Uberization Effects on Freight Procurement

by

Ignacio Helguera Sánchez
Bachelor of Science, Industrial Engineering, Universidad Pontificia Comillas, 2009

and

Lydia Paramita Hendra Mukti
Bachelor of Science in Business, Finance and Operations Management,
Indiana University Bloomington, 2011

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Signature of Author.....

Ignacio Helguera Sánchez
Department of Supply Chain Management
May 11, 2018

Signature of Author.....

Lydia Paramita Hendra Mukti
Department of Supply Chain Management
May 11, 2018

Certified by.....
Dr. Christopher Mejía Argueta
Director, Supply Chain and Global Logistics Excellence Network for Latin America
Capstone Supervisor

Accepted by.....
Dr. Yossi Sheffi
Director, Center for Transportation and Logistics
Elisha Gray II Professor of Engineering Systems
Professor, Civil and Environmental Engineering

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ABSTRACT

According to a report by A. T. Kearney, in 2016 the US business spent $1,392.64B on logistics costs. 90% of transportation spending is procured in the form of Long Term Contracts. A Long Term Contract drives long procurement cycles that can last over 6 months, which results in significant financial risk for both shippers and carriers. It is estimated that 10% of freight under Long Term Contracts fall out and ends up in the spot market due to low tender acceptance and market volatility. The spot market, on the other hand, can be highly dynamic. Typically, shipper pays 20% more for freight in spot market compared to what would be agreed upon in a Long Term Contract. Regardless of the freight procurement method, shippers are constantly faced with market volatility and are left scrambling to find a new carrier capacity when carrier fall off occurs. Assuming a shipper could book a truck instantly, how would their procurement strategy and supply chain network change? We hypothesized that there is a financial benefit to all parties from faster, more liquid transportation transactions, through lower labor costs spent on freight procurement transaction and shorter planning cycles in transportation procurement. Digital freight matching via an on-demand app, facilitates long arduous transactions in a real-time low-cost manner. Using System Dynamics models, this project developed a behaviorally based conceptual model to analyze effects of a digital freight matching app on shippers' freight procurement. Our analysis shows the shipper will choose a more efficient, low-cost alternative to the spot market, provided that the shipper's total spending is lower than what would be agreed upon in a Long-Term Contract. Digital freight matching benefits shippers by providing needed freight capacity at lower cost. Individual changes in market volatility, shipper volatility, app efficiencies, or carrier and shipper adoption rates would potentially add more than 10% variability in freight rate paid by shipper and more than 50% digital freight matching app adoption rate for both shippers and carriers.

Capstone Supervisor: Dr. Christopher Mejía Argueta
Title: Director, Supply Chain and Global Logistics Excellence Network for Latin America

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1. Introduction

In 2016, US business spent $1,392.64B on logistics related expenses. 19% of it was accounted for by full-truckload alone[1]. A large consumer packaged goods (CPG) company, for example, can spend roughly $100-400M annually for full-truckload shipments. With that amount of spending, it is not surprising that transportation is the largest logistics cost for most shippers, averaging over 60% of a firm's total logistics costs. Truckload (TL) expense is typically the largest component of a shipper's transportation budget[2].

As logistics costs become increasingly high, shippers become more strategic in handling their freight procurement. It is common for shipper to utilize various freight contractual agreements available in the market. The most common ones are private fleets, Long Term Contracts (LTC), and spot market. It is difficult to estimate the exact proportion of Long Term Contracts vs spot markets used by shipper. These statistics are not reported directly to government agencies or analyst firms (Caplice, 2007). Commonly, 90% of freight procurement is conducted through a Long Term Contract (LTC), leaving 10% of the transactions in the spot market.

A Long Term Contract (LTC) is essentially a reverse auction organized by the shipper. The method has been around since the U.S. surface transportation industry was deregulated in the 1980s[3]. The agreement is typically concluded at the end of the year to be fully executed by the next year, and repeated annually. However, shippers often start the negotiation process long before the year ends. According to Caplice (2009), a shipper's general procedures when conducting a Long Term Contract are:

1. Shipper forecasts the upcoming period freight demand based on historical data and creates a representative network of expected weekly (or monthly) flows on each primary lane.
2. Shipper determines carriers to be invited to the auction and what information the carrier should provide regarding price (per move, per mile, per weight, etc.), service details (days of transit, capacity availability, equipment type, etc.), and the types of bid allowed.
3. Shipper communicates the lanes to the carriers, commonly via email.
4. Carriers analyze the network, determine the rates to offer, and submit their bid rates.
5. Shipper receives carriers' bids and determines the winner(s). During this time, it is common for a shipper to negotiate the offer with chosen carriers to get the desired price. Some shippers also conduct multi-round auctions to determine the winner.
6. A Long Term Contract is agreed upon by shipper and carrier. Auction results then are uploaded to the electronic catalog (routing guide) used in operations.

[1] A.T. Kearney. (2017). Accelerating into Uncertainty. Annual Council of Supply Chain Management Professionals State of Logistics Report, 28, 2.
[2] Wilson, R. 2005. 16th Annual State of Logistics Report, Security report card—Not making the grade. Council of Supply Chain Management Professionals.
[3] Caplice, C. (2009). Electronic Markets for Truckload Transportation. Production and Operations Management, 16(4), 423-436. doi:10.1111/j.1937-5956.2007.tb00270.x

In the agreement, the carrier is contractually obligated and expected to provide service along the pre-determined lanes (origin-destination pairs) at an agreed price when the shipper requires such service. In practice, however, an LTC is not completely binding.

Carrier cancellation is a common cause of fall out in Long Term Contracts. The carrier is obligated to provide service according to the stated tender acceptance rate, a percentage relative to the overall shipments required by the shipper within the contractual period. As a result, the carrier can decline to take a shipment when it has no capacity to serve. In another scenario, when the market tightens, carriers are often benefited by selling their capacity at a higher rate in the spot market. Thus, they cancel the previously agreed upon commitment so they can accept another shipment.

Market uncertainty also brings unexpected shipments outside of the projected demand. Because a Long Term Contract is arranged based on historical data, there will always be variation in the future demand. When actual demand is higher than projected demand, the shipper has to find additional capacity. If chosen carriers are unable to take those loads, shippers resort to finding carriers through the spot market. On the other hand, when actual demand is less than what is projected, shippers lose money by paying an upfront fee for unnecessary capacity.

Similar to a Long Term Contract, the spot market utilizes a reverse auction method, but in the form of electronic portals or exchange. Shippers post requests for quotations (RFQ) and carriers respond by competitively bidding on the load tenders. Shippers can submit their loads either in the public marketplace or a private marketplace. A private marketplace for a shipper consists of its contracted carriers or in-house carriers. In a public marketplace, all approved carriers can participate in the auction. In spot markets, the shipper posts urgent shipments or sometimes hypothetical loads to test the market and gauge the pricing system (Nandiraju & Regan, 2008).

The spot market can be highly dynamic. Market volatility, for example, affects both available capacity and pricing. When there are severe shortages of carrier capacity, especially in certain lanes, with relatively high and volatile prices, shippers must actively bid for capacity in the spot market (Lindsey & Mahmassani, 2016).

In December 2017, the Federal Motor Carrier Safety Administration (FMCSA) required full implementation of the Electronic Logging Device (ELD) mandate, affecting more than 3 million commercial truckers in the US. The mandate requires drivers to use an Electronic Logging Device (ELD) as a substitute for a paper logbook to record their compliance with Hours of Service (HOS) requirements. The immediate effect of ELD implementation was increasing freight spot rates and demand for trucks.

As of March 2018, DAT truck rates showed a 5%-15% increase in spot rates as the ELD penalty phase began (shown in Figure 1)[4].

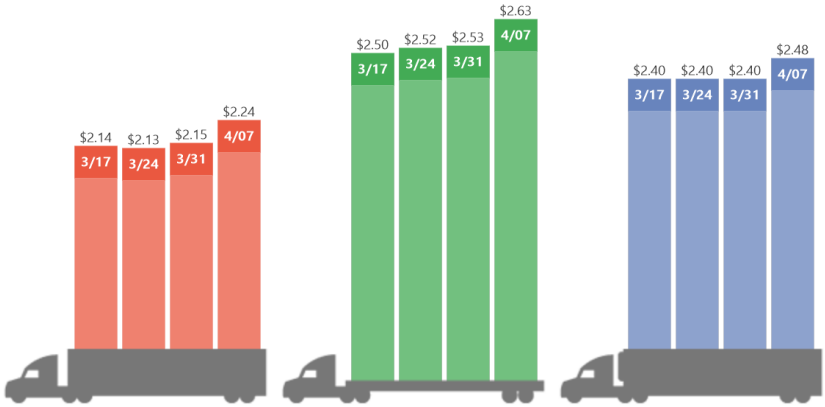

Figure 1: DAT National Spot Rates for Van, Flatbed, and Reefer Trucks.

This recent example aligns with the common practice that a shipper pays 20% more for freight in the spot market compare to what agreed upon in an LTC.

To help secure the desired freight in a tight market, the shipper often engages with third party logistics (3PL) brokers. 3PL brokers help shippers by taking responsibility for securing capacity for a shipment. In return, the 3PL broker takes a commission per transaction, further increasing total cost spent on freight.

Thus far, utilizing either an LTC or the spot market can result in significant financial risk for both shippers and carriers. Regardless of the freight procurement method, shippers are constantly faced with market volatility. When a natural disaster hits, demand surges, or carrier capacity shortens, the shipper is left scrambling to find a new carrier capacity.

As of 2016, there were well over 15,000 registered freight brokerages in the US[5]. Still as a shipper, it is often difficult and inefficient to navigate these different options to secure carrier capacity in the most price-efficient way. Current freight procurement methods provide shippers with limited visibility and certainty regarding carrier availability, desired shipment time, and expected price to pay.

Assuming that a shipper could book a truck instantly, how would their procurement strategy and supply chain network change? Our hypothesis is that there would be a financial benefit to all parties from faster, more liquid transportation transactions, through lower labor costs spent on freight procurement transaction and shorter planning cycles in transportation procurement.

[4] Sterk, R. (2018, March 6). Realities of e-logging lead freight costs higher. Retrieved April 10, 2018, from http://www.bakingbusiness.com/articles/news_home/Business/2018/03/Realities_of_e-logging_lead_fr.aspx?ID={73806D50-B77B-4559-B852-F83669BB3D0B}&cck=1

[5] Longman, N. (2017, March 29). Spotlight on the US freight broker industry. Retrieved April 19, 2018, from https://www.supplychaindigital.com/logistics/spotlight-us-freight-broker-industry

We tested this concept by looking at the recent surge on technology platforms that provide instant booking for freight, commonly known as Digital Freight Matching.

Digital Freight Matching (DFM) is a digital platform that matches a load with a nearby available carrier. It is an on-demand app that pairs shipper and carrier. The platform allows shippers to "directly and almost immediately find drivers with the capacity to transport their truckload freight on the right types of trucks on the dates and routes they need.[6]" While many mobile platforms provide many different offerings, the most commonly used features are tracking and monitoring.

A report published in July 2016 by Armstrong & Associates, Inc. (A&A) highlighted that the Digital Freight Matching sector has attracted over $180 million in venture capital investment since 2011, including $67 million in 2016 alone. Each year, there are an increasing number of digital startups in logistics. Oliver Wyman, a leading global management consulting firm, noted that 74 digital startups with more than $2.5M investment received were created globally in 2015[7].

Along with our hypothesis, we foresee that this on-demand app will reduce inefficiencies in the procurement process by shifting the labor-intensive negotiation activities online. Having transparency regarding availability and freight price drives the creation of liquid transportation market and increases freight matching. Ultimately, Digital Freight Matching can 1) reduce transactional inefficiencies in traditional method with technology (real-time access) and non-negotiated price per shipment, 2) eliminate slow, manual, and high margin transportation providers, 3) provide real-time visibility to both shipper and carrier. As more shippers and carriers join the digital platform, the marketplace will build its density, and freight transactions will become more liquid.

To study the effects of "uberization" on freight procurement, we partnered with Uber Freight, a service offered by the global technology-based transportation company, Uber. Uber Freight (UF) operates as a tech-enabled transportation provider with an application providing digital freight matching services.

As of Fall 2017, Uber Freight provides truck drivers with the instant freight-booking app, seven days of payment (upon receiving of an accepted proof of delivery), and paid "accessorial rates" for any unforeseeable circumstances that inhibit the driver's job, such as detentions, layovers, or truck orders not used.

It is expected that Uber Freight will extend its product offering to the shipper side in the near future. Following the Uber Rides app, we foresee the shipper side of the Uber Freight app providing 1) digital freight management dashboard, 2) real time visibility of nearby available carriers, 3) freight match to one (or more) carriers, 4) secured online payment for published price, and 5) price surge capability based on market volatility.

[6] "Digital Freight Matching And The New Era Of Freight Logistics." (2017, March 04). Retrieved April 17, 2018, from https://www.inddist.com/news/2017/03/digital-freight-matching-and-new-era-freight-logistics
[7] http://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2017/aug/How_Start-ups_Are_Digitalizing_Logistics.pdf

With these assumptions and company information, we built a behaviorally based conceptual model to analyze the effects of a digital freight matching app on a shipper's freight procurement. We developed a System Dynamics model that represents the ecosystem and conducted sensitivity analysis to understand the behavior of different related variables. We believe a System Dynamics model is the appropriate tool to understand the nonlinear behavior of complex systems over time using stocks, flows, causal loop diagrams, and table functions.

Our model does not intend to forecast a specific point at which the business will change (for example, the number of loads to increase shipper adoption rate or a price point at which a shipper will switch to a different procurement method, etc.). Instead, our model analyzes the behaviors of different stakeholders (shippers, carriers, Uber Freight) at different levels of variables.

Based on our analysis, a shipper will choose a more efficient low cost alternative to the spot market provided that the shipper's total spending is lower than what it is agreed upon in a Long Term Contract. Digital freight matching benefits shippers by providing needed freight capacity at a lower cost. The digital freight matching provider, Uber Freight in this project, can offer price efficiency through app efficiency, building density on both the shipper and carrier side, while increasing market liquidity.

The results of this project can be used as inputs for possible product extensions of existing technologies that would benefit shippers, carriers, and ultimately the entire freight industry. With that intention, in this project, we specifically focused on the effects of the newly launched Uber Freight app (as opposed to the traditional 3PL brokerage) in freight procurement. We also dedicated more variables on the shipper's side of freight transaction without diminishing the importance of carriers in affecting shippers' procurement strategy. At the time this project is being conducted, there is no publicly available Uber Freight app for shipper. Thus, the results will be beneficial for our sponsor company.

While many types of truck and freight sizes are available in the market (e.g., dry van trucking, refrigerated shipping, flatbed trucks, truckload, less-than-truckload), in this project, we refer to a load as full truckload shipment in a 53-foot trailer that typically carries approximately 52 pallets.

The remainder of this report is organized as follows. Section 2 discusses the research used as a basis for our analysis. Section 3 describes the overall project approaches and methodology. Section 4 presents the sensitivity analysis of the System Dynamics model. Finally, Section 5 summarizes the report and recommends areas for future research.

2. Literature Review

In this section we describe studies of the most important concepts on which our study is based. Sections 2.1 to 2.4 covers studies that support our hypothesis that an increase in the liquidity of the process by introducing digital freight matching systems, will increase the ratio of the spot market over LTC, while improving the efficiency of the freight industry. Section 2.5 reviews previous studies that have used System Dynamics models to approach similar problems within the freight industry.

2.1. Long Term Contract vs. Spot Market

In our study of the Uber Freight (UF) effects on freight procurement, we analyze the transition from the current model, in which the ratio of a Long Term Contract (LTC) to spot market is approximately 90:10, to a future state, in which this ratio may be reversed. Our hypothesis is that there will be an increase in the percentage of the spot market, but will the spot market eventually become the only method of use?

Several studies in different industries conclude that there is an equilibrium between the spot and contract markets that provides more efficiency than those markets where there is only one type of market structure.

Oliveira (2017) analyzed the dynamics of online spot markets for non-storable commodities in which the suppliers have market power. The author proved that, when suppliers readjust their forward positions until the start of the spot market, the number of time periods has no effect on either the suppliers' strategic procurement or on market efficiency. According to the study, the availability of both markets, spot and forward, tends to decrease prices and profits (when compared with a situation in which only one market is available) and this phenomenon is more important in industries with highly competitive intensity.

Oliveira, Ruiz and Conejo (2013) compare the implications on supply chain coordination and on the players' profitability of a pool-based market structure vs. bilateral contracts. They conclude that there are multiple equilibria in the supply chain contracts and structure and that the two-part tariff is the best contract to reduce marginalization and increase efficiency in the management of the supply chain. The authors compare how the existence of futures markets and the different types of contract influence the market equilibrium. Their results suggest that the development of a futures market would improve the efficiency of the electricity market.

We believe there will be a reduction in the percentage of the forward market and an increase in the volume of the spot market, but both methods will continue to exist to guarantee the highest efficiency in the industry. Our study will focus on identifying which variables affect the transition to a fully liquid market but not on the specific equilibrium point for the freight industry.

2.2. Market Liquidity

As stated in our hypothesis, an increase in the market liquidity will benefit both shippers and carriers by enabling more efficient freight transactions. In order to explain this hypothesis, we first need to define the term: market liquidity.

Uber Freight explains on its official blog[8] that liquidity for a carrier means the ability to book a load with the tap of a button. It also means that carriers are not missing their shot at hauling the best loads because those opportunities are difficult to find, painstaking to negotiate, complex to book, or difficult to get paid for. For shipper, a liquid market means moving freight reliably at a price that is discoverable and transparent.

Higher transparency within the market will provide a faster flow of information throughout the industry. Alexandridis, Sahoo, Visvikis (2016) analyzed how the liquidity and economic information transmission affect the shipping markets. They concluded that more efficient information transmission will provide higher profits for the industry.

2.3. Digital Freight Matching

How will an internet-based platform such as a smartphone app affect the number of freight transactions over a period of time?

Although Uber Rides may first come to mind when answering this question, it was not the first internet application that has affected user behavior in an industry. We can also reference the impact of internet on stock market trading, travel agencies, and more recently, the retail industry.

Choi, Laibson and Metrick (2001) analyzed the impact of a web-based trading channel on traders' behavior and performance in two large corporate 401(k) plans. They analyzed and compared these two companies versus a control group of firms without a web channel over an 18-month time horizon. The study focused on the impact of the Web on trading volume, trader performance, and behavior that is sometimes associated with speculative activity. They found that the frequency of trading nearly doubles, but the volume of each trade tends to be smaller than phone trades, both in dollars and as a portfolio fraction.

Based on the above study, and on our own experiences with internet-based apps, we expect that the number of freight transactions over a period of time will increase through the usage of digital freight matching technology.

[8] Why market liquidity matters in freight – Official Uber Freight Blog – Medium. (2018, February 09). Retrieved from https://medium.com/official-uber-freight-blog/under-the-hood-at-uber-freight-5a82110d717

2.4. Spot Market Provides Increased Social Surplus

How will market liquidity impact the efficiency of the spot market? In the previous sections, we concluded that an increase in market liquidity will increase the percentage of the spot market, but how will that increase affect the efficiency of the industry?

Yi (2008) found that, in the container industry, as the spot market participation rate increases, the contract market shrinks under all market structures. For all the single-seller settings with large capacity, the seller's surplus generally increases in spot market participation. However, the effects on buyer's surplus are hard to determine. Therefore, the effects of the combination of the two, total social surplus, are not easy to determine.

Depending on demand variation, an increase in the spot market participation rate may or may not benefit the buyers, and thereby may or may not increase the total social surplus. For the under-capacity case, the surpluses of all players are invariant to spot market participation if all the buyers have the same utilities. If buyers have different utilities, the results do not hold any more. Numerical results show that both the buyers and the seller are better off with a higher participation rate. They also prove that all the players have higher surpluses with full participation in the spot market compared to the contract market, only in the case when the capacity is tight. As the market structure moves from single seller to many sellers, an increase in spot market participation always improves the total social welfare, although it may hurt either the sellers or the buyers.

We consider the truckload freight industry to be similar enough to the container carrier industry for us to assume that the level of spot market utilization will have similar effects on both of them. We can assume, then, that the transition to a more liquid market provided by the usage of a technology for matching freights, and by the simplification of the negotiation stage, will benefit all parties by increasing market profit.

2.5. System Dynamics

System Dynamics is a methodology and mathematical tool that helps explain the behavior of complex systems. It has been commonly used in studies on freight transportation to analyze both qualitative and quantitative factors of specific case study.

In "Describing and explaining urban freight transport by System Dynamics," Thaller, Niemann, Dahmen, Clausen and Leerkamp (2016) studied how the socio-demographic and socio-economic system affects the urban freight transport from a qualitative perspective. The System Dynamics causal loops diagrams developed in their models help visualize the impact of different variables such as employment rates, fuel consumption of cars, noise or GHG emissions, over the global urban freight industry. Their study does not pretend to provide answers for a given city or a specific case; rather, their intention is to provide a general framework that can be applied by other researchers in future studies.

We have found similarities between this study and our project in focusing on analyzing the impact of behavioral variables in the freight industry. We will focus on the line and medium haul lanes and on the shipper behavioral variables rather than on global socio-demographic or socio-economic characteristics.

Dikos, Marcus, Papadatos, and Papakonstantinou (2006) used a hybrid process, where they combined a System Dynamics model with econometrics, to create a model for the tanker industry to support a specific company. By doing so, they intended to get the best from both models. System dynamics helped them identify the feedback between the average productivity function and the lay-up module, and econometrics allowed them to calibrate the results.

Both these papers helped us identify and confirm the capabilities that System Dynamics may have for the study of the freight industry. In our project, we create a model that could be extendable to the whole freight industry and we validate the model with data collected by the company Uber Freight.

3. Methodology

To study shipper behavior and changes in freight procurement, we conducted qualitative research with our sponsor company, Uber Freight. We first studied different freight procurement processes through interviews and literature review. Taking common industry knowledge, we identified shipper's decision factor in conducting freight procurement. To fully portray the dynamics of the system, we built a system dynamics model and conducted sensitivity and scenario analysis. Lastly, we derived results and conclusions.

3.1. Qualitative Research on Freight Procurement

We conducted interviews with Uber Freight team members to learn about the Uber Freight business model, different freight procurement methods in the market, freight procurement process through digital freight matching, as well as shippers' decision factors when booking freight through Uber Freight.

We visited Uber Freight's San Francisco office in October 2017 and Chicago office in December 2017. During each of our one-and-one-half-day visit at both offices, we met and had discussions with 10-15 Uber Freight employees from various teams ranging from Strategy & Planning to Sales to Carrier Operations. At the time of our visit, Uber Freight had not developed a dedicated team for shipper-related product.

In our discussions, we gathered information on LTC, spot market, and digital freight matching freight procurement processes. Many of the team members have a background in logistics, transportation, and third party logistics (3PL) brokerage. In our interviews we tried to understand the different variables that affect shipper freight procurement.

The shipper considers different variables when choosing a specific method of freight procurement. Freight rate (price) is certainly the most important factor in freight procurement. However, we also found that there are other qualitative variables that a shipper looks for in a carrier, for example, tender acceptance, safety level, on time pick-up and delivery, and environmental factors (e.g., CO_2 emission).

3.2. System Dynamics Modelling

With the different procurement methods available in the market and various stakeholders affecting the process, freight procurement is complex and dynamic. We needed a tool to illustrate effects of decisions in complex situations. We decided to use a System Dynamics model to capture the different decision factors (variables) that affect shipper behavior throughout freight procurement transaction.

Originally, System Dynamics was developed by MIT Sloan School of Management's professor Jay W. Forrester, in 1961. Forrester believed that human perception has difficulty grasping non-linearity and modeling complex behavior. System Dynamics is

a suitable method to learn about dynamic complexity, understand the cause of changes in decision, and design more effective product (Sterman, 2000).

A model represents a system. With the model, we can simulate interactions among different variables in order to understand how complex systems change over time. Different scenarios are then used to test the model and to gain insight into a complex situation, such as freight procurement.

A System Dynamics model consists of causal loop diagrams, stocks and flows, and table functions. All of these combined create interactions of the physical and institutional structure of the system with the decision-making processes of the agents acting within it.

A Causal Loop Diagram is made of variables connected by arrows expressing the causal links between the variables. Each causal link is assigned a polarity, either positive (+) or negative (-), to indicate effect of the independent variable towards the dependent variable. A positive link means that if the cause increases, the effect increases above what it would otherwise have been, and if the cause decreases, the effect decreases below what it would otherwise have been. A negative link means that if the cause increases, the effect decreases below what it would otherwise have been, and if the cause decreases, the effect increases above what it would otherwise have been (Sterman, 2000). We added loop name and identifier to highlight important loops and shows whether the loop is a positive (reinforcing) or negative (balancing) feedback.

It is important to note that link polarities describe the structure of the system. They do not describe the behavior of the variables. That is, they describe what would happen IF there were a change.

A causal loop diagram is a sufficient tool to map a system with all its constituent components and their interactions. By understanding the structure of a system, it becomes possible to ascertain a system's behavior over a certain time period (Donella 2008). However, a causal loop diagram alone cannot capture the stock and flow structure of a system.

To perform a more detailed quantitative analysis, we transformed causal loop diagrams into a stock and flow diagram. The stock and flow diagram helps us to analyze the system in a quantitative way.

Stocks are represented by rectangles (suggesting a container holding the contents of the stock). Inflows are represented by a pipe (arrow) pointing to (adding to) the stock. Outflows are represented by pipes pointing out of (subtracting from) the stock. The valves control the rate of the flow (Sterman, 2000). The stock and flow structure is composed of these elements.

Stocks are accumulation. The stock level (or quantity of material in any stock) is the accumulation of the material flowing in less the material flowing out. The rate (valve) is the rate of change of the stock. Hence in general, we can formulate the structure as an integral equation:

$$Stock(t) = \int_{to}^{t} [Inflow(s) - Outflow(s)]ds + Stock(to)$$

Equivalently, the net rate of change of any stock, its derivative, is the inflow less the outflow, defining the differential equation

$$d(Stock)/\ dt = Inflow(t) - Ouflow(t)$$

Once we chose the method, we continued to formally define variables, each with its own equation and initial value, which allowed us to not only portray the freight procurement system but also calculate the stock.

3.3. System Dynamics Variables

We utilize different variables related to shipper and carrier freight procurement processes in the System Dynamics model. The input values used in this model do not represent real Uber Freight shipment data. We determine initial values for some variables based on common approximations in the market with validation from Uber Freight, a leading industry practitioner. **Table 1** shows all the variables we used in our System Dynamics model.

Table 1: System Dynamics Variables

No	Name	Formula / Initial Value	Unit	Description
1	Admin Cost	FTE Cost*RFQ Process Time	Units: USD	The admin cost relative to the RFQ manual process.
2	Apps Efficiency	1	Units: Dimensionless	This variable captures the efficiency and reliability of the app to find the best match. There are different components affecting apps efficiency, for example easiness to use, reliability, etc.
3	Average Spot Mkt Multiplier	1+2*Market Volatility	Units: Dimensionless	Average difference of LTC and Spot price.

No	Name	Formula / Initial Value	Unit	Description
4	Average Time to adopt UF	1	Units: Year	The average lead time for shippers to shift their procurement to Uber Freight.
5	Average Time to adopt UF for a Carrier	0.5	Units: Year	The average lead time for carriers to shift their load bookings to Uber Freight
6	Average Total Price	Price in LTC+Admin Cost+Routing Guide Failure Cost	Units: USD	Average total cost per load considering shipper has to book freight through spot market for portion of the overall shipment. Generally, spot market price is higher than what is agreed in Long Term Contract. Thus, the average total cost per load (for the whole year for example) is higher.
7	Carrier Adoption Rate	Market Attractiveness for Carrier*Max Carrier Adoption Rate	Units: Load/Year	The actual rate at which the carrier register to Uber Freight app and process all his loads through Uber Freight.
8	Carriers Load Capacity in UF	INTEG (Carrier Adoption Rate, 900)	Units: Load	Total carrier's load capacity able to be booked in Uber Freight.
9	FINAL TIME	10	Units: Year	The final time for the simulation.
10	Freight Match	Liquidity Rate*EXP(5*Apps Efficiency-5)	Units: Dimensionless	Ability to match freight in real time for specific time and lane; represented by 1=easy 0=difficult.

No	Name	Formula / Initial Value	Unit	Description
11	FTE Cost	50000	Units: USD/Year	The cost of each Full time equivalent per year.
12	INITIAL TIME	0	Units: Year	The initial time for the simulation.
13	Liquidity Rate	min(1, (Carriers Load Capacity in UF + Shipper Density in UF)/Total Freight Market Volume)	Units: Dimensionless	Ratio of loads being booked through UF over the total capacity of shippers and carriers
14	Market Attractiveness for Carrier	min(1,Freight Match*(1+Liquidity Rate))	Units: Dimensionless	The desirability to use Uber Freight app for a carrier; represented in a scale from 0 to 1.
15	Market Attractiveness for Shipper	min(1,max(0,(1-Relative Price to Long Term Contract)*(1+Liquidity Rate)))	Units: Dimensionless	The desirability to use Uber Freight app for a shipper; represented in a scale from 0 to 1.
16	Market Rate	1000	Units: USD	Estimated market rate for a specific load in a given lane.
17	Market Volatility	0.2	Units: Dimensionless	Market disruption affecting price (natural disasters, demand surges, capacity shortages, etc.).
18	Max Carrier Adoption Rate	Total Carriers Load Capacity in the Market/Average Time to adopt UF for a Carrier	Units: Load/Year	The maximum possible carrier adoption rate considering the maximum market attractiveness for carrier.

No	Name	Formula / Initial Value	Unit	Description
19	Max Shipper Adoption Rate	Shipper Density in LTC Stock/Average Time to adopt UF	Units: Load/Year	The maximum possible shipper adoption rate considering the maximum market attractiveness for shipper.
20	Price in LTC	Market Rate* (1-Shipper Bargaining Power) * (1+Traditional Brokerage Profit Margin)	Units: USD	Price agreed by shipper and carrier/broker in Long Term Contract.
21	Price in Spot Market	Average Spot Mkt Multiplier*Market Rate	Units: USD	Average price spent in spot market throughout the year, due to fallout in Long Term Contract.
22	Price in UF	(1+UF Profit Margin)*Market Rate *(1- Freight Match/8)	Units: USD	Price paid by the shipper for load in Uber Freight App.
23	Processing Time per Load	1*10^-9	Units: Year/Load	Average Shipper's RFQ Processing Time per load.
24	Relative Price to Long Term Contract	Price in UF/Average Total Price	Units: Dimensionless	Price difference incurred by shipper to book shipment from Long Term Contract to Uber Freight App.
25	RFQ Process Time	Processing Time per Load*Shipper Density in LTC Stock	Units: Year	Total time spent by shipper in RFQ process.
26	Shipper Adoption Rate	Market Attractiveness for Shipper*Max Shipper Adoption Rate	Units: Load/Year	The actual rate at which a shipper registers to Uber Freight app and is able to book loads.

No	Name	Formula / Initial Value	Unit	Description
27	Routing Guide Failure Cost	Price in Spot Market*Shipper Volatility Profile*Shipper Density in LTC Stock/Total Load Volume in the Market	Units: USD	Associated cost for a shipper due to the failure of the Routing Guide system to match freight.
28	Shipper Bargaining Power	Shipper Density in LTC Stock/Total Load Volume in the Market*0.3	Units: Dimensionless	This variable captures the bargaining power of the shipper to reduce the price of the shipment. We are considering that the max bargaining power will allow them to reduce 30% the price.
29	Shipper Density in LTC Stock	INTEG (-Shipper Adoption Rate, 3e+006)	Units: Load	Portion of demand load managed through traditional LTC process over the total available demand in the market for a specific lane.
30	Shipper Density in UF	INTEG (Shipper Adoption Rate, 1000)	Units: Load	Portion of demand load with Uber Freight over the total available demand in the market for specific lane.
31	Shipper Volatility Profile	0.1	Units: Dimensionless	The average percentage of loads originally included in Long Term Contract that goes into Spot Market. Typically, the % of load Spot Market is a reflection of Tender Acceptance of carriers.

No	Name	Formula / Initial Value	Unit	Description
32	Total Carriers Load Capacity in the Market	INTEG (-Carr adopt rate, 3e+006)	Units: Load	Total number of loads in the market being able to be fulfilled with the existing carriers.
33	Total Freight Market Volume	6.00E+06	Units: Load	Sum of maximum number of carriers loads and Shipper loads.
34	Total Load Volume in the Market	3.00E+06	Units: Load	Total number of loads in the market offered by shippers.
35	Traditional Brokerage Profit Margin	0.18	Units: Dimensionless	Profit Margin charged by Traditional Freight Brokerage.
36	UF Profit Margin	0.1	Units: Dimensionless	Profit margin charged by Uber Freight.
37	Spot Market Broker Profit Margin	0.18	Units: Dimensionless	Profit Margin charged by Spot Market Freight Brokerage.

3.4. Variable Equation

In this section we will further explain the equation (formula) for the main variables in our model, as well as the assumptions we made in determining those variables.

3.4.1. RFQ process time

This is calculated as the average processing time per each load included in the LTC, multiplied by the number of loads included in the LTC. The average processing time is defined as a constant value in our model. This variable will follow then the same curve shape over time as the Shipper Density in LTC stock:

$$RFQ\ Process\ time = Shipper\ Load\ Volume\ in\ LTC\ stock\ \times\ Processing\ Time\ per\ Load$$

3.4.2. Administrative cost

The administrative cost variable is calculated as the product of the RFQ process time and the average FTE cost. We understand that the administrative cost that the shipper bears depends largely on the size of the company, size of freight network, employment wage, technology used, etc. In our model we have assumed a constant value for the FTE cost: the average cost per year of a full-time employee for the company. This cost includes base salary and additional benefits for the employee. As with the RFQ process time, the shape of the Admin Cost curve will follow the same pattern that the Shipper Density in LTC stock:

$$Admin\ cost = FTE\ cost\ \times\ RFQ\ Process\ time$$

3.4.3. Routing Guide Failure Cost

This variable represents the additional cost that a shipper pays when the routing guide fails to find a carrier for a specific load. When this situation occurs, the shipper pays the price of the spot market at that specific point in time. The shipper volatility profile defines the probability of this failure happening within a specific shipper:

$$Routing\ Guide\ Failure\ Cost = \frac{Price\ in\ Spot\ Market\ \times\ Shipper\ Volatility\ Profile\ \times\ Shipper\ Load\ Volume\ in\ LTC\ stock}{Total\ Load\ Volume\ in\ the\ market}$$

3.4.4. Shipper Bargaining Power

We calculate this value by dividing the number of loads that each shipper includes in the LTC negotiation by the total number of loads available in the market. In this sense, the bigger a shipper is, the more bargaining power it will have to negotiate the price for each load. In our model, we have assumed k_1 as the maximum bargaining power a shipper can have. We chose a maximum of a 30% reduction of the price in the LTC:

$$Shipper\ Bargaining\ Power = \mathrm{k}_1\ \mathrm{x}\ \frac{Shipper\ Load\ Volume\ in\ LTC}{Total\ Load\ Volume\ in\ the\ Market}$$

3.4.5. Price in LTC

The price in the LTC is calculated as the Yearly Average cost price per load for a given lane, multiplied by the Brokerage Profit Margin and reduced by the effect of the shipper's bargaining power:

$$Price\ in\ LTC =$$
$$Market\ rate\ \times\ (1 - Shipper\ Bargaining\ Power) \times (1 + Traditional\ Brokerage\ Profit\ Margin)$$

3.4.6. Price in Spot Market

The price for those loads that are rejected by the carriers in the LTC, and therefore fall in the spot market, can be considerably higher compare to what the shipper would pay in the LTC. There is no fixed multiplier in the spot market vs. the LTC, as it varies with the market volatility. In our model we have used the following formula to calculate the price in spot market:

$$Price\ in\ Spot\ Market =$$
$$Market\ rate\ \times\ (1 + Average\ Spot\ Mkt\ Multiplier \times Mkt\ Volatility) \times (1 + Spot\ Market\ Broker\ Profit\ Margin)$$

Using this formula, if we consider a null market volatility, the Price in the spot market will be the same as the Freight cost, while in a fully volatile market, the price increase in the spot market could increase dramatically based on the multiplier assigned. Based on the recommendations of industry practitioners, we have set the multiplier to be 2.

3.4.7. Average Total price in Long Term-Spot Process

This variable takes into account all the costs incurred in processing traditional Long Term Contract, in addition to the agreed freight rate itself:

$$Avg\ total\ price = Price\ in\ LTC + Admin\ cost + Routing\ guide\ failure\ cost$$

3.4.8. Price in Uber Freight

The price that the shipper will pay in Uber Freight will be based on the Freight cost at the time of the shipment, the margin applied by Uber Freight, and the ease of creating a match between shipper and carrier. This price will be fixed by Uber Freight and will not be negotiated by the shipper or the carrier. In this sense, the friction created during price negotiation is eliminated:

$$Price\ in\ UberFreight = (1 + UF\ Profit\ Margin) \times Lane\ rate\ \times (1 - Freight\ Match/k_2)$$

k_2 is a factor to determine the reduction effect of the Freight Match over the Price in UF. According to industry practitioners, a reasonable value will be between 7 and 10, so that the maximum reduction effect it could have is less than 15%

3.4.9. Liquidity Rate

The liquidity rate is defined in our model as the ratio between the carriers' and shippers' capacity in UF vs the total capacity of carriers and shippers in the market:

$$Liquidity\ Rate = min\left\{1, \frac{Carriers\ load\ capacity\ in\ UF + Shipper\ Load\ Volume\ in\ UF}{Total\ Shippers\ \&\ Carriers\ Loads}\right\}$$

3.4.10. Freight Match

The ease of creating a match between shippers and carriers within the UF platform is defined as a variable with values between 0 and 1. A value equal to 0 represents extreme difficulty, while a value equal to 1 means that the match is done with no difficulty at all. In our model, we have set the formula for the freight match as indicated below:

$$Freight\ Match = Liquidity\ Rate\ \times\ e^{k_3 \times Apps\ Efficiency - k_3}$$

We have assumed that app efficiency does not have a linear relation to the ease of freight matching. The efficiency of the app needs to be very high, above 90%, in order to be seen as an improvement over the traditional LTC process.

The k_3 parameter will define the shape of the exponential curve. In our model we have selected a value of 5 to account for the high requirements of app efficiency.

3.4.11. Market attractiveness for carriers

In our model we define the attractiveness of Uber Freight platform for carriers to be set by two variables. The liquidity rate, the number of loads per carrier that a new adopter can expect in the app, and the freight matching, which ultimately will reduce the idle time by facilitating the ease of finding loads. We limit this variable to be between 0 and 1, with 0 being no attractiveness for the shipper, and 1 being full attractiveness. The formula used to calculate this variable is:

$$Market\ attractiveness\ for\ carriers = \min(1, Freight\ Match \times (1 + Liquidity\ Rate))$$

3.4.12. Relative price in Long Term Contract

This variable is the ratio between the "Price paid in Uber Freight" over the "average total price paid in Long Term Contract":

$$Relative\ price\ to\ Long\ Term\ Contract = \frac{Price\ in\ UberFreight}{Average\ Total\ Price\ in\ LTC}$$

3.4.13. Market Attractiveness for shippers

We calculate the attractiveness for shippers based on the effect of Liquidity Rate and the cost that a shipper will be able to save by adopting the Uber Freight platform vs. staying with the traditional LTC-SPOT model. We have limited this variable to be between 0 and 1, with 0 being no attractiveness for the shipper, and 1 being full attractiveness:

$$Market\ Attractiveness\ for\ shippers =$$
$$min\{1, max\{0, (1 - Relative\ price\ in\ Long\ Term\ Contract) * (1 + Liquidity\ Rate)\}\}$$

3.4.14. Shipper adoption rate

This variable defines how many shipper loads are transferred to the Uber Freight platform by unit of time. In our model we have defined it as the product of a max adoption rate and the attractiveness for shippers:

$$Shipper\ adoption\ rate = Market\ Attractiveness\ for\ shipper \times Max\ Shipper\ Adoption\ Rate$$

3.4.15. Carrier adoption rate

As with the shipper adoption rate, this variable is defined by the product of a maximum carrier adoption rate feasible and the attractiveness for carriers:

$$Carrier\ adoption\ rate = Market\ Attractiveness\ for\ carrier \times Max\ Carrier\ Adoption\ Rate$$

3.5. Dynamic Hypothesis

After identifying a set of variables related to freight procurement, we defined the problems dynamically. We looked at the three stocks: Shipper Density in LTC, Shipper Density in UF, and Carrier Density in UF in terms of patterns of behavior over a set period of time. And we developed three reference modes, a set of graphs and other

descriptive data showing the development of the problem over time, to help us see the three main stocks in a long-term perspective.

3.5.1. Shipper Density in UF

Our hypothesis is that Shipper Density in Uber Freight will follow an S-shaped curve as shown in Figure 2: Expected shipper density growth in UF. Shippers will switch from using a combination of Long Term Contract and the spot market to Uber Freight once they realize the cost benefits of using the app. The adoption rate increases quickly as the app gains higher efficiency and users get used to booking via the app. Since a Long Term Contract is renewed on annual basis, potential shipments are locked one year in advance. There will be a delay in realizing the change in procurement strategy. However, once materialized, freight procurement completed through the Uber Freight app will be more frequent, hence the sharp increase in its adoption. At one point, the adoption will become stagnant as it reaches the maximum number of available shipments in that particular lane at a particular time.

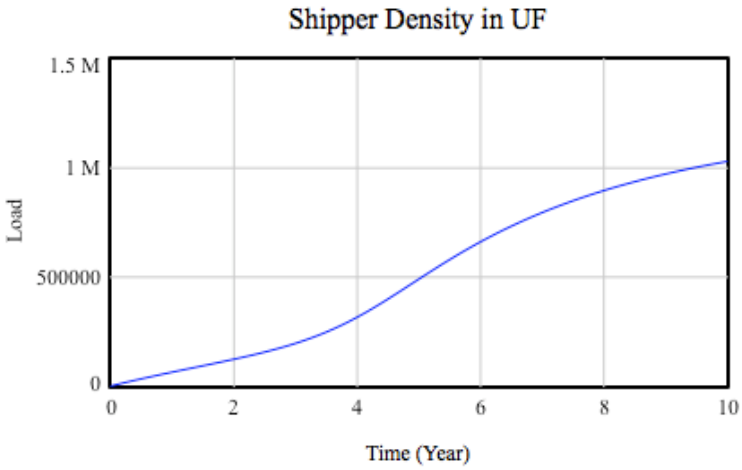

Figure 2: Expected shipper density growth in UF

3.5.2. Carrier Density in UF

Uber Freight needs to build carrier density to be able to fulfill the freight procurement and attract shippers to use the app. In order to build density, Uber Freight needs to provide incentives to the carrier. There are many initiatives to attract carriers, from transparent market rates to shorter payment terms. As we focus on the shipper side, we simplify the carriers' variables. As freight matching on the app grows and there is enough carrier capacity in the market, the carrier load within Uber Freight will grow as shown in Figure 3: Expected Carriers Base development.

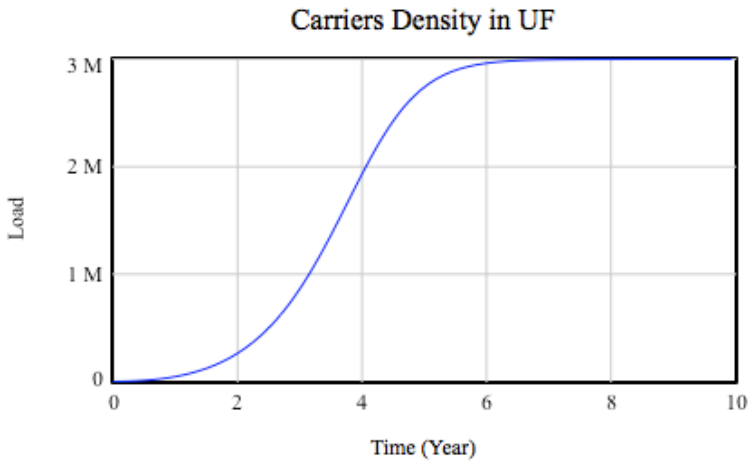

Figure 3: Expected Carriers Base development

3.5.3. Shipper Density in LTC

We foresee a decrease in freight procurement through Long Term Contract as shown in Figure 4: Expected LTC Stock reduction once shippers realize the cost benefits of utilizing the Uber Freight app. The decreasing rate of density depends on the cost benefit from using the app and the proportion of LTC vs. spot market.

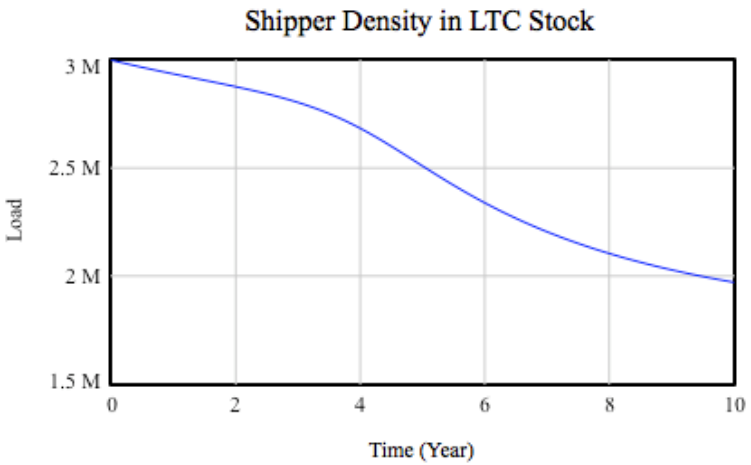

Figure 4: Expected LTC Stock reduction

4. System Dynamics Simulation and Analysis

We presented the main factors in the freight procurement process with special attention to the shipper's behavioral change in our System Dynamics model. Our model represents the variables that affect the shipper's decision to keep the traditional Long-Term process vs. the new model proposed by Uber Freight (See Appendix A for the full diagram.)

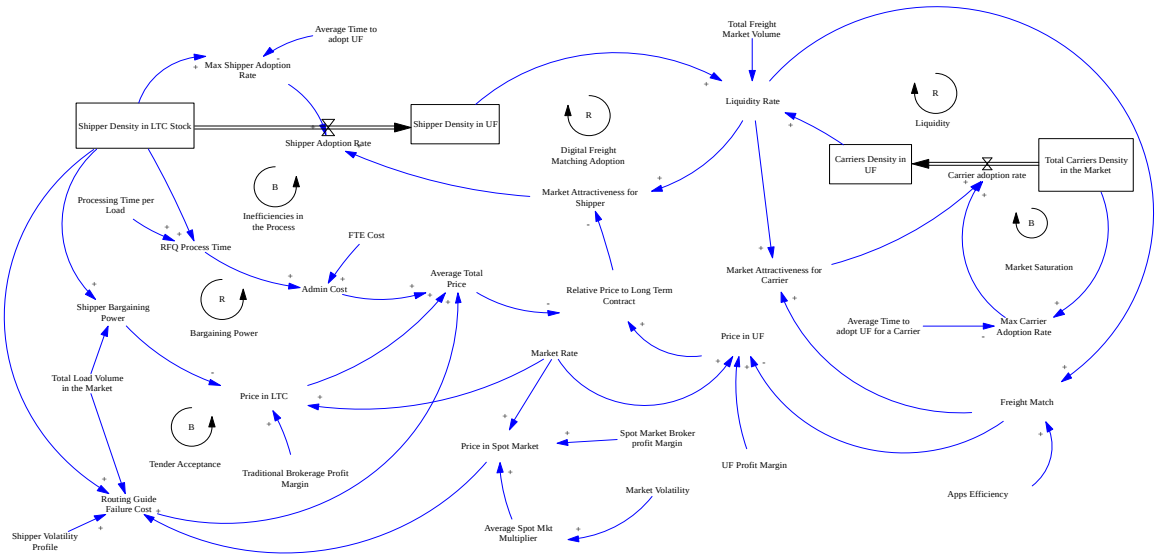

Figure 5: Stock and Flow and Causal Loop Diagram

4.1. Inefficiencies in the process

To formalize the RFQ process at a big enterprise is a time-consuming process. Depending on the size of the company, and the number of loads they want to introduce in the negotiation, this process could range from 1-2 weeks for a small company to 2-3 months for a big enterprise. This time spent in the negotiation process has some associated administrative costs, due to the utilization of company staff. In our model, we are assuming a variable cost associated with the number of human hours spent in this process, which will increase the average total price of each load. Some organizations have adopted a misconception by assuming this cost is diluted in the overall overhead expenses and cannot be reduced. We assume that by reducing this time, the company could either reduce the size of the transportation department or reallocate their resources to other tasks.

In the causal loop represented in

Figure 6: Inefficiencies in the process, we indicate a balancing loop for the processing time. The higher the number of loads included in the Long Term Contract, the more administrative costs the company will have, and therefore the more attractive it is for the shipper to change to the Uber Freight platform, thus reducing the stock of loads included in Long Term Contract.

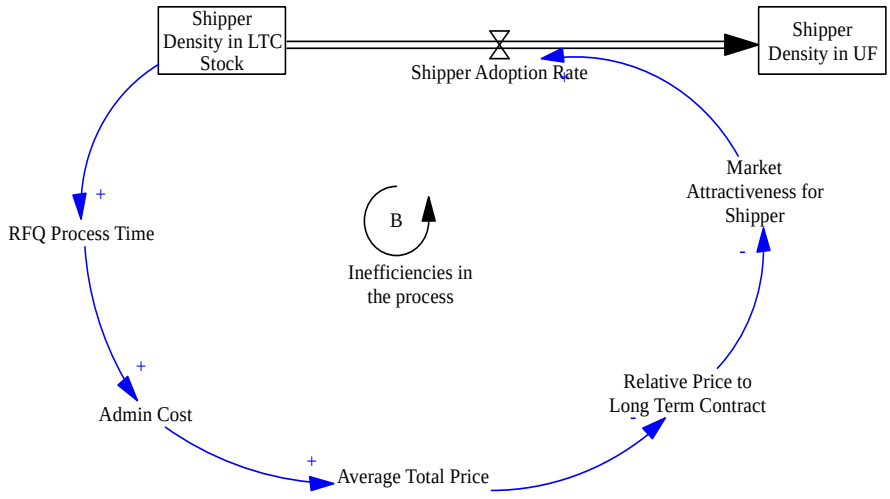

Figure 6: Inefficiencies in the process

4.2. Tender Acceptance

The percentage of the loads rejected by the carriers under the LTC will determine the number of loads handled through the spot market. This will be based on the profile of the shipper and the consistency of their actual load requirements versus what is estimated during the RFQ process. Prices in the spot market are usually higher due to inefficiencies in the freight match; this will lead to a total higher average price and therefore a lower attractiveness for the shipper. In the causal loop represented in Figure 7: Tender Acceptance, we show a balancing loop, in which a higher routing guide failure cost will reduce the number of loads in the LTC stock by increasing the UF shipper adoption rate.

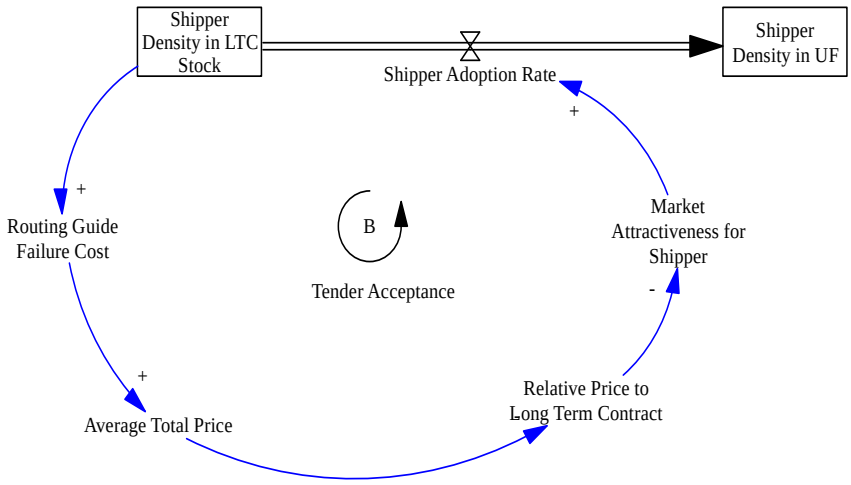

Figure 7: Tender Acceptance

4.3. Bargaining Power

During the RFQ process, both shippers and carriers will try to negotiate the best or most convenient deal for themselves. The capacity that one part has over the other part to achieve a better deal is explained by bargaining power. Many factors affect the bargaining power of a shipper. Among those factors are not only quantifiable aspects, such as the size of the company, but also non-quantifiable human aspects. For the simplicity of our model, we have only considered those aspects that are quantifiable, assuming that, under all circumstances, a shipper will have greater bargaining power if the number of loads included in the negotiation of the LTC is higher.

Having greater bargaining power will lead to a better deal and therefore, in the case of the shipper, a reduced price per load. This will then make it less attractive to change to the Uber Freight process where their bargaining power will be null, as the price is the same for all the shippers independent of their size. This process leads to a reinforcing loop like the one represented in Figure 8: Bargaining Power.

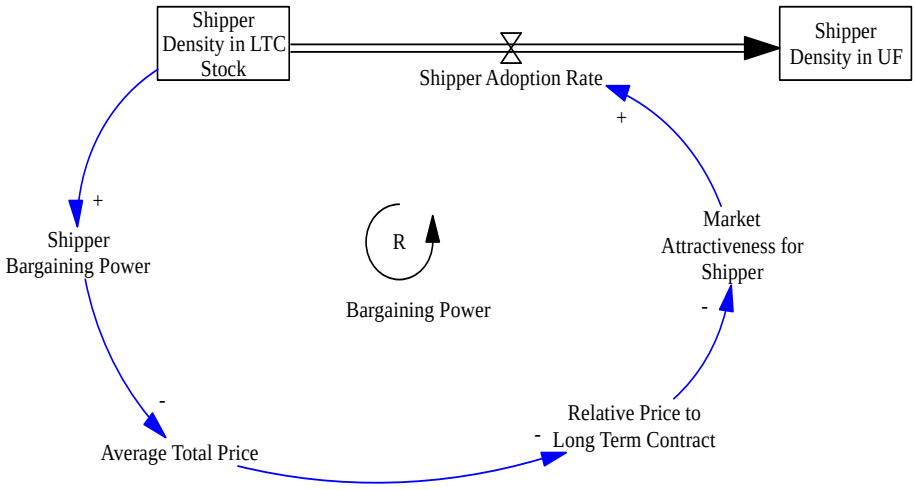

Figure 8: Bargaining Power

4.4. Digital Freight Matching Adoption

Digital Freight Matching adoption is fueled by market liquidity. As defined earlier, liquidity can be calculated by the availability of a carrier at any time and the instantaneous price quotation. In our model, we calculated liquidity as the ratio between shippers and carriers available in Uber Freight vs. the total shipper and carrier capacity available in the market. Market liquidity increases the attractiveness of utilizing digital freight matching platform and creates a reinforcing loop as represented in Figure 9.

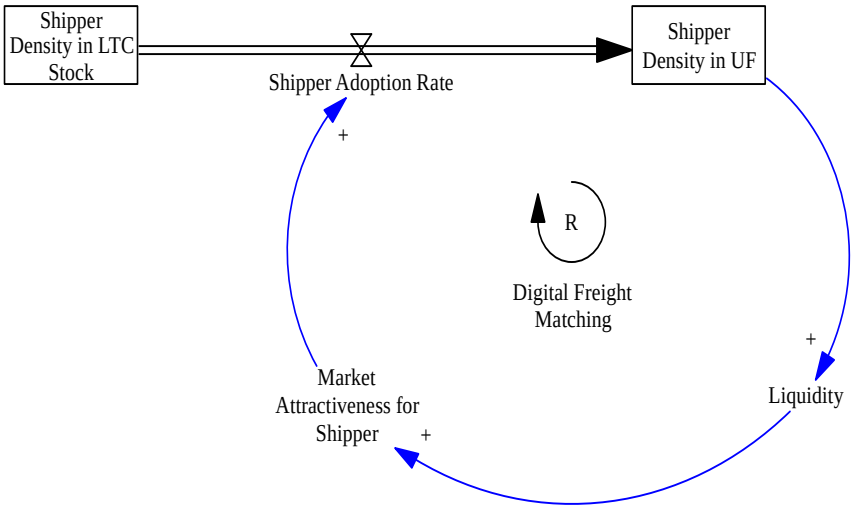

Figure 9: Digital Freight Matching Adoption

4.5. Market Saturation

There are a finite number of carriers in the market, and the carrier adoption rate of UF will be determined by the maximum carrier adoption rate, which multiplies the average time for a carrier to adopt UF by the total carrier load capacity in the market at a specific point in time. As the stock of loads outside of UF is reduced, the carrier adoption rate of UF will decrease. This represents a balancing loop called market saturation as shown in Figure 10: Market Saturation, which will provide the right equilibrium between the number of shippers and carriers.

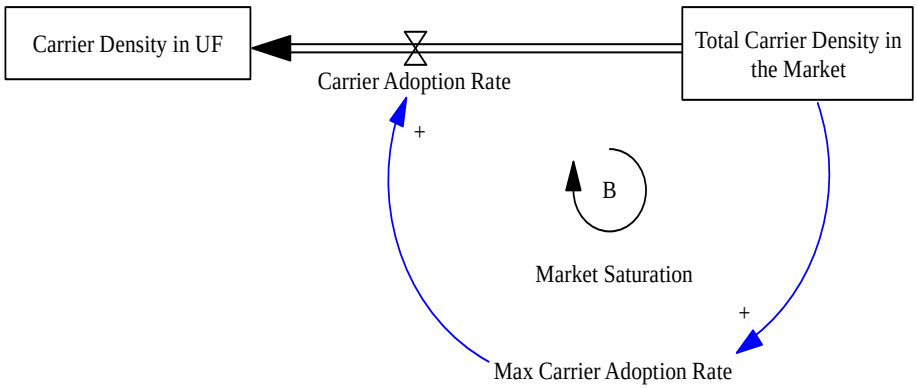

Figure 10: Market Saturation

4.6. Liquidity

Under the liquidity causal loop, we capture the effect of the liquidity rate over the freight match. This is a variable that is important for both shippers and carriers. From a carrier perspective, the easier it is to find a freight match, the less idle time they will have; and thus the higher asset utilization will be. Higher asset utilization could result in greater profit for carrier. This creates a reinforcing loop as shown in Figure 11: , in which the higher liquidity rate will increase the ease of freight matching and will increase the profitability of the carriers, thus reinforcing the creation of higher liquidity in the Uber Freight platform.

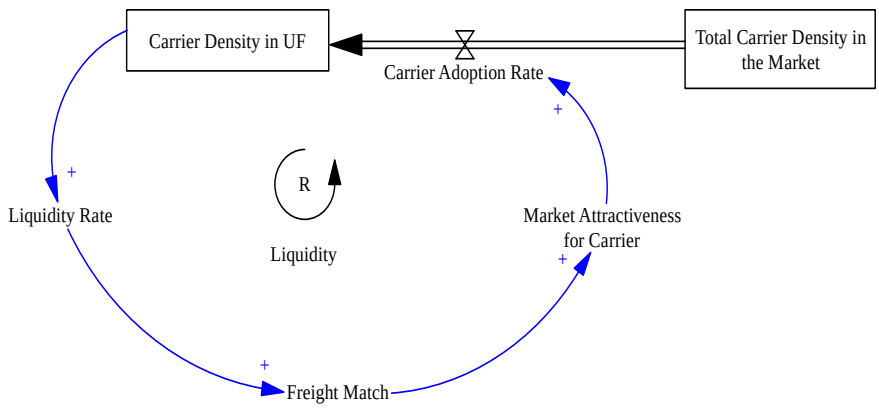

Figure 11: Liquidity

4.7. Sensitivity and Scenario Analysis

The real power of System Dynamics is utilized through model simulation. We used Vensim Simulation Software (developed by Ventana Systems) to create a System Dynamics model and then conducted simulations. We conducted simulations over period of 10 years to analyze the impact of the main variables on the adoption of shippers and carriers in UF. All analyses were derived from results of the simulation in Vensim.

It is important to note that our model does not predict UF business strategy: is intended to provide an understanding of cause and effect between the different variables under different parameters.

4.7.1. Market Volatility

To understand how the volatility affects the adoption of the Uber Freight platform, we have run several simulations with different volatility values. In this model, 1 represents the highest volatility, while 0 is the lowest. Figure 12 shows the shipper adoption rate, based on the setup parameters.

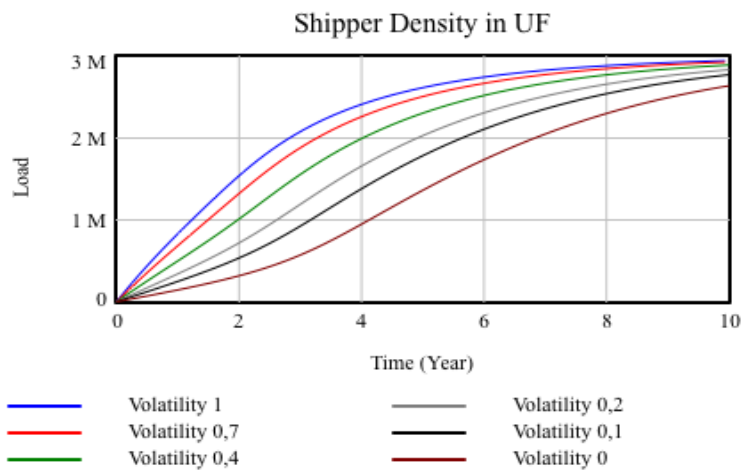

Figure 12: Market Volatility effect on Shipper Density in UF

We can clearly see that an increase in the volatility of the market leads to a higher adoption rate of the UF model. This can be explained by the added value provided by the Uber App at the time of finding matches in a volatile situation. In order to better understand this concept, in Figure 13 we can see the price difference between UF and LTC. Under higher volatility, UF provides lower total cost than LTC. The extra cost of LTC is due to the additional costs of the spot market under high volatility, which, as shown in Figure 14: Market Volatility effect on Routing Guide Failure Cost, could be as high as 3.5 times the market rate. Higher spot market prices will lead to a higher routing guide failure cost.

We can see the effect of the volatility on the routing guide failure cost in Figure 15. Looking at the UF price in Figure 16, we can see that the reduction over time occurs faster under higher volatility, which is explained by the higher adoption rate of carriers under higher volatility.

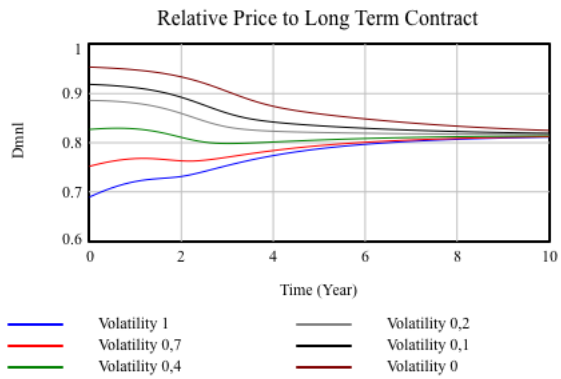

Figure 13: Market Volatility effect on Relative Price to LTC

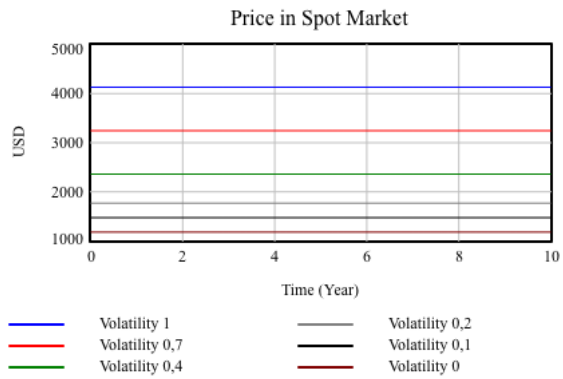

Figure 14: Market Volatility effect on Routing Guide Failure Cost

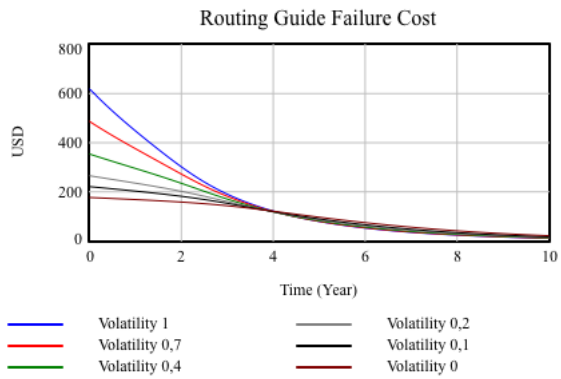

Figure 15: Market Volatility to Price in Spot Market

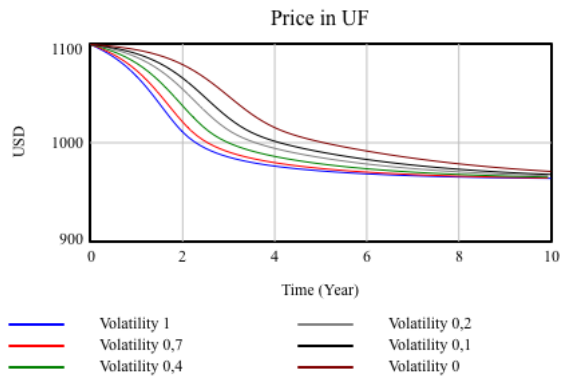

Figure 16: Market Volatility to Price in UF

In Figure 17 we can see that by increasing the volatility from 0 to 1, similar adoption levels in carrier capacity can be attained in less than one-third of the time.

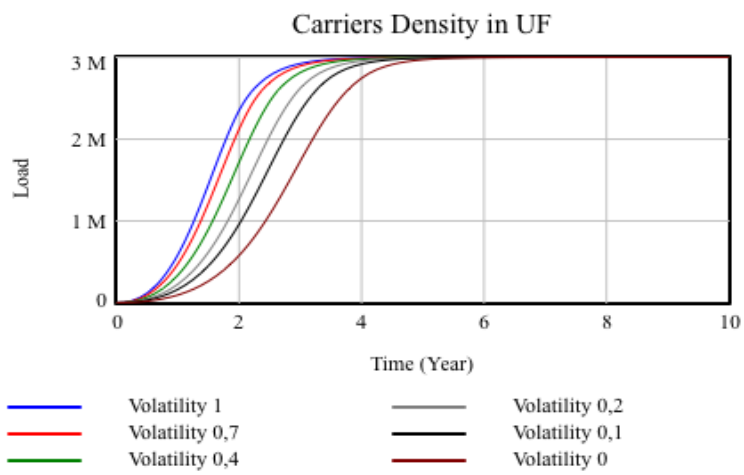

Figure 17: Market Volatility effect on Carriers Load Capacity in UF

4.7.2. App Efficiency

Following the same procedure as with volatility, we ran several simulations with different values for the App Efficiency, with the minimum App Efficiency of our analysis being 60%.

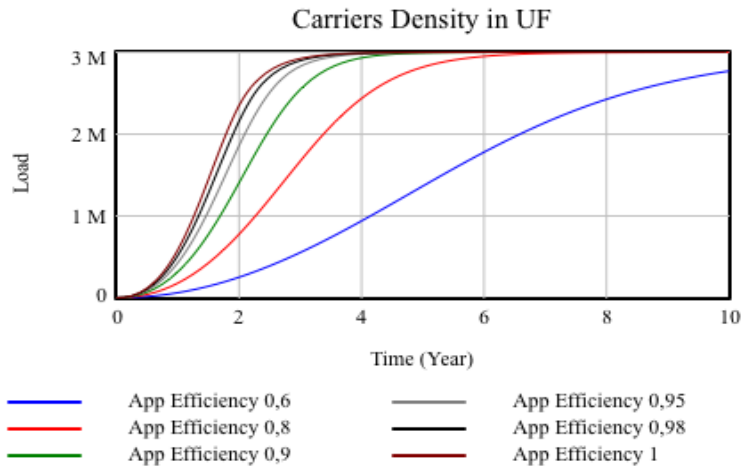

Figure 18: App Efficiency in Carrier Density in UF

As we can see in Figure 18, reduction of efficiency of the app below 80% has an important effect on the adoption rate for carriers. This is explained by taking into account that low efficiencies will reduce the advantages of digital freight matching (see Figure 20).

To better understand the impact of the efficiency of the Uber Freight App, we need to look at in Figures 19 to 22.

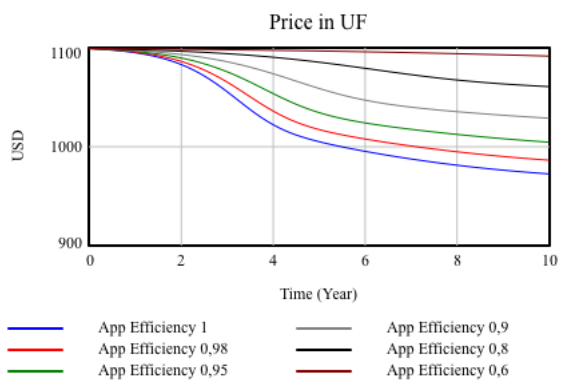

Figure 19: App Efficiency effect on Price in UF

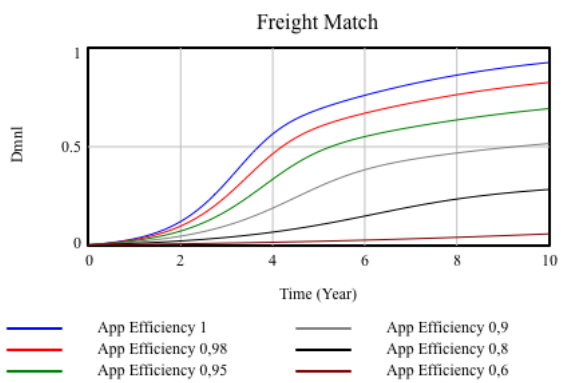

Figure 20: App Efficiency effect on Freight Match

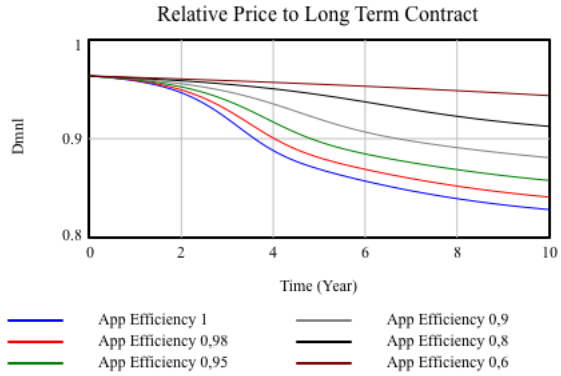

Figure 21: App Efficiency effect on Relative Price to LTC

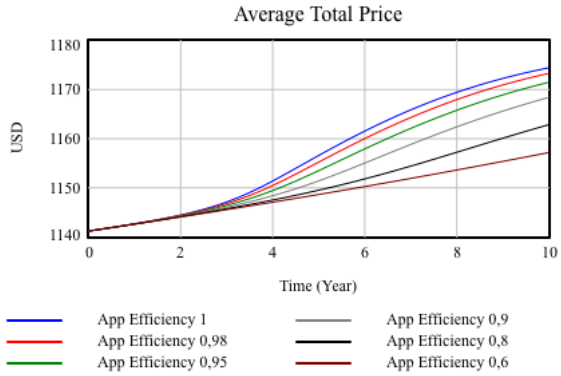

Figure 22: App Efficiency effect on Average Total Price

As we can see in Figure 19, the price of Uber Freight decreases faster as the efficiency of the app increases. On the other hand, the effect of the app efficiency on the average total price in the LTC-SPOT process, as shown in Figure 22, is attributable only to the change in the number of loads managed by the LTC-SPOT process, which affects the bargaining power and the administrative cost. This is the reason that we do not see important differences until year 3, when the number of new adopters starts to be considerable.

When analyzing the impact on the Shipper's adoption (see Figure 23), we see that the effect of the efficiency of the app is similar to its effect on the carrier's adoption.

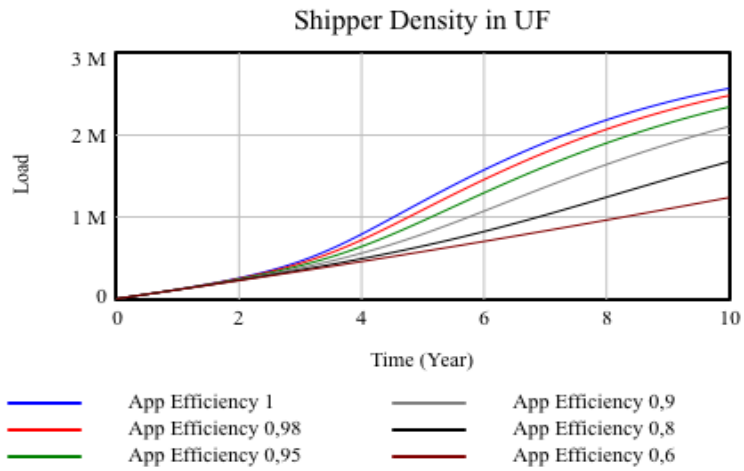

Figure 23: App Efficiency effect on Carriers Load Capacity in UF

4.7.3. Average time to adopt UF for shippers

The average time to adopt the UF platform by a shipper will determine the maximum adoption rate by fraction of time. When this variable is set to 1 year, it means that the total number of loads that a shipper is managing through the traditional Long-Term process could be transitioned to the UF platform in just one year. This variable will vary for each shipper: one of the main limiting factors is the interface between shipper

TMS and UF platform. For simplicity, we have not included this variable in our model and we consider it to be represented by the time it takes a shipper to adopt Uber Freight.

Figure 24 shows how the number of UF adopters increases over time based on the different values for this variable. The lower the value for this variable, the faster it can be adopted the UF platform. By reducing the value for the average time to adopt UF, we will achieve a higher number of adopters. A reduction of 66.6% in the number of years to adopt (from 1.5 to 0.5 years) brings an increase of approximately 150% (from ~2M to ~3M) in the number of loads within a period of 10 years.

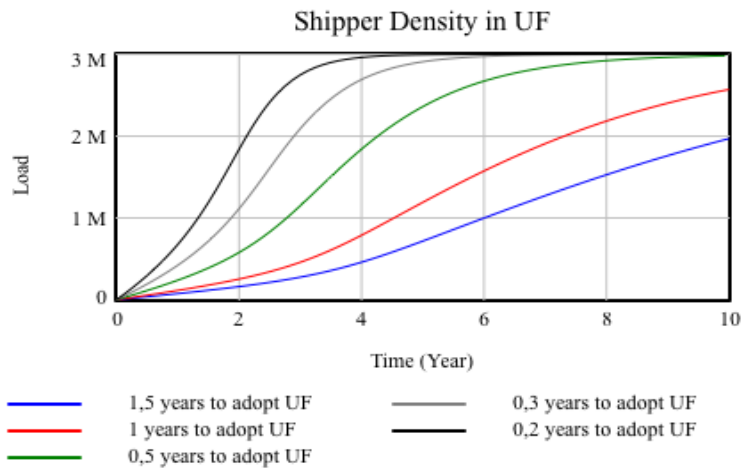

Figure 24: Average time to adopt UF for Shippers effect on Shipper Density stock in UF

It is also interesting to see how, for shippers, the average time to adopt the UF platform affects the number of carriers. As expected, an increase in the number of shippers within the UF platform will attract more carriers. This effect is represented in Figure 25.

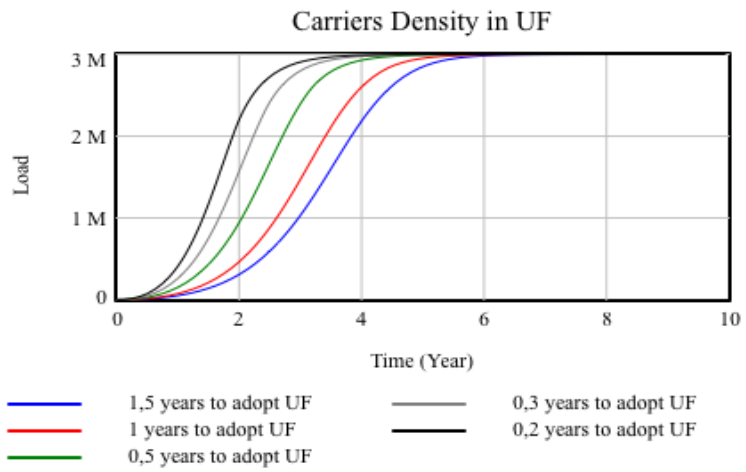

Figure 25: Average time to adopt UF for Shippers effect on Carriers Load Capacity in UF

The average time for shippers to adopt will also influence the liquidity rate and the Freight Match, as shown in Figure 26 and Figure 27 respectively.

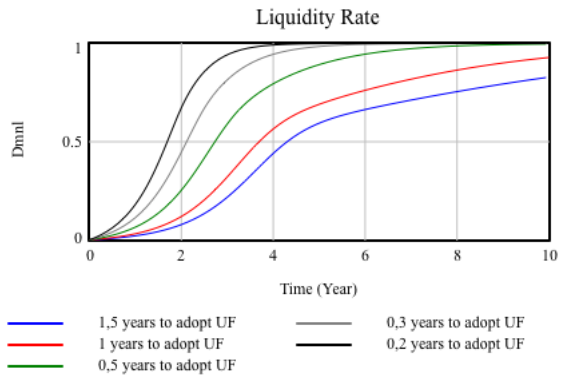

Figure 26: Average time to adopt UF for Shippers effect on Liquidity Rate

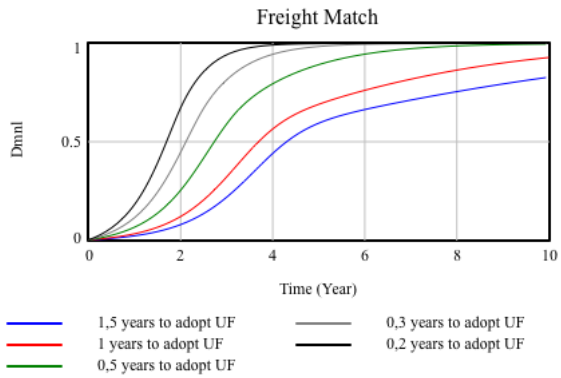

Figure 27: Average time to adopt UF for Shippers effect on Freight Match

4.7.4. Average time to adopt UF for a carrier

As with the shippers, we have defined in our model an average time for a carrier to adopt UF. As shown in Figure 28 and Figure 29, decreasing the time to adopt UF for a carrier increases the carrier's load capacity in UF over the same period of time.

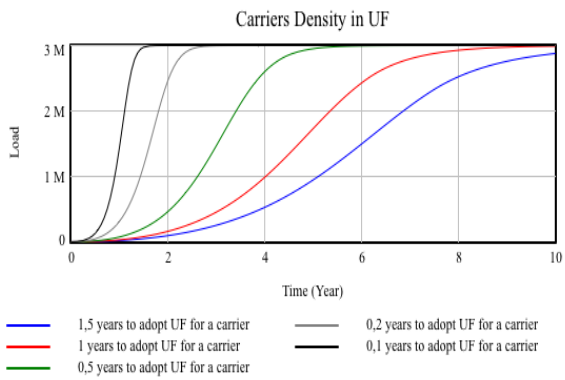

Figure 28: Average time to adopt UF for Carriers effect on Carriers Density in UF

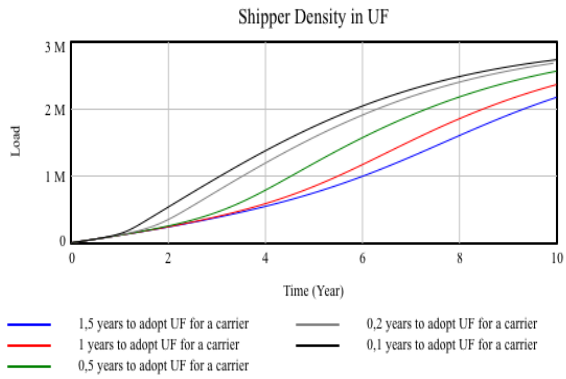

Figure 29: Average time to adopt UF for Carriers effect on Shipper Density in UF

4.7.5. Shipper Volatility Profile

Market volatility changes throughout the year. Shippers needs to realign their shipment strategy, add additional lanes, or shift the number of shipments in a particular lane to another lane. The shipper volatility profile measures the consistency of a shipper to provide loads to the carrier according to what has been agreed upon in the Long Term Contract. This variable can take values of 0 or 1.

When the value is 0, it means that all loads are accepted by the carriers and included in their routing guide system; a value of 1 means that all the loads are rejected. As shown in Figure 30, as the Shipper Volatility Profile increases, the adoption of UF platform

by shippers increases as well. This is explained by recalling that the main objective of having an LTC is to reduce the dependency on the spot market; in this sense, if the Shipper Volatility Profile increases, it means that the amount of time that the shipper needs to handle a load through the spot market also increases, decreasing the benefit of having an LTC. The same logic applies for a carrier, as can be seen in Figure 31.

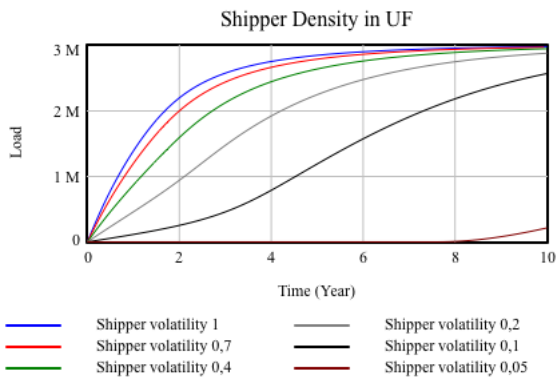

Figure 30: Shipper Volatility effect on Shipper Density in UF

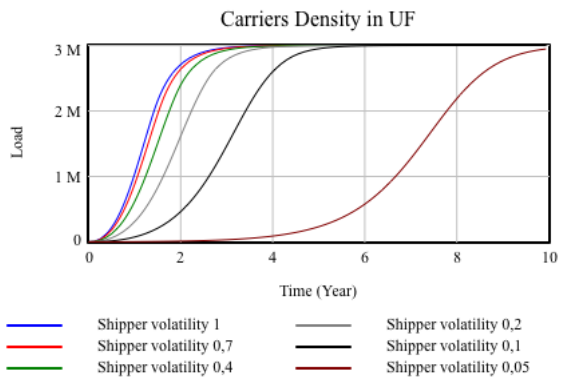

Figure 31: Shipper Volatility effect on Carriers Density in UF

To better understand this concept, we plotted in Figure 32 the curves for the Routing Guide Failure cost for each Shipper´s Volatility Profile value. As we can see, as we increase the Shipper´s Volatility Profile, the Routing Guide Failure cost increases.

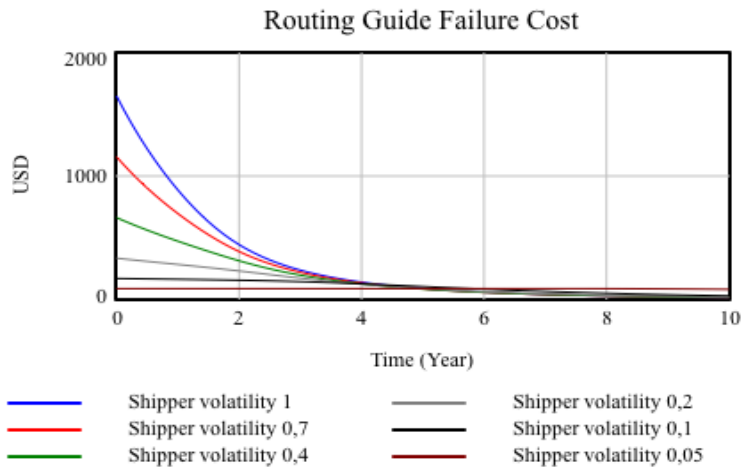

Figure 32: Shipper Volatility effect on Routing Guide Failure Cost

4.8. Results

Out of the many variables affecting both carrier and shipper, price is certainly the most important factor in freight procurement. A shipper's total spending on freight and the opportunity cost of switching to another method determines its procurement strategy. Our analysis yielded four main findings:

1. Increase in market volatility speeds up the adoption of digital freight matching. The behavior is proven on the basis that the app provides considerable added value (that translates into lower total freight cost). A 100% increase in market volatility (from 0.1 to 0.2) creates a 15% increase in shipper density by half of the time needed to achieve market saturation. A similar effect is experienced on the carrier density.
   This concept has been proven when Uber Freight helped Niagara Bottling, the largest family-owned bottled water company in the United States, to send 127 truckloads with 4.8 million bottles of water into Houston, right after Hurricane Harvey hit the area in September 2017.
   Late Friday afternoon shipping, in the wake of a hurricane, combined with tight trucking market condition in early September 2017 left Niagara with no capacity to haul those loads. In that instance, they resorted to one of its newest logistics partners. The loads were booked within hours by the small trucking companies and independent truck drivers. The average time it took to book a Niagara Bottling load that Friday, from the time it appeared on the Uber Freight app until it was accepted by a driver, was 34 minutes. Some were even booked in under a minute (Cassidy, 2017).

2. In general, higher apps efficiency leads to higher adoption rate. Changes in app efficiency, however, have a higher positive impact on carrier density compared to shipper density. An increase of 10 basis points in the app efficiency (from 80% to 90%) reduces the total time to achieve the maximum carrier density by 30%. While apps efficiency below 80% leads to very low adoption rate. A less efficient technology will be deemed to be impractical and equivalent to the traditional spot market.
   We compared these behaviors to the drivers and shippers market in the US. 90% of trucking operators owns 6 or less trucks (Garber, 2016), which means truck owner-operators represent the majority of US truckers. Having the autonomy to select and set shipment schedule and receiving quick payment will significantly benefit these individual drivers.
   On the other hand, there are many different type of shippers in the market, ranging from large enterprise, small-medium-businesses, to mom-and-pop shops. Larger enterprises typically has the resources and budget to manage their freight procurement processes. And with the vast array of brokers and alternative methods in freight procurement, there is less incentive for larger enterprise shipper to choose digital freight matching with low efficiency. The app itself will also need to be fully integrated with the company's transportation management system to really make a benefit for larger enterprise.

3. The time it requires for shipper and carrier to join and utilize digital freight matching app determines the adoption rate of the app. The adoption time also affects market liquidity. Thus, it is important to create a balance between shipper and carrier density across time. A reduction of 50% of the carrier adoption time, from 1 to 0.5 year, will increase shipper density by 10% in half of the time required to achieve equilibrium in the shipper density. Similarly, a reduction of the shipper adoption time will increase the carrier density over the same period of time. The slope of carrier density is higher than the slope of shipper density. Thus, we can see a higher increase in carrier density (compared to shipper density) using the same changes in adoption time.
   In this case, reducing the adoption time will benefit Uber Freight in increasing market liquidity. However, driving adoption rate costs money. It requires additional resources, sales, and marketing efforts to be able to increase and handle the added capacity. Uber Freight needs to balance between the costs to drive adoption rate and the benefits of having larger density.

4. Similar to market volatility, shipper internal volatility affects the total freight price the shipper has to pay and the shipper adoption rate of Uber Freight. Failure to provide loads to the carrier will increase a shipper's total freight cost because the shipper's has to find capacity in the spot market. Interestingly, an increase in the shipper internal volatility will also have an important effect on the carrier density creation. A 100% increase in Shipper Volatility Profile, from 0.1 to 0.2, will reduce approximately by 30% the time it will take to achieve the equilibrium in carrier density.
   Similar to our first conclusion above, shipper internal volatility speeds up the adoption of digital freight matching. In a more volatile market, it is more difficult for shipper to attain high forecast accuracy. Uber Freight provides flexibility for shippers to secure capacity in fast-changing environment. Thus, we see opportunities for Uber Freight to attract shipper operating in a highly volatile environment or having limited transaction data. For example, Uber Freight will be beneficial for shipper that expands its network to new lanes or area with little to no historical data.

5. Conclusion

This project developed a behaviorally based conceptual model to analyze the effects of a digital freight matching app on a shipper's freight procurement. We developed a stock and flow model that shows different freight procurement alternatives. In a more liquid market, a shipper can secure carrier capacity instantaneously when needed. Given the option, the shipper would willingly switch to the lower cost faster alternative, abandoning the fixed Long Term Contract method. As a result, the shipper eliminates the long traditional procurement process, reduces administrative costs, and has fewer instances of over and under ordering truck capacity.

In a more liquid market, a shipper will benefit from using the on-demand app to book freight, compared to locking down the price and particular shipment lanes through a Long Term Contract. We proved our hypothesis that there is financial benefit to all parties in a more liquid transportation market.

We acknowledge that the simulation results are generalizable because the projected behavior is likely to be encountered in an on-demand technology based company.

The primary limitation of the model is that we aggregated some qualitative variables and converted them into financial-based variables. For this reason, the model does not show the behavior of a shipper in terms of changing qualitative variables described earlier, including carrier performance level, tender acceptance, and preference for a specific carrier.

We were unable to conclude a fair assessment of certain shipper behaviors specifically for qualitative variables, as we needed a larger data set from independent sources (shippers). These variables are very shipper-specific. While the accepted asking price data is available on the digital freight matching app, we could not justify the shipper's reason behind the decision. We incorporated the accepted level of qualitative variables the shipper considered when selling a load to Uber Freight into the Average Total Price variable. Thus, all loads in the model are assumed to be at or above the shipper's accepted level in terms of the qualitative variables.

In many technology adoption cases, marketing plays a pivotal role in attracting market adoption. While we believe this is true, we did not use Uber Freight marketing effort or word of mouth variables in the model. We considered app efficiency and freight price as drivers to attract market adoption.

When a Long Term Contract is put in place, the shipper allocates administrative costs on processing and negotiating the agreement. When Uber Freight offers a better freight rate and the shipper switches to the app, according to our model, the shipper will eliminate these administrative costs. In practice, there is a delay in eliminating these administrative costs because a company may not easily remove a full-time permanent freight procurement team within the same year.

Freight procurement is difficult, as there are interdependencies between one lane and the next one. While a shipper may realize savings from one lane, the savings is strongly affected by the probability of finding a follow-on load out of that destination as well.

Despite these limitations, the research makes a significant contribution to the logistics literature. The model visualizes changing shipper behavior in the presence of digital freight matching. It gives digital freight matching providers valuable information on different attributes adding to a shipper's total freight price, which becomes the most important consideration when contemplating switching to a different procurement method. In this manner, it proves the opportunity and potential of a digital freight matching app as an alternative to, and eventually as replacement for the traditional Long Term Contract method. Additionally, the model is flexible enough to allow other digital freight providers to incorporate into it their own direct knowledge and data that is undoubtedly more extensive than the simulated data used to demonstrate the model.

For further research, we see potential studies assessing behavior for different type of shippers (e.g. large enterprises, medium sized, and small-medium businesses) to understand decision factors of each shipper type.

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7. Appendix

Appendix A: Stock-and-Flow and Causal Loop Diagram