Modelling Trade Logistics based on Multi-method Simulation Approach: Case-in-point: Mongolia

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Abstract
Most of land locked developing countries (LLDCs) such as Mongolia suffer economically due to its geographical location, lack of access to seaports and underdeveloped infrastructure. Political influences and cross-border delays add to the challenges in which Mongolian firms involved in trade operate. However, recent changes in the political atmosphere of North-East Asian region has encouraged firms to conduct trade through advanced logistics designs. This chapter discusses a multi-method simulation approach using *Anylogic* software as one of few approaches which can be used to model end to end cross border trade logistics in Mongolia with a view to optimise/improve trade opportunities/operations. Successful implementation of this method could significantly impact the effectiveness of supply chain networks, trade logistics of LLDCs with similar geographical and political attributes.

1 Introduction

Historically, landlocked countries have been pessimistic about creating an export-oriented economy and associated development strategies. With stringent trade policies and complex border problems often cited, most of these nations remain poor and requiring so much improvement regarding infrastructure development. Mongolia, being a large nation without any direct access to a sea, shares its border with China and Russia. Although considered huge economies themselves, there has been very limited trade exchange between Mongolia with either of China or Russia resulting in low revenue generation. While China is the major export destination for Mongolia with 64.5% of overall exports of products such as minerals, apparels or livestock, a large portion of the rich mineral deposits of this East-Asian nation remain unexploited (Lv & Li, 2009). Even with such abundant choices, available transportation and logistics have not excelled in Mongolia, a major hurdle in carrying out trade with global partners. Everything from road conditions to political will have been identified as reasons for such a calamitous logistics system in the country (Pomfret, 2011).

Improvements in talks with neighboring countries (ASEAN and the Northeast Asia region) have played a crucial role in developing the idea of a better logistics system to support industrial development in the nation (Opasanon & Kitthamkesorn, 2016). Other nations in the region have started to identify Mongolia's geo-political location as advantageous for trade and its abundant mineral resources as potential resources for trading. Although developments in transportation and infrastructure have not been rapid, it has not been slow either in essentially improving the trading situation in the country. This has urged major firms willing to trade across borders to enhance production and improve talks within themselves and with governments of Northeast Asian nations (Jazairy, Lenhardt, & von Haartman, 2017; Opasanon & Kitthamkesorn, 2016). An improved and well-organized logistics system that ensures smooth transportation of goods delivered on time at a lower cost. . Trade logistics, a relatively new concept that welcomes changes in policies for smoothening the logistics process has become the aim of developing countries, Mongolia included. This calls for improvement in many soft capabilities of governments and officials by being open to negotiations and trade talks ignoring political rifts existing in the region.

The constraints that still exist in trade logistics in Mongolia had little effect in the efforts put by firms to develop logistics strategies that support their trade activities. Whilst there is improvement in the logistics activities in the country, understanding the real time challenges remain a major hurdle (Pomfret, 2011). An easy way to identify bottlenecks and improve efficiency of a logistics system in a complex environment is by developing a software model encapsulating the same characteristics as that of the real world system. As a result, practitioners and researchers have identified that building a process model could provide a comprehensive overview of the major logistics networks, which could be useful in identifying and capturing inefficient and/or less value adding process steps/tasks in the overall logistics system. Although many soft capabilities such as government policies and political issues may still not be largely captured in a process model, the suitability and sufficiency of using models that use real time data has been well-established (Fleischmann et al 1997).

The aim of the proposed logistics delivery model is to improve the effectiveness and efficiency of delivery of goods from manufacturer to the customers. Effective utilisation of trucks and the manufacturer/ warehouse capacities have always been a challenge in firms in Mongolia owing to a lack of proven methodology. Without sufficient access to advanced technology in process management, identifying the bottlenecks and rectifying issues are always risky, time consuming and error prone due to excessive human interventions. As for this chapter, the *Anylogic* process modelling software is utilised to develop and simulate the logistics delivery process. A simple but powerful tool, *Anylogic* is easy to understand and easy to modify as per user requirements.

In this chapter, we have identified some of the challenges that trade logistics in Mongolia faces as discussed in the relevant literature and thereby potentially include them in the modelling process. Complete details on the implementation of the software including the parameters and their descriptions are explained in different sections of this chapter. Furthermore, as an ultimate purpose of the study, we concluded our chapter with the results and suggestions that would help improve the system in consideration.

2 Literature Review

There has been significant growth in the volume of trade and transportation in Asia in the past two decades. The rise of more efficient production networks and improved regional economic integration in the Northeast Asian region has provided major stimulus to trade and investment flows across borders. The emergence of China as an economic superpower has helped countries in Northeast and Southeast Asia to conduct increased trading opportunities thereby higher revenue generation. Such countries that lie near China have been supplying products that are deemed necessary as additional supplies for China. Such activities have helped both the exporting and importing countries in their trade activities (Warr 2015). Even when trading partnerships are established, countries still found it difficult to transport and deliver products in a timely manner. The countries that find logistics the hardest to implement and expensive to remain efficient are those countries without a seaport (Warr 2015). Subsequently countries with nearest seaports being located in another country find themselves entrapped in series of bilateral talks and conduct trades at the mercy of the neighbouring nation (Li, 2017). Such countries, known as landlocked countries, have very limited options of transportation which occur predominantly through roads or rails. While it appears simple, landlocked countries often have very limited infrastructure in roads and rail owing to their poor economic condition (Opasanon & Kitthamkesorn, 2016). Mongolia is one such nation that has found itself in a similar situation.

A study conducted by the World Bank and Policy Research Corporation (2003) has identified that only 2.2% of the total roads are paved in Mongolia shedding light into its dismal state of infrastructure and economic development. Furthermore, only 1.2 square kilometres out of an area of 1000 square kilometres has rail facilities. Although this result may seem dated it cannot be ignored as infrastructure development has not been rapid in this country (Opasanon & Kitthamkesorn, 2016). Truckers, for instance, have reportedly lost several hours in reduced speed due to poor roads. More importantly, it has been reported that there are high costs in terms of time and money associated with trade in Mongolia (Pomfret, 2011; Ulzii-Ochir & Vorshilov, 2016). Increasing the cost of local produce in foreign markets has clearly placed small and medium enterprises in Mongolia out of competition. In addition, such firms find it difficult to take advantages of trade opportunities due to their inability to compete in a market that requires so much investment with little returns on those investments made. Besides, Mongolia has been affected, like many land locked nations to show lack of export penetration making them vulnerable to demand and policy shocks (Biggs, 2007). Adding further to delays related to geographical features and low road density, the literature suggests that delays associated with trade is primarily happening at border crossing points between countries. In Mongolia, a survey conducted by the International Exhibition Logistics Associates suggest that there is a delay of at least a few days to a few weeks at the Mongolia-China Border. In addition, some managers have indicated that the trucks sometimes get stopped intermittently which adds to the overall time taken for delivery. Evidences of bribery and corruption at the borders is quite common that adds to the transaction costs of conducting business (Jazairy et al., 2017; Opasanon & Kitthamkesorn, 2016; Pomfret, 2011).

Delays lead to excess costs in terms of inventory and storage. Subsequently, when the goods are perishable, delays could even affect the quality of the product due to spoilages (Hanaoka & Regmi, 2011). Measurements of performance and subsequent delays have evidently resulted in Mongolia being ranked 73 among 180 countries using a survey that was conducted to identify the ease of doing businesses in these regions (Arvis et al., 2016). While this survey did not suggest that Mongolia is among the poorest performers, the country's position is not encouraging as there are still many improvements required. (Behar & Venables, 2011) outlined in their study on logistics in landlocked countries that the cost of transportation to and from a landlocked country is much higher (15-20%) than a country with sea ports. Further to this, governments of countries through which landlocked nations have to transport their goods to the sea ports levy undue taxes for goods transported adding to the cost related challenges faced by countries. Lim (2017) in a study to identify key factors in developing transit trade corridors in East Asia has found that safety and security of resources transported as well as the performances of government agencies and political concerns at national borders to have significant impact in ensuring smooth cross-border trade. Stricter and less safe the borders are, tougher it would be to conduct business.

An important additional challenge to trade faced by landlocked countries is uncertainty. Limited research has been done in the area of uncertainty in trade logistics. (Christ & Ferrantino, 2011) suggest that uncertainty in costs and time is becoming more crucial and needs to be treated with great care and attention. Uncertainty arises when factors known as soft factors enter into the picture. Similar to the findings of Lim (2017), this article also mentioned factors such as regulations, market structure, administrative barriers and corruption as some of the major hurdles in supply chain and logistics that add to uncertainty that might even pull traders out of businesses. The susceptibility of destruction of road facilities has been one identified reason that limits smooth operations leading to uncertainty in delivering goods on time, especially in the supply chain of a multinational or large domestic firm. Unavailability of alternate routes has added to uncertainty with regards to road infrastructure (Christ & Ferrantino, 2011; Jazairy et al., 2017).

As the extent of transportation and logistics related activities increase, this uncertainty also tends to amplify. For instance if multimodal transportation is used in a transportation system and if not supported by proper guidelines culminated in poor road conditions, uncertainty with regards to both time and cost would create problems. Practitioners have commented that uncertainty in ports is extremely high, and it affects the whole system (World Bank & IFC, 2008). Landlocked countries that only have dry ports find that uncertainties associated with a dry port is even higher. The agencies, both government and firms therefore are forced to improve warehouse capacities with anti-theft facilities. In the absence of such facilities the goods remain in trucks that might be susceptible to theft adding to the uncertainty of goods security. Inclusion of insurances to compensate for thefts add to the hefty costs, which is already being paid by firms in logistics. This could further undermine profitability and viability particularly for small firms. The focus, therefore, should be to reduce uncertainty.

Trade logistics have been a concept that academicians and managers alike have tied to address particularly in the case of developing nations (Arvis et al., 2016). It requires active participation from government agencies as well implying that cooperation is mandatory for logistics across borders. But research suggest that often government policies in the case of trade logistics lack stability, transparency and consistency (Christ & Ferrantino, 2011; Lv & Li, 2009). A major area in which government agencies ted to fail is in the standardization of processes. Reportedly, developing countries have remained poor with limited development in trade and economics due to poor policy coordination between the centre and subsidiary agencies. A case study report by (Jazairy et al., 2017) found out that standardization within the process, such as that of standardising product packaging, barcoding of logistics information, container unitisation for loading and unloading, transportation, and storage, could effectively reduce uncertainty, minimize logistics cost and promote overall efficiency. From the same case study, it was argued that achieving customer satisfaction could only be satisfied if factors such as communications, trust, and culture system compliance are satisfactory in addition to work standardization. This in fact implies that successful trade logistics is possible only if all the parties develop a good relationship between themselves. A bad relationship could even result in failure in completing the logistics process (Havenga, Van Eeden, & Pienaar, 2013; Pomfret, 2011).

Relationships across borders have often been attributed to cultural differences between the parties involved. In case of Mongolia, although cultural differences are not reported, cultural distance with China cannot be ignored (Opasanon & Kitthamkesorn, 2016). With Tianjin (China) a major destination for Mongolian exports to both China and subsequently to other countries, it is crucial that Mongolia maintain a healthy relationship with China. In addition to hard factors such as contracts, system compliance and standardization, what also matters are soft factors such as trust and proper communication (Arvis et al., 2016; Jazairy et al., 2017). It is important to have transparent communication channels so that there are limited chances of conflicts between the parties involved. Additionally, trust is often considered a logistics performance enhancement that when coupled with proper communication channels generate excellent results (Khabbazi, Hasan, Sulaiman, & Shapi'i, 2013). A lack of such attributes could be the reason for delays at borders in the case of Mongolia.

A good logistics system would be very beneficial in terms of reducing the gap between consumer and producer prices, reduced inventory costs, insurance against regional price fluctuations, and more developed markets for countries such as Mongolia (Hanaoka & Regmi, 2011). This reduces the gap in expectation and reality in terms of cost and time for the customers. The requirement for any customer would be to receive an order on time and in full. In a logistics system in which they are the end users, they would be keen to keep track of their deliveries and the expected expenditure for the entire process. Until now, firms in Mongolia have not been well supported by overall processes involved in the cross border logistics, which could provide a clear picture of the process that could in effect translate to customer satisfaction on the other end of the supply chain. Thus, there is an increased need for an overhaul concerning the logistics operations conducted in developing nations such as Mongolia.

An encouraging trend that has emerged among the global firms is the h usage of information technology and the internet. Improved technology has quickly gained popularity for various business applications such as e-sales, e marketing, and to monitor vendors and enterprise management associated to strategic planning and warehouse accounting (Golosinki 2001). A recent report from the European Bank (2017) suggested more help was needed from the finance institutions in Mongolia to the firms indulged in trading operations

Limited research in the field of trade logistics of landlocked countries is a major drawback once a process model-based approach is planned to be undertaken. Although a simulation model with organisation and logistic attributes and parameters could be developed, soft factors as mentioned previously in this world would still be largely missing that could still be problematic while implementing the system (Khabbazi et al., 2013).

This book chapter aims to reduce the gap between customer expectations and logistics efficiency in a Mongolian context.

3. Modelling Methodology

3.1 Agent Framework

The model used for the proposed problem uses an integrated agent-based modelling methodology where delivery logistics processes are simulated through a set of agents. The proposed integrated model employs discrete event models for simulating processes and agent-based models for the distributed agents involved in the logistics delivery system.

Figure 1 illustrates the conceptual overview of the overall approach used for modelling logistics delivery problem in a Mongolian context.

The methodology starts when orders are generated by the retailers in the logistics process. The orders, considered as agents, contain details of customers or retailers to whom the final product needs to be delivered.

The subsequent stage involves a Manufacturer agent who receives the orders and creates shipments based on pre-defined rules. Depending on the availability of the product as inventory at the manufacturer's location, the incoming orders can be fulfilled directly or if the inventory is low then the order can be manufactured (based on processing times per unit product). Further, based on the transport capacity, the order could either be split or delivered in full by the available transport option (truck or rail). Orders are batched to create shipments based on the proximity of customer locations to which the order must be delivered. This step is followed by processing of the shipment according to the needs of the customers (quantity, lead time).

The next step involves a transport agent, specifically either trucks or railways. An intriguing concept that is quite common in the field of logistics is the concept of full truck load (FTL). A full truck load means a transport system would be ensured to be filled before its despatch which could ultimately aid in cost reduction. Much attention is given to the concept of truck load where the shipments to be delivered filled in full by the transport provider (in case of our model, it is referred as transport agent).

A statistics generation (or performance calculation) step is also used such that overall system performance can be monitored. These are designed to provide results based on the inputs provided and the variations included in both the expected quantity and the number of trucks available.

3.2 Agents

There are six agents used in this process each serving its own specific tasks while also interacting with other agents.

3.2.1 Retailer Agent

Retailer agents generate orders intermittently using a uniform time distribution. The orders generated by retailers or customers could be of different quantities, lead times and have to be delivered to different locations. These details are contained in the orders the retailer agent generates. The entire process thus starts with the demand generated by a retailer agent and ends once the requirement is delivered to the retailer in full and potentially on time (ideal case). The parameters involved by the retailer agent determines the movement of transport and subsequent delivery. The parameters used by the agent are

i. Name of retailer.
ii. Location of the retailer in the form of latitude and longitude.
The details of each retailer and their location are stored in the database.

<Insert Image 1 over here>

Figure 1: Overall methodology used for simulating a logistics system

While the parameters used in generating the orders are

i. Lead time for processing and delivery
ii. Amount of products required
iii. Customer location as specified in the database (to be discussed later).

Orders are generated on a case by case basis where the amount is distributed uniformly between 100 to 550 units and the lead time is distributed normally and truncated while varying the minimum and maximum values for each case from 0 to 20 hours as illustrated in Table 1. These parameter values are assumed to illustrate the working of proposed model. A user can change these values appropriately to simulate any specific scenarios.

<Insert Table 1 over here>

Table 1: Demand parameters for five different demand profiles (cases)

3.2.2 Order Agent

The orders generated by the retailer agents are considered as agents and referred to as “order agents”. The parameters for order agents could vary depending on the conditions invoked in

the modelling process as indicated in Table 1. The lead-time and order amount associated with the process is stored in the order agent and it is subsequently used for creating shipments and its processing.
In addition, there is an option of invoking priority (a variable used by the agent) for orders as well as to allocate waiting time for the product. These are crucial while orders interact with other agents in subsequent stages while processing.

3.2.3 Manufacturer Agent

A Manufacturer agent conducts two major functions.

i. *Rule based shipment processing* where shipments are created from orders using two rules depending on
   - The truck capacity, whether it can hold the shipment wholly or partially; and,
   - Proximity of customer locations.

Figure 2 illustrates the rule-based shipment processing process.

<Insert Figure 2 over here>

Figure 2: Rule based shipment creation and delivery (where C1-C5 represent customer order amounts)

Figure 2 shows customer orders with size of the ellipse depicting the quantity ordered. In the model developed, the orders are sent to the manufacturer who processes the orders and creates shipments. The rules for creating this shipment are as discussed earlier. For instance, if we assume C1 and C2 locations are within 100 Kms radius, orders being delivered to these locations can be combined to create shipments utilising the full transport (truck or rail) capacities. In this process, large orders may be split appropriately into multiple shipments. This process is also represented in Figure 2. This is to make sure the transport capacities are fully utilised. The Manufacturer agent considers this shipment request and processes it further for fulfilling the order in the next stage. Another instance that could be noted is customer order location represented by C5. Assuming it is a large order, it can appropriately fill the truck capacity, and then the shipment (in this case having 1 order only) is transported only to the location C5.

ii. *Manufacturing stage batching operation*: if the required number of products to fulfil the shipments/orders is not available in the inventory, then these are manufactured and later appropriately batched for delivery. As per step (i) above, the orders are converted to shipments and processed at the manufacturer agent.

Being a critical agent in this process, the parameters are well defined and complement the processing of orders. The following parameters are defined:

i. Transport agent capacity
ii. Name of retailer/customer
iii. Retailer/customer location in the form of latitude and longitude
iv. Cost parameters, that are utilized in calculating the cost of the process involved:
   a. Manufacturing setup cost - the constant cost of setting up for the process.
   b. Manufacturing cost per item - cost of manufacturing a unit product that is updated whenever a product is produced
   c. Holding cost per item per day - these costs are associated with storing inventory that remains unsold at the manufacturer locations
   d. Shortage cost per item per day - the cost allocated due to shortage of finished products for dispatch.

These cost parameters are used to calculate overall manufacturing costs, inventory holding costs, and shortage costs.

3.2.4 Transport Agent

The transport agent is the carrier of finished products from the manufacturer's warehouse location to the customer/retail location. Trucks and railways are used as the transport agents in this setup. Optimal utilization of trucks and timely delivery of products could be achieved only by rightfully managing this agent, especially with regards to full-load and delivery-in-full on-time to the retailer. This agent uses a cyclic loop logic to carry out this function (see Figure 3).

Based on the shipment (which is a group of order(s)) message (sent by the manufacturer agent), the transport agent loads the required number of products and travels towards the customer location before unloading the goods at the customer location(s) and then finally returns back to the manufacturing warehouse location for the next delivery. Based on the customer locations, shipments are delivered to customers one by one. See Figure 3 for details.

<Insert Figure 3 over here>

Figure 3: Working process flow for transport agent

3.2.5 Shipment Agent

The shipment agent stores a set of order agents (to fill transport capacity and customer proximity). Figure 2 illustrates the variations in shipments that are created because of the rules applied at the manufacturing location. One point to be noted is concerning the priority of the shipments to be delivered. Delivery of the finished goods would follow the priority given to the products (if initially set).

3.3 Software Implementation

The software used for developing this model was *Anylogic*. The Anylogic software has multimethod modelling capabilities and has the unique ability to use geographic Information System (GIS) maps within in the simulation models in a Java-based architecture, enabling the integration of multiple levels of simulation modelling. This integration is critical to identify breakthroughs associated with complex logistics systems. Integrating diverse types of data with multi-method simulation can advance our understanding of logistics systems to deliver higher value in improvement analysis. It enables the use of multiple methods such as system dynamics, agent based and discrete event simulation models within one modelling language and it also provides a Java based programming environment to implement new concepts and techniques. It is envisaged that the logistics simulation model will interact with the changes in policy reforms to provide scenario-based analysis of the performance of logistics systems. Broad performance objectives including throughput, delivery time, wait times, resources required can be used to evaluate cost and benefits of the policy level reforms and its impact on the operations of logistics systems.

A map including the road/rail network of Mongolia using Open Street Map (OSM) Classic has been used (see Figure 4). Note: Open Street Map Classic (OSM) is a collaborative project to create a free editable map of the world with limited restrictions on the use or availability of the map (Source: Wikipedia). The manufacturer locations can also be identified in the frame as a red icon with the icon of a truck on top of it (in red circle). Input to this model is provided through two range tabs, viz. number of trucks (zero and 100) and production rate of the manufacturing plant (50-1000 products produced per hour). One could develop different scenarios by varying these inputs that would aid in clearly understanding the model capabilities.

The values of the cost parameters (e.g. manufacturing, inventory holding, shortage) is updated once the model is run and is instrumental in identifying the associated costs and extent of improvements that need to be included. Here, manufacturing cost represents the cost of products manufactured. The inventory cost represents the cost of holding the inventory for other shipment to be sorted and batched. Shortage cost represents the cost compensated for shortage in the inventory. A scenario-based evaluation of the process could effectively provide a glimpse of better utilisation and optimization opportunities in terms of both time and cost for the organisation.

<Insert Figure 4 over here>

Figure 4: Initial model graphical interface

The initial simulation is based on the default settings. The simulation (see Figure 5) shows movement of trucks (transport agents) through the road network to the destination specified in the development stage of the model (in red circle). The change in the values of the cost parameters are also shown (in red rectangle).

<Insert Figure 5 over here>

Figure 5: Snapshot of interface when the model is running

In addition to the virtual representation of truck movements the statistics bar shows four different statistical outputs generated during the simulation of the model (see Figure 6).

<Insert Figure 6 over here>

Figure 6: Output statistics generated while the model is running

Figure 6 provides a snapshot of the outputs generated following the simulation of logistics network. The outputs required to be displayed by the system can be chosen in the programme settings. For the current model, outputs generated are:

i. Truck Utilisation – representing the utilisation rates of the truck fleet at the manufacturing firm
ii. Waiting time for product – representing the waiting time for orders to be manufactured at the manufacturing plant
iii. Order in delivery – representing the overall time taken by the orders to be fulfilled (including production, ordering, delivery in full)
iv. Delivery performances – representing the delivery performance of the logistics system (i.e. delivery in full and on-time)

In all these four outputs, the horizontal axes represent time taken. The four outputs are discussed briefly in subsequent paragraphs.

Transport agent utilization shows the percentage of trucks involved in delivery being effectively utilized in the system. In Figure 7, the percentage utilization is 95%.

<Insert Figure 7 over here>

Figure 7: Truck utilisation rates from the model

Waiting time for the product provides a time related assessment of how effective the manufacturing process is. It essentially indicates the delay associated with the production/ availability of the product before batching in the shipment processing stage of the Manufacturer agent (refer to Figure 1). In Figure 8, the percentage of orders is plotted against waiting time, which in the default set-up indicates that 15% of the orders have typically a waiting period of 40 hours.

<Insert Figure 8 over here>

Figure 8: Waiting time of trucks for products to be available at manufacturing plant

Order in delivery indicates the overall time a product was in the system. It gives the percentage of orders in the system against the total time it is available in the system. In Figure 9, approximately 17% of the order had a total time in system of around 120 hours.

<Insert Figure 9 over here>

Figure 9: Time duration when order was in delivery

Delivery performance shows the continuous performance of the manufacturing firms which consists of various "agents" in the system throughout the operation starting from when the order was received until its delivery. As indicated in Figure 10, delivery performance is the difference between expected lead time and delivery time.

<Insert Figure 10 over here>

Figure 10: Delivery performance (Order arrival duration – Order lead time)

4 Model Parameterization

The model uses several parameters associated with the different agents involved. The details of each of those parameters are discussed in this section.

4.1 Agent attribute values

The agent attribute values are reported separately for each of the agents. The details of parameters, variables, functions and collections are given below.

4.1.1 Retailer

In the modelling process, the retailer agent represents a group of customers. The relevant parameters and events used for modelling the retailer agent in the system are illustrated in Tables 2 and 3.

<Insert Table 2 over here>

Table 2: Parameters used in modelling the Retailer Agent

Note: Column Type represents the type of variables used.
String type is used for character variables. Integer and double are used for numerical variables.

<Insert Table 3 over here>

Table 3: Events used in modelling the Retailer Agent

4.1.2 Order Agent

The order agent represents the orders generated by the retailer agent. The relevant parameters and events used for modelling the order agent are illustrated in Tables 4and 5

<Insert Table 4 over here>

Table 4: Parameters used in modelling the order agent

<Insert Table 5 over here>

Table 5: Functions used in modelling the order agent

4.1.3 Manufacturer Agent

The Manufacturer agent represents the key processes carried out in this logistics delivery system. The relevant parameters, functions, datasets and events used for modelling the manufacturer agent is illustrated in Tables 6, 7 and 8.

<Insert Table 6 over here>

Table 6: Parameters and Functions used in modelling the manufacturer agent

<Insert Table 7 over here>

Table 7: Datasets used for the manufacturer agent

<Insert Table 8 over here>

Table 8: Cost parameters used in manufacturer agent

4.1.4 Transport Agent

The Transport agent represents the transport system (Trucks and Railways) used in this logistics delivery system. The relevant functions used for modelling the transport agent is illustrated in Table 9.

<Insert Table 9 over here>

Table 9: Functions used in modelling the transport agent

4.1.5 Shipment Agent

Shipment agents represent the processed orders. The relevant parameters and functions used for modelling the shipment agent is illustrated in Table 10.

<Insert Table 10 over here>

Table 10: Parameters and functions used in modelling the shipment agent.

4.2 Datasets used

A model that illustrates a real-life scenario requires external datasets that would essentially provide relevant data associated with the situation. The model developed requires data for the road and rail systems requires information of routes, type of roads, normal traffic, distance between manufacturing and delivery points of the firms of interest in Mongolia. An application that supported this need was Open Street Map Classic (OSM Classic). OSM classic provides an open view of road/ rail network shape files with the inclusion of street views that make retailer locations accurate to a fair extent. OSM Classic provides Geographic Information System data (GIS). GIS is a system designed to capture, store, manipulate, analyse, manage, and present all types of geographical data. Hence the geography of Mongolia and the topography of the route to other ports were available and gave us sufficient idea regarding the challenges faced in this regard.

5. Numerical Model Visualisation

The integrated logistics delivery system presented in this chapter encapsulates the challenges faced in the land locked countries and has effectively developed a multi-method methodology that could be used in the Mongolian context. It has taken into account the types of logistics aspects such as manufacturing, retail, as well as distribution of a particular product type. In addition, this model has also incorporated transportation type used as well as time required for order production and delivery by the manufacturing firm. Apart from the maps used to depict directions of the routes used in Mongolia, this study has also utilised evidences from literature indicating general characteristics of Northeast Asia region. Those characteristics include size of roads, average delay at borders and average time taken to move from one location to another. The flexibility associated with the model helps users to vary inputs and generate simulation results thereby providing ample opportunity to develop strategies aimed at improving time taken for transportation, delivery in full as well as lowering the costs associated with the business depending on the estimated results.

A major advantage of this model is in effectively utilising transport capacity. The process is designed to make use of trucks effectively, thereby minimising underutilised capacities. If there is less than full truckload orders then these are combined together to make them near full truckloads. A common problem in real-world logistics systems is the concept of full truck load, a problem easily rectified in this current process by batching the finished products based on truck capacity as well as customer location. The customer also benefits due to reduced time constraints on each shipment.

Excessive loss in terms of time and costs associated with logistics remain a challenge that has yet to be fully resolved. This model is designed to make proper utilisation of truck capacity that could save the cost of multiple trips to the same location. The manufacturing process is so designed that creates delays only when there is an absence of products in the inventory. If the manufacturer can make sure products in the right amount are available in the inventory, time required for completing the process could also be saved. Once the products are manufactured and transported the waiting time for customers to receive the shipment in full capacity is reduced by effectively combining both customer locations and order amounts. Additionally, this model can be used as a supporting tool for forecasting events. Since simulations could indicate the optimal number of trucks and production capacity required for satisfactory operations as well as better control over a shipment due to consolidated shipments, strategies can be easily developed using data obtained as a result.

Further, the model can be effectively used for capacity planning, such as warehouse planning. As the firm becomes more aware of their logistical capabilities, it would be easy to identify the number of excess products that might have to be stored as the system waits for the next set of transport agents to a particular location.

With continuous improvements imminent in logistics delivery systems in developing countries, this model could assist in assessing the impact of process change that has occurred. Monitoring the delivery performance during a process change could determine the extent of improvement thereby measuring the impact this change has had on the system. A process change could range from an update in the machinery to an acquisition/ merger to improve businesses.

6. Conclusions and Future Research

The above discussion has indicated the relevance of a logistics delivery process model. Process models are effective methodologies for creating scenarios that best relates to real-life situations. As businesses today are heavily reliant on planning and strategy development, a process model could be a useful tool to provide data on resource utilization and capacity forecasting which in turn enhances the competitiveness of Mongolian firms. An improved competition drives innovation and performance. Therefore, firms participating in trade logistics can utilise and better develop efficient logistics systems to improve its manufacturing and export. A problem faced by developing and landlocked countries like Mongolia in Trade logistics is the lower amounts of export (Bigg, 2017). Excessive involvement of public entities has often been a factor for corruption, in this case the cross border trade. An enhanced supply chain would increase the volume of goods transported thereby reducing the power exercised by governments thereby improving cross-border transportation.

For developing nations, such models could be crucial so that the process runs optimally with available resources such as trucks and an organisation's capabilities. For Mongolia, which has many untapped natural resources, improvements in logistics and processes associated with it could be crucial not just for organisations within the country but for the government as well. Governments have the opportunity to increase a country's revenue by enhancing the gap between exports and imports. As exports are increased, revenue generated would improve substantially. A country still categorized as a poor nation, exporting their reserves could be the best way of improving their economy. Nations such as Mongolia could follow some of the successful models such as that of Switzerland to gain momentum in trade where they have been excellent in border policies with their neighbouring nations. Although, circumstances of Switzerland and Mongolia are quite different in terms of its political treaties, one could argue that good trade negotiations could do wonders to improve the trade from Mongolia to other nations and vice versa. Since border delays remain a major challenge for Mongolia, even a highly optimal process model would not yield the best results due to uncertainty related to time and cost associated with these administrative issues that are out with the control of firms.

Additionally, as poor infrastructure persists, transportation through roads could be a major hurdle. A solution to this problem could be the improvement in rail tracks and utilizing intermodal transportation techniques so that there is comparatively less delays associated with transportation. Meanwhile, better utilization of available railways is still a better option than relying just on road transportation. An encouraging development in this direction has been the bilateral agreement between China and Mongolia along the Silk Road Economic Belt that is likely to improve transportation in this region.

While there is growth in technology and trade relationships, there still is a responsibility from the government's side to build healthy relationships with their neighbouring countries. Mongolia should make the best use of the economic growth of China by creating an opportunity of smooth trade in the borders. A logistics delivery system can be successful only if trust and communication is clear and well preserved.

Future research in this area should therefore be focusing on trade logistics identifying best practices in manufacturing and logistics when applied especially to Land Locked Developing Countries. More research needs to be done on the efficiency and effectiveness of government bodies in their effort to improve border performances so that simulation models can be put into practice in a real life scenario. A quantitative approach using process models where such soft factors that determine undue delays in borders could be developed and collated so that policy makers could identify the bottlenecks and generate solutions that satisfy all parties involved. A firm could remain competitive only when its development both internal and external is aligned with the changes happening globally.

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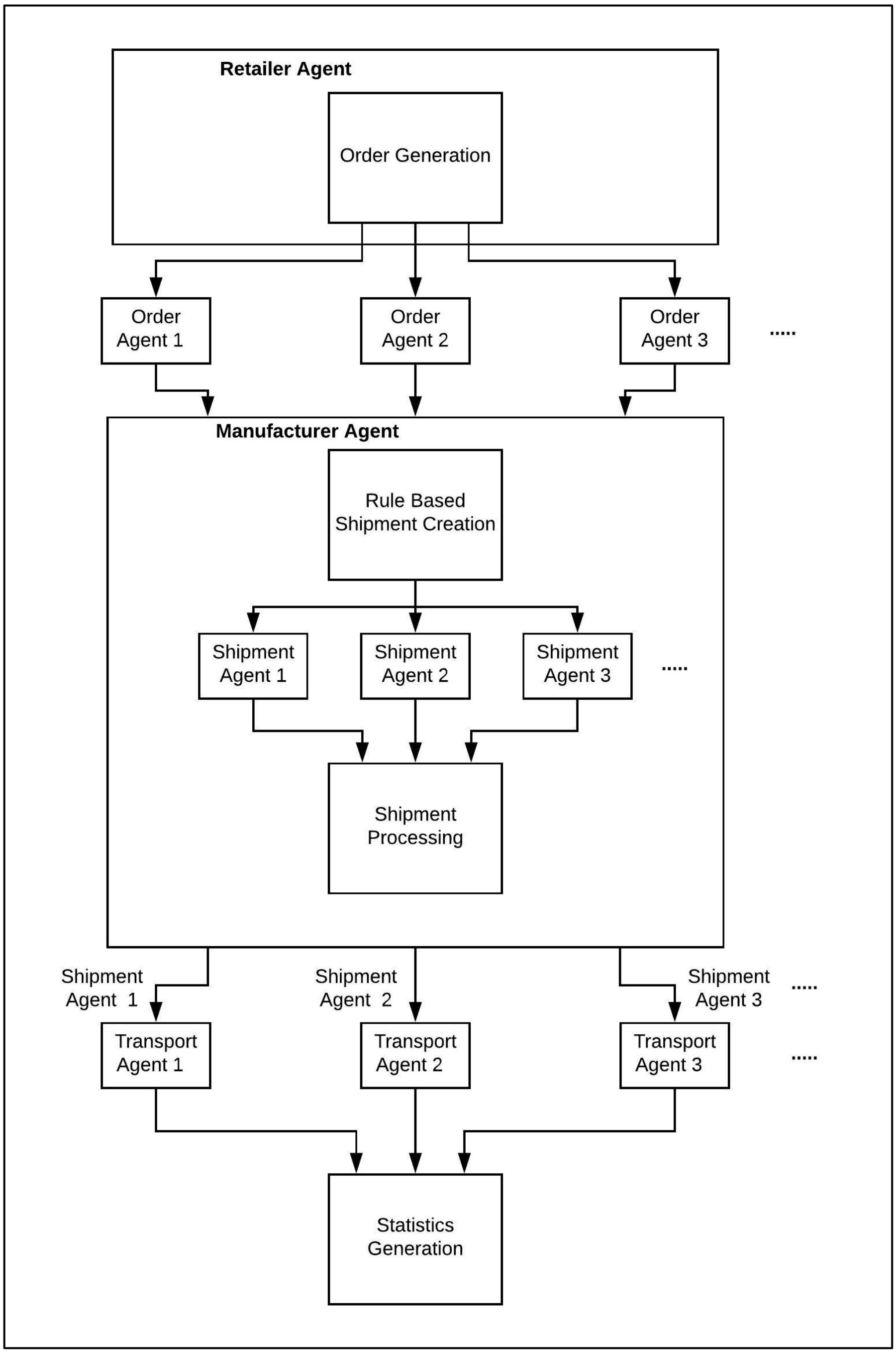

Retailer Agent
Order Generation
Order Agent 1
Order Agent 2
Order Agent 3
.....
Manufacturer Agent
Rule Based Shipment Creation
Shipment Agent 1
Shipment Agent 2
Shipment Agent 3
.....
Shipment Processing
Shipment Agent 1
Shipment Agent 2
Shipment Agent 3
.....
Transport Agent 1
Transport Agent 2
Transport Agent 3
.....
Statistics Generation

Figure 1:

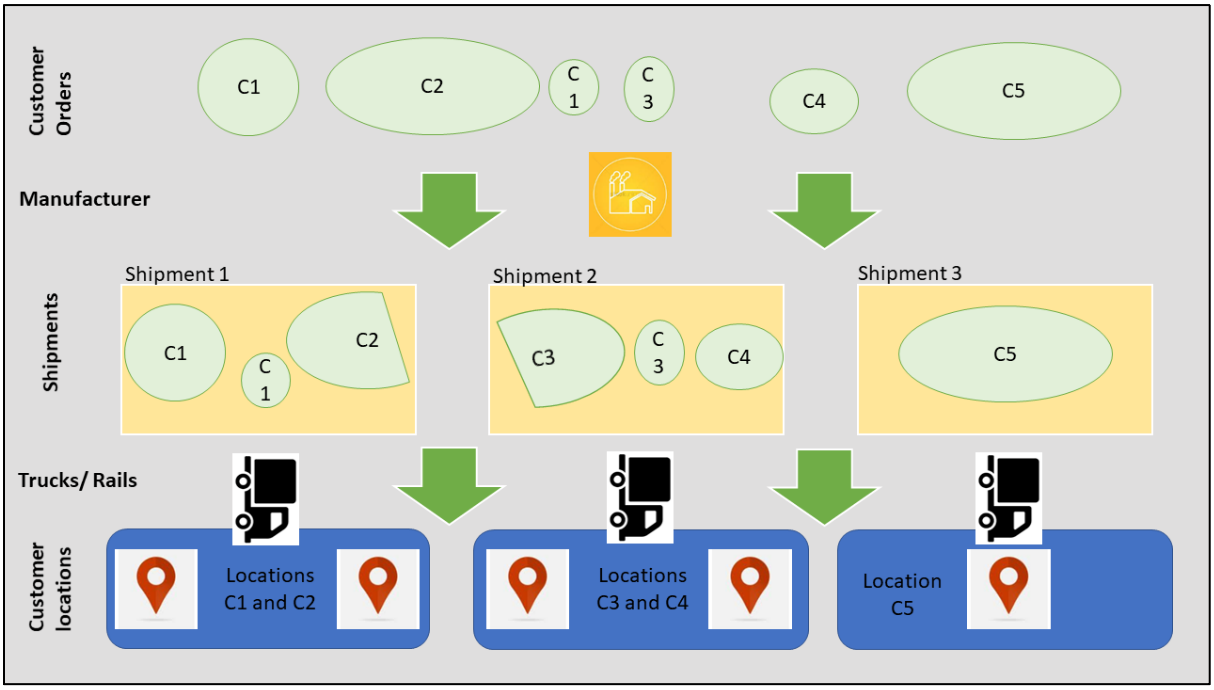
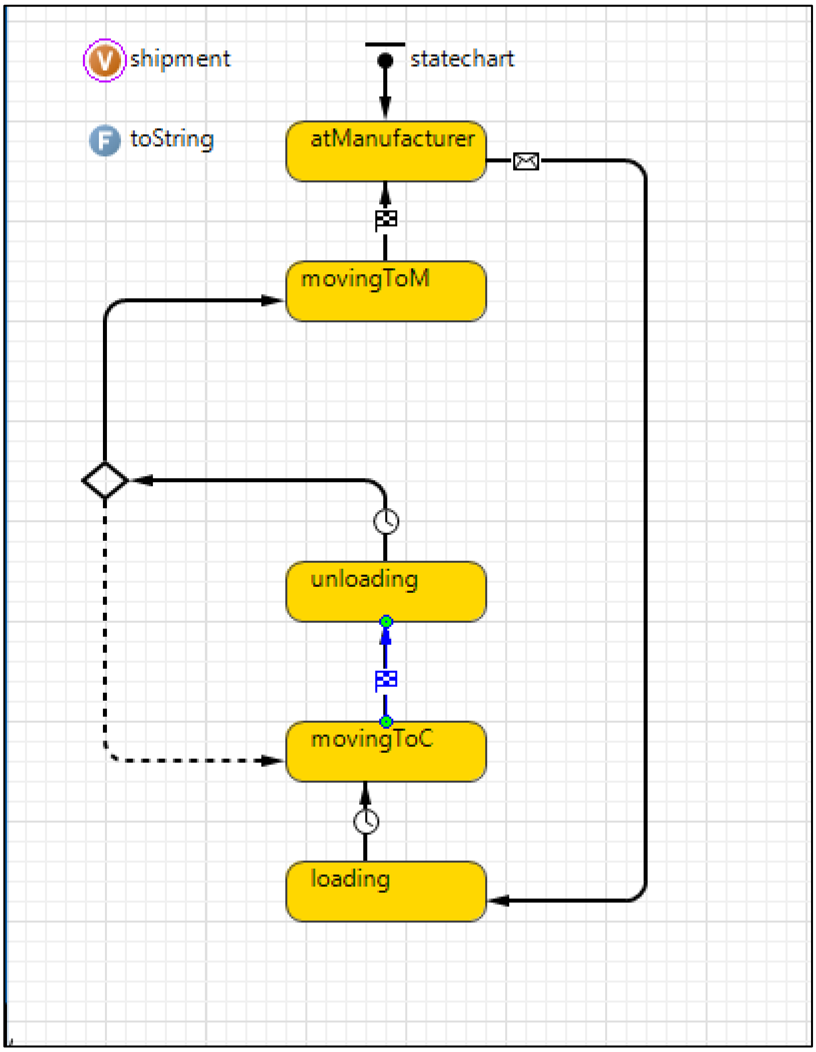


Figure 2:



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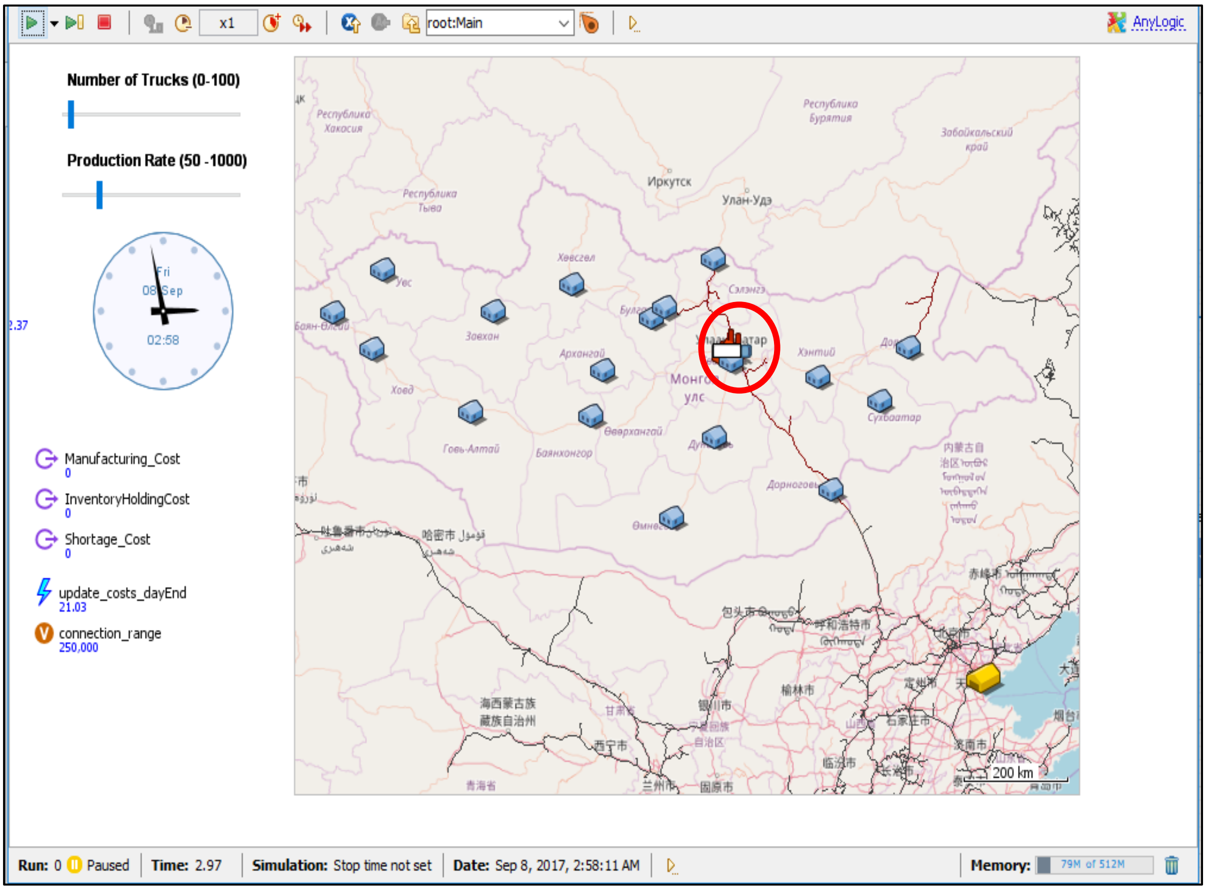

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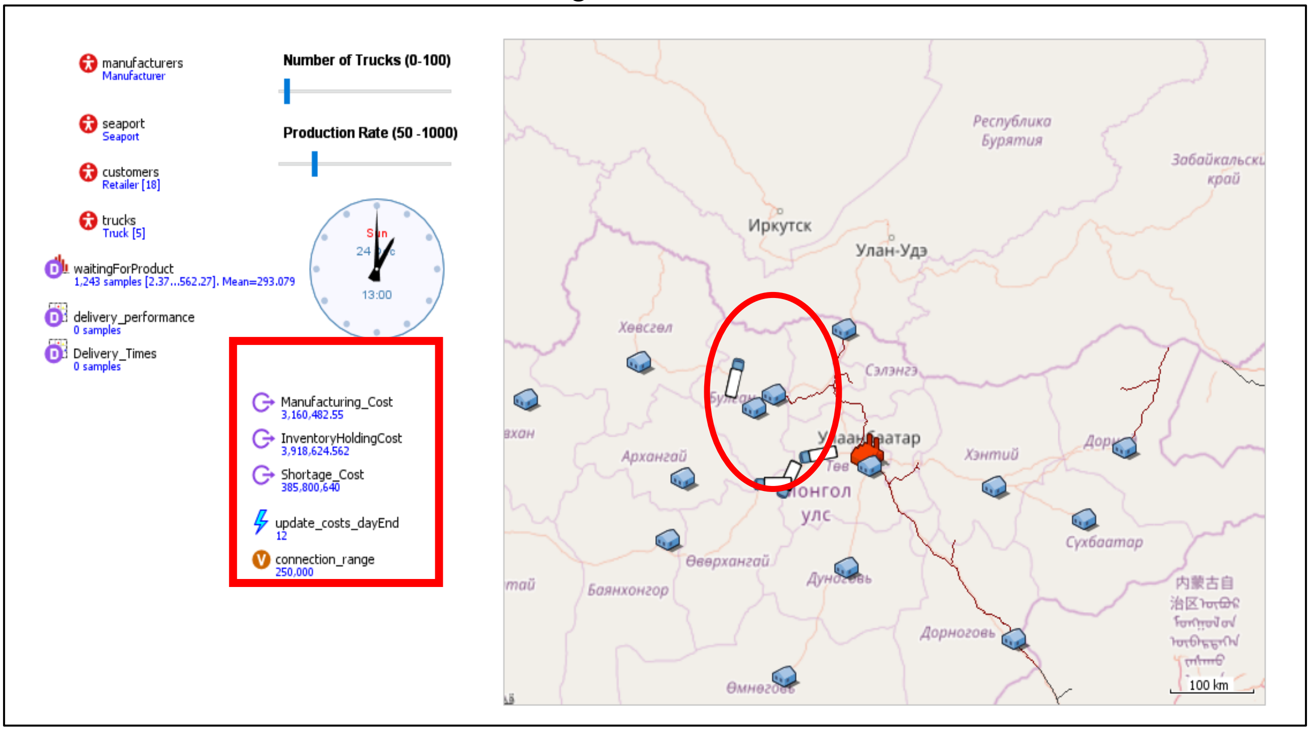

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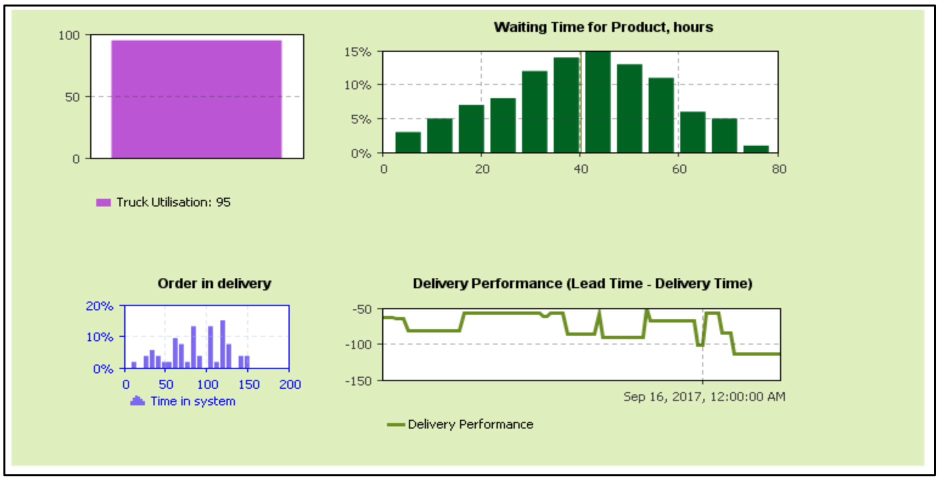

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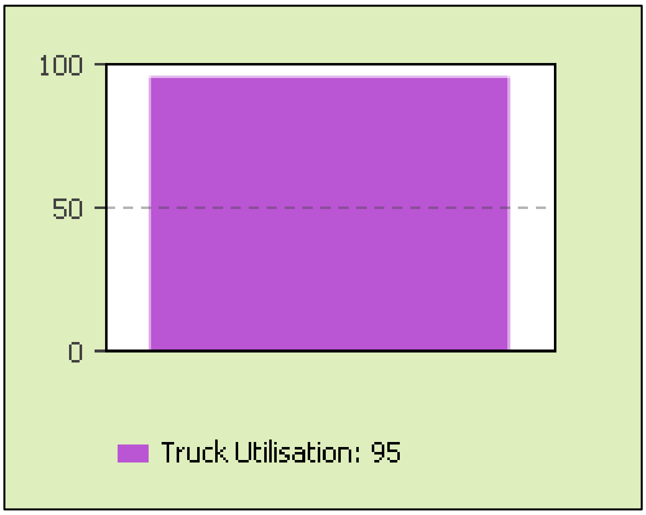

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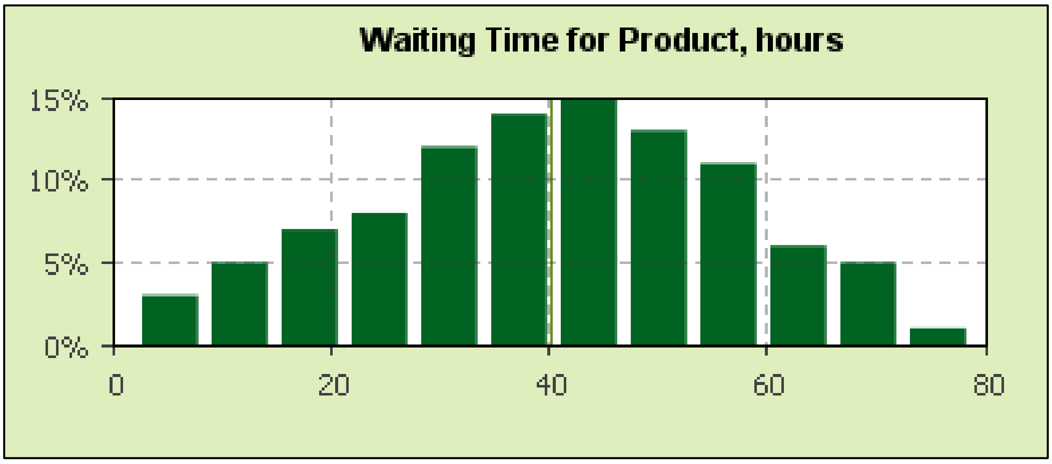

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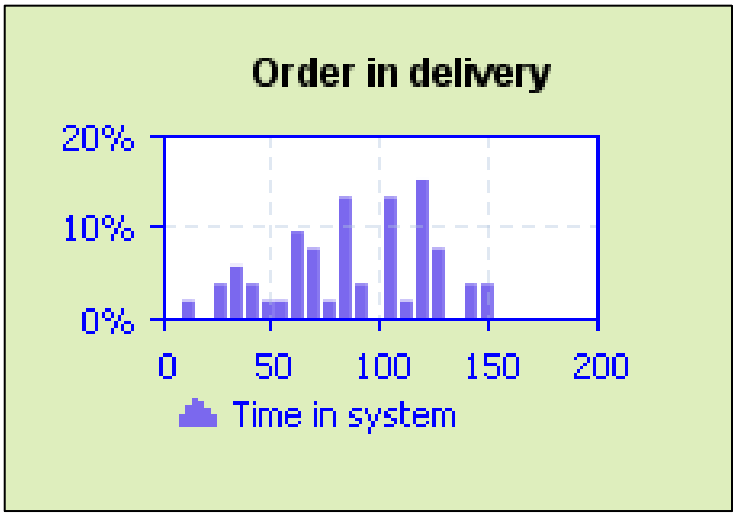

Figure 9:

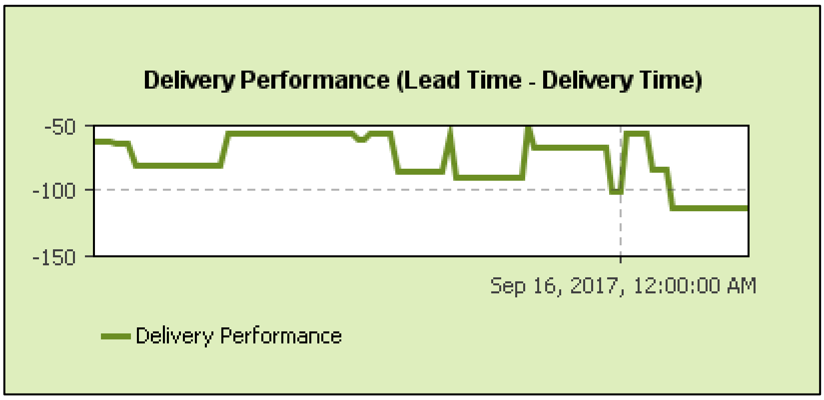

Figure 10:

Tables

Table 1: Demand parameters for five different demand profiles (cases)

Case 0					
Lead Time				Order Amount	
Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum
1	80	20	8	100	200
Case 1					
Lead Time				Order Amount	
Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum
1	80	30	8	150	250
Case 2					
Lead Time				Order Amount	
Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum
1	80	40	8	200	300
Case 3					
Lead Time				Order Amount	
Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum
1	80	50	8	250	350
Case 4					
Lead Time				Order Amount	
Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum
1	80	60	8	400	500
Case 5					
Lead Time				Order Amount	
Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum
1	80	70	8	450	550

Table 2: Parameters used in modelling the Retailer Agent

No.	Name	Description	Type
Parameters			
1	Name	Name of the retailers/ customers as per the database	String
2	Latitude	Location of customer	Double
3	Longitude	Location of customer	Double

Table 3: Events used in modelling the Retailer Agent

No.	Name	Description	Trigger type	Mode	First Occurrence time (hrs.)	Recurrence time (days)
Events						
1	Demand	Generates demand on a case by case basis where the amount is distributed uniformly between values of 100 to 550. A case program methodology is utilised which includes 5 different cases. Lead time is distributed normally.	Timeout	Cyclic	0	Uniform distribution

No.	Name	Description	Type	Default Value
Parameters				
1	Lead Time	Lead time is the amount of time that passes between the commencement and the end of a process	Double	_
2	Amount	Amount of item requested by customer	Integer	
3	Customer	Customer or Retailer who generates demand	String	

Table 4: Parameters used in modelling the order agent

No.	Name	Description	Type	Default Value
Functions				
1	ToString	Returns value for each of the parameters used in the order agent	String	

Table 5: Functions used in modelling the order agent

Table 6: Parameters and Functions used in modelling the manufacturer agent

No.	Name	Description	Type	Default Value
		Parameters		
1	Truck capacity	Capacity as pre-defined for the transport agent	Integer	300
2	Name	Name of the retailers/ customers as per the database	String	
3	Latitude	Location of customer	Double	
4	Longitude	Location of customer	Double	
5	*S*	Lower threshold value for inventory or re-ordering point	Integer	20
6	*S*	Upper threshold value for inventory or re-ordering point	Integer	80
7	Manufacturing set up cost	Cost of setting up for the process	Double	50
8	Manufacturing cost per item	Cost of production per item	Double	5
9	Holding cost per item	Amount required to keep items in inventory	Double	0.75
10	Shortage cost per item	Amount required to compensate for the lack of availability of an item	Double	4
No	**Name**	**Description**	**Type**	**Agent**
		Functions		
1	Waiting time	Calculates overall time waited for products to be produced	Double	Order
2	Get_priority	Function to simulate higher priority for higher amount + lower delivery time (70 is average speed)	Double	Order
3	Getorder_Split	Function that returns a value if amount of products is greater than truck capacity	Integer	Order
4	Check_Amount_Order	Function to check if amount is between 250 and truck capacity	Boolean	
5	Waiting for trucks	Function that calculates amount of time waiting for trucks to be available and returns if priority needs to be given	Integer	Order
6	Packing	Function that is used for packaging. Starts from 0 as amount is already from agent in delay. ensure max 100 previous orders are looked at packaging	Just Action	Order

No	Name	Description	Time Std.	Trigger	Mode	First Occurrence time
Parameters						
1	Updating backlog	Calculate orders waiting	Model time	Timeout	Cyclic	1 hrs.
2	checkPriority_dayEnd	Checks priority for each order waiting for trucks. If an order is waiting for more than a day. Force the order to be picked up by next available truck	Model time	Timeout	Cyclic	1 day

Table 7: Datasets used for the manufacturer agent

No.	Name	Description	Horizontal axis value	samples limit	Updating
Datasets					
1	Dataset	Set of samples used in the process	Time	100	Not updated automatically

Table 8: Cost parameters used in manufacturer agent

No	Name	Description	Time Std	H- axis value	Update	Recurrence
Cost Parameters						
1	Holding cost	number of products (every hour)×holding costs (/hour). inventory_Manuf× (HoldingCostPerItemPerDay /24)	Model time	Continuous duration of time in hours.	Auto	1 hrs.
2	Manufacturing cost	Kicks in after each order is processed. Variable Cost (per Item) × amount + Set-up costs: assuming it is per Order. (ManufacturingCostPerItem ×order_agent_process.amount) + ManufacturingSetupCost		Continuous duration of time in hours.	Do not update automatically	
3	Shortage cost	Cost of non-availability of item in the inventory. amount_WaitingToBeProducted×ShortageCostPerItemPerDay		Continuous duration of time in hours.		

Table 9: Functions used in modelling the transport agent

No.	Name	Description	Type	Default Value
Functions				
1	ToString	Returns value of shipment after each iteration	String	_

Table 10: Parameters and functions used in modelling the shipment agent.

Parameters			
No.	Name	Description	Type
1	Destination	Destination of shipment as indicated by retailer location	Retailer
2	Leadtime	Latency between order request and delivery	Double
Function			
1	toString	Returns value of above parameters after each iteration and updates it to collection orders	