person-month *(exclude <15 yrs old)*	3.1/person-month *(exclude <15 yrs old)*
Ave. total monthly purchase value [b)]	11 USD/HH (3% of total expense)	38 USD/HH (26% of total expense) [c)]	62 USD/HH (26% of total expense) [c)]

Note: a) According to Holguin-Veras and Wang's research (2020); b) estimated according to data from The Atlantic (2019) and the Bureau of Labor Statistics of the United States of America (2020).

Organizing oneself in preparation for the operation of vehicles: The module that was responsible for planning the operation of vehicles included the establishment of specific parameters. The two major configurations are as follows, broken down into their component parts:

- Dwelling time: the standard for the average dwelling time per parcel was determined to be 2.3 minutes. (According to the findings of a survey conducted in London, Allen et al. (2018) suggest that the average amount of time spent parking one package is 2.3 minutes.)
- Capacity of the Vehicle: The vehicle volume capacity and the weight-to-volume conversion have been adjusted such that the average number of parcel deliveries made during a shift is around 18 for groceries and 44 for products that are not foods.

Statistical Analysis

In order to determine whether or not the implementation of e-commerce has had an effect on the company, we need to. Agent replies have mentioned the proportion of sales transactions made via e-commerce that has been considered for study. The precise sales data of transactions have not been provided; nonetheless, the analysis has taken into account this proportion.

Table 6
One-Sample Statistics of Agent Performance

Sales Period	N	Mean	Std. Deviation	Std. Error Mean
Sal1 (2012-13)	310	92.75	215.881	12.261
Sal2 (2013-14)	310	98.23	215.023	12.212
Sal3 (2014-15)	310	181.13	314.597	17.868
Sal4 (2015-16)	310	256.94	433.778	24.637

It is possible to investigate the question of whether or not the implementation of e-commerce has had an effect on the performance of agents by testing the hypothesis that the average performance of agents has not significantly changed during the time period from 2012 to 2016, which is when the majority of the unit's implemented e-commerce. This will allow one to answer the question of whether or not the implementation of e-commerce has had an effect on the performance of agents.

Table 7
One-Sample t Test of agent Performance

Sales Period	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Sal1	7.564	309	.000	92.748	68.62	116.87
Sal2	8.043	309	.000	98.226	74.20	122.26
Sal3	10.137	309	.000	181.129	145.97	216.29
Sal4	10.429	309	.000	256.935	208.46	305.41

According to the findings of the one sample t test, the significance threshold for the mean sales of all four years is 0.000, with p less than 0.05. This indicates that the sales were significantly different from chance. As a consequence of this, the hypothesis that the sales performance of agents has not significantly altered over the period of the four years that have passed since the installation of e-commerce may be rejected with a degree of confidence that is equal to or greater than 95 percent.

Table 8
2015–2016 tests to determine if levels 1 and 2 have comparable means and variances

Sal1 RL	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
Equal variances assumed	2.694	.102	.745	273	.457	25.278	33.924	-41.507	92.064
Equal variances not assumed			1.159	215.15	.248	25.278	21.810	-17.710	68.266

The findings of the independent t-test conducted on adoption levels 1 and 2 make it abundantly evident that the significance p>0.05 for 2 is anticipated to be the same. As a result, there is not sufficient evidence to rule out the likelihood that there is a significant gap between the average agents in 2017-2018 who adopted at level 1 and those who adopted at level 2, and this is due to the fact that there is not enough information available.

Result

Figure 4 illustrates the standard deviation of the number of deliveries completed by each driver. According to Kuo (2018), the typical FedEx driver is capable of delivering between 75 and 125 packages in a single day, but the typical number of deliveries made by home delivery companies ranges from 15 to 35 in a single day (Jaller and Pahwa, 2020). This anecdotal evidence, to a greater or lesser extent, is supported by the findings, which are consistent with one another. Figure 5 presents the breakdown, by hour of the day, of the number of operating vehicles that were on the road at any given time. It is estimated that between 20 and 30 percent of all cargo trucks that are out on the road during the daytime are those that make deliveries for online shops. The percentage of automobiles that make deliveries for online retailers is rather high. This conclusion, which is calibrated at the shipment level with the data that is available, reveals that the demand for traffic caused by e-commerce has increased to the point where it is no longer trivial. Despite the fact that in the future, validation using the data from the traffic count will be necessary, this result, which is calibrated at the shipment level using the data that is available, may be used. It is imperative that this point be brought up because the "household-based e-commerce demand model was calibrated against the pre-Covid-19 pandemic norm".

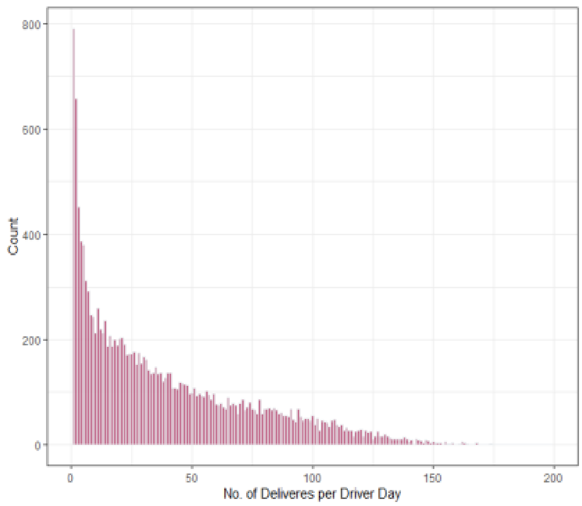

Figure 4. The average number of deliveries made by each driver on a given day (E-commerce deliveries)

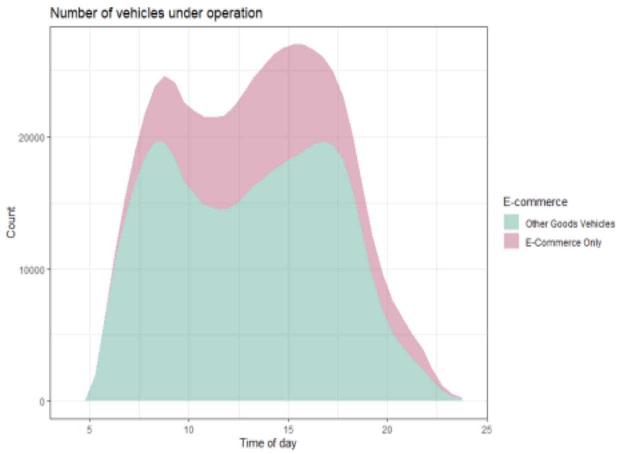

Figure 5. The total number of cars that are currently in use

Conclusion

In light of the outcomes of this research, a unique modelling technique for estimating the supply and demand of e-commerce delivery has been developed. The model that has been proposed is able to accurately forecast not only the overall average value of e-commerce purchases but also the amount spent on individual transactions as well as the delivery method preferences of customers. This is because the model takes into account not only the total number of transactions but also the total amount spent. Demand is sensitive to the features of the many delivery alternatives within the framework, which is of the highest relevance when seeking to ascertain the consequences of novel urban logistics solutions that modify delivery speeds and prices. In addition to this, the model has been included into Sim Mobility, and a traffic study has been carried out on the Auto-Innovative prototype city using it. E-commerce and other agent-based applications that require secure and quick agent deployment are currently being developed in the meanwhile. In the meanwhile, these procedures are being carried out, and the system is now being improved upon and subjected to further development. A restricted number of agents have been included in each of the agent systems that have been developed for the system up until this point.

References

1. Allen, J., Bektas, T., Cherrett, T., Bates, O., Friday, A., McLeod, F., ... & Wise, S. (2018). The scope for pavement porters: addressing the challenges of last-mile parcel delivery in London. Transportation Research Record, 2672(9), 184-193
2. Allen, J., Piecyk, M., Piotrowska, M., McLeod, F., Cherrett, T., Ghali, K., ... & Wise, S. (2018). Understanding the impact of e-commerce on last-mile light goods vehicle activity in urban areas: The case of London. Transportation Research Part D: Transport and Environment, 61, 325-338.
3. Amir, . F., Suhron, M., & Sulaihah, S. (2021). Family care model development in treating schizophrenia patients that have self-deficit nursing based system: Structural equation modeling analysis. International Journal of Health & Medical Sciences, 5(1), 7-14. https://doi.org/10.21744/ijhms.v5n1.1808
4. Holguin-Veras, J. & Wang, C. (2020). “Impact of the COVID-19 Pandemic on Person-Trips and Tele-Activities (Part 2)”. Webinar. July 22, 2020.
5. Jaller, M., &Pahwa, A. (2020). Evaluating the environmental impacts of online shopping: A behavioral and transportation approach. Transportation Research Part D: Transport and Environment, 80, 102223.
6. Kuo, M. (2018). How do experts like FedEx plan their routes? Routific. Lepthien, A., & Clement, M. (2019). Shipping fee schedules and return behavior. Marketing Letters, 30(2), 151-165.
7. Noor, M. M. N., Rosmayati, M. (2010) New Architecture for Intelligent Multi-Agents Paradigm in Decision Support System. Decision Support Systems, InTech, ISBN: 978-953-7619-64-0.
8. Oke, J. B., Aboutaleb, Y. M., Akkinepally, A., Azevedo, C. L., Han, Y., Zegras, P. C., ... &BenAkiva, M. E. (2019). A novel global urban typology framework for sustainable mobility futures. Environmental Research Letters, 14(9), 095006.
9. Oke, J. B., Akkinepally, A. P., Chen, S., Xie, Y., Aboutaleb, Y. M., Azevedo, C. L., ... &BenAkiva, M. (2020). Evaluating the systemic effects of automated mobility-on-demand services via large-scale agent-based simulation of auto-dependent prototype cities. Transportation Research Part A: Policy and Practice, 140, 98-126.
10. Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2021). Health and treatment of diabetes mellitus. International Journal of Health Sciences, 5(1), i-v. https://doi.org/10.53730/ijhs.v5n1.2864
11. The Atlantic. (2019). “Why People Still Don’t Buy Groceries Online”. https://www.theatlantic.com/technology/archive/2019/02/online-grocery-shopping-has-been-slowcatch/581911/ Feb 5, 2019. Accessed August 17, 2020.
12. Vymětal, D., Šperka, R. (2011) Agent-based Simulation in Decision Support Systems. Distance learning, simulation and communication. Proceedings. ISBN 978-80-7231-695-3.

13. Wilson-Jeanselme, M., & Reynolds, J. (2017). Understanding shoppers' expectations of online grocery retailing. International Journal of Retail & Distribution Management.
14. Zhao, F., Pereira, F. C., Ball, R., Kim, Y., Han, Y., Zegras, C., & Ben-Akiva, M. (2018). Exploratory analysis of a smartphone-based travel survey in Singapore. Transportation Research Record, 2494(1), 45-56.