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Supply Chain Coordination and Contracts in the Sharing Economy—a Case Study at Cargo

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Introduction

Founded in 2016 by Jeff Cripe and Jasper Wheeler, New York-based Cargo¹ is the leading provider of in-car goods and services for the rideshare economy (e.g., Uber, Lyft), an economy that is expected to grow to \$285 billion by 2030.² Soon after founding, Cargo had raised \$7.3 million in seed funding from CRCM Ventures, eighteen94 capital (Kellogg's venture capital fund), Techstars Ventures, and other prominent venture firms.

Cargo's mission, as stated on its homepage, is to help "rideshare drivers earn more money by providing complimentary and premium products to passengers." In essence, Cargo sources goods from suppliers to provide a platform for gig economy drivers to run small convenience stores out of their vehicles, thus creating a vast, mobile, and distributed retailer. In so doing, Cargo allows drivers to earn additional income, and riders to enjoy convenient and affordable access to products during their rides.

As Cargo grew, the founders considered how to most efficiently manage the company's two-sided supply chain: Would a *centralized* or *decentralized* model best serve Cargo and its drivers? And, how might *supply chain contracts* with its suppliers help support the company's profitable growth?

BACKGROUND ON CARGO

Cargo's flagship product is a hardware- and software-enabled in-car commerce platform that helps drivers earn additional income by distributing snacks, electronics, and personal care items to passengers. Cargo launched in 2016, and by early 2018, 25,000 drivers had signed up

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The discussions in this case are based on the analytical challenges faced by Cargo during its early days, but to protect the company's confidential and proprietary data, all events, experiments, methodologies, products, operational details, and data recorded in this case are purely fictional and were chosen to best illustrate the learning concepts behind these analytical challenges.

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for Cargo across two dozen countries (see **Exhibit 1**). Global consumer packaged goods companies like Kellogg, Mars Wrigley, Red Bull, and Mondelēz use Cargo as a marketing and distribution channel to reach millennial passengers, and hot new brands like RXBAR, Leaders Cosmetics, Blowfish for Hangovers, and Pure Growth Organic are also on board, using Cargo to reach new customers on the go.

Drivers sign up to receive, at no cost to them, a Cargo box stocked with a dozen carefully selected products to be sold to passengers. A picture of the Cargo box is presented in **Exhibit 2**.

In addition to items for sale, each Cargo box contains free sample products provided to Cargo by brand partners interested in connecting to their customers, testing new products, or generating aggregated data on transactions, such as time and location that products are consumed. Retail items are sold under a more traditional model, in which riders can purchase products like over-the-counter medicines, energy drinks, snack bars, and phone chargers. This case study will focus exclusively on retail items.

Passengers order from the box by going to www.cargo.menu (see **Exhibit 3**) and entering their driver's four-digit code printed at the top of the Cargo box or by scanning the box's QR code. Passengers can buy products in seconds using various digital payment options such as Apple Pay or Venmo. If riders order only sample products, no account or login information is needed. Once the passenger completes checkout, the driver receives a notification letting them know what products to give the passenger, and the driver earns a commission on the order.

CARGO'S SUPPLY CHAIN CHALLENGES

As the company grew, Cargo faced a number of supply-chain-related challenges:

- Considering space constraints in the Cargo box, which products should be offered at each point in time?
- Should replenishment orders be driven by drivers (i.e., drivers would place an order when they need new products), or should Cargo make these decisions?
- If Cargo is to decide, how often should replenishment orders be sent to drivers? And how might the company use historical data to customize orders for each driver in each time period?
- How should Cargo charge drivers for inventory, if at all? How should it negotiate contracts with its suppliers?

In meeting these challenges, the founders' priorities were threefold: (1) simplify operations as much as possible for drivers; (2) use state-of-the-art, data-driven prediction and implementation models for replenishment and ordering decisions; and (3) ensure their supply chain decisions resulted in a system that was efficient and did not "leave money on the table."

As a first step, the founders hired Eric Aleman as their chief of staff and Stuart Clark as their head of software and operations. Aleman had studied mathematics at the University of

Michigan and worked on National Nuclear Security Administration research before consulting for various early-stage startups. Clark was an early and long-tenured employee at Birchbox, a subscription company that distributes beauty products to millions of global subscribers on a monthly basis. He had helped design and build the company's logistics architecture.

Cripe knew Aleman's extensive mathematical research background and Clark's expertise in scalable logistics and software engineering would help Cargo develop an analytics-based approach to guide operational decisions. Among other innovations, Cargo quickly implemented state-of-the-art data infrastructures that allowed real-time tracking of the inventory in each vehicle and the time stamps and geolocation of each transaction. The next step was to optimize the effectiveness of these new systems to address the complexities of the firm's two-sided supply chain.

CARGO AND ITS DRIVERS: SUPPLY CHAIN CENTRALIZATION

Supply chain theory suggests that supply chains are more efficient when decision making is centralized (i.e., when a single player is in control of decisions at every level). As supply chains become increasingly fragmented and decisions become increasingly decentralized, inefficiencies can develop, and these can cost suppliers and retailers dearly.

In determining how and when Cargo should send products to its drivers to replenish their display boxes, Cargo's operations team first had to decide *who* should handle these decisions. Should they allow the drivers to decide when they wanted to order supplies to replenish their inventories, or should they centrally monitor each driver's inventory and make these decisions automatically for each driver? Since they had the ability to individually track each driver's inventory through their platform, the Cargo team could use this information to automatically decide when to replenish each driver's inventory.

The Cargo team's initial gut feeling was strongly in favor of the centralized model, in which they would make decisions for drivers, for a number of reasons:

- They knew they would have far more time to devote to the optimization of these complicated inventory replenishment decisions than did the drivers, many of whom had busy driving schedules and often had other jobs.
- They were convinced that accurately predicting demand would be an essential part of these replenishment decisions. With a view on *every* driver's data, they knew that they would be in a better position to predict demand than individual drivers—especially new ones—who only had access to their own (sparse) data.
- Making centralized decisions would be the most “hassle-free” method for drivers, who would not be responsible for making any of the complex demand forecasting and inventory decisions.
- It is a well-known fact that supply chains are more efficient when decision making is centralized (i.e., when a single player is in control of decisions at every level). As supply

chains become increasingly fragmented and decisions become increasingly decentralized, inefficiencies can develop, and these can cost suppliers and retailers dearly.

Nevertheless, there could be severe drawbacks to this kind of “remote” decision making. Having spoken to colleagues in similar industries and to other supply chain experts, Cargo knew that retailers often did not take kindly to being “micromanaged” by headquarters. Retailers have often argued that if they have to make capital outlays to buy inventory, they should be given the freedom to decide how much to order. Cargo feared this would be particularly true for rideshare drivers with sometimes limited revenue and little capital available to order the “right” amount of inventory as prescribed by Cargo. A fundamental part of Cargo’s mission was to make life *easier* for drivers and to provide them with a share of additional income.

As a result, Cargo decided to modify its centralized strategy—in the scenario in which the company made decisions for drivers, it would provide the inventory to them “for free,” recouping the costs when the products were later sold. Cargo expected this to be attractive to drivers, in light of the comments from them reflecting their reluctance to incur capital risk. This would, of course, transfer the capital risk (the financial risk of having to discard unsold units at the end of the selling season) from the drivers to Cargo, but the company was willing to take this risk. (Unfortunately, in a decentralized framework, this would be a risky choice, because it would encourage drivers to severely over-order, since ordering costs would be borne by Cargo. Thus, in a decentralized system, Cargo would be forced to charge drivers for their orders, and drivers would bear the capital risk.)

Cargo was confident this new centralized strategy would be superior, for all the reasons above. Nevertheless, given the importance of the decision, the company wanted to gather some data to assess the quantitative strength of this approach over the decentralized strategy.

THE HERBACETAMOL TEST

To test their theory, the Cargo team decided to focus on a product for which replenishment decisions were quite straightforward: Herbacetamol, an herbal painkiller. Market data revealed that the painkiller was particularly popular in a number of coastal cities served by Cargo, and the company expected it to be representative of many of the products it wanted to include in the boxes.

Herbacetamol comes in liquid form and is distributed in one-ounce bottles, similar to those used for energy drinks. It acts much like paracetamol, aspirin, and similar drugs, to relieve minor aches and pains. The small bottle size, together with the product’s effectiveness and popularity, make it a particularly attractive item for Cargo to stock. It should be noted, however, that because Herbacetamol is completely free of preservatives, each bottle has a maximum shelf life of two months. Furthermore, for logistical reasons, the manufacturers of the product are only able to fulfill orders every other month (on January 1, March 1, May 1,

etc.). Like most wholesale producers, Herbacetamol manufacturers are only willing to fulfill orders for large quantities.

These characteristics made replenishment decisions for Herbacetamol quite simple—drivers could only begin stocking the product at the start of an ordering cycle. At the end of each cycle, any leftover inventory would be lost, with no salvage value due to perishability, and new inventory would be ordered for the next cycle.

Bottles of Herbacetamol retail at \$5 per bottle in cars, and Cargo can procure them from the supplier at \$2 per bottle. As discussed, Cargo had to decide between one of two replenishment strategies:

1. In the **decentralized** strategy, Cargo would make bottles of Herbacetamol available to drivers at the start of each period at a price of \$4 per bottle (thus netting a \$2 profit per bottle). Drivers would place orders with Cargo, and Cargo would place an aggregate order with the producer to fulfill each driver's order. Drivers would then be free to collect \$5 for each bottle they sold. In this scenario, each driver would need to decide how much to order in each period.
2. In the **centralized** strategy, Cargo would decide how much to send each driver at the start of each replenishment cycle, at no cost. Cargo would then place the aggregate order with the producer and fulfill each driver's order. In this scenario, Cargo would make ordering decisions for drivers and then compensate them accordingly (for each unit sold).

With the help of pilot drivers, Cargo conducted a simulated two-year study to compare these strategies. The company recruited 15 drivers for this experiment and monitored the performance of the resulting supply chain.

Each driver started selling Herbacetamol on a given date and began with 78 units of the product. Drivers were then shown simulated demands for the next two months and were given the opportunity to decide how much to order for the next period. The experiment was then repeated over the course of two years. The simulated demands were generated using a model calibrated using historical data.

The data associated with this part of the case can be found in the tab “Part 1 (summarized)” of the spreadsheet associated with this case. Each row summarizes one ordering period and contains the following columns:

- driver: the driver ID of the driver in question.
- date: the starting date of this replenishment period.
- order_quantity: the quantity ordered by the driver for that period in the simulation.
- mean_demand, sd_demand: the mean and standard deviation of the demand in that period, as estimated using the model above.

- demand: the simulated demand during this specific ordering period, generated using the same model.

CARGO AND ITS SUPPLIERS: SUPPLY CHAIN CONTRACTS

The other side of Cargo's supply chain—the orders it had to place with its suppliers—presented the team with further challenges.

In the early days of the company, Cargo only stocked inexpensive products with very long shelf lives. The long shelf lives made ordering decisions very simple, and the fact the items were inexpensive meant that minor ordering mistakes didn't have a significant impact.

The downside of these cheap items, however, was that their retail margins tended to be inherently limited. As Cargo started growing, it therefore started looking to the possibility of stocking more expensive, and higher-margin, items in the display boxes—for example, consumer electronics such as phone chargers.

It was important to ensure these new, more expensive items did not cannibalize Cargo's core business (cheap convenience items). Thus, given the limited space in the display boxes, the company decided to only stock *a single* expensive item in each box at any one time. Given this restriction, Cargo also decided to rotate this more expensive item every month, to provide customers with an offering as varied as possible. At the end of the month, any remaining items were shipped back to Cargo by drivers and sold to a third-party at rock-bottom clearance prices.

This suddenly made Cargo's ordering decisions far more difficult. The items were now expensive and effectively "expired" at the end of the month. Thus, Cargo would need to be careful not to order too many items from its suppliers and to cautiously balance uncertainty when deciding the number of items to order. The supplier, on the other hand, would have to make a decision of its own—knowing the decisions Cargo would have to make, how much should the supplier charge for each item, and under what conditions?

As Cargo had discovered in experiments with drivers, the optimal way to handle these operations would have been to centralize all decisions with suppliers and make all decisions in tandem. Unfortunately, that wouldn't have been possible in this instance—the suppliers and Cargo were different entities, each looking out for its own interests.

Instead, Cargo wanted to create a contractual agreement with its suppliers to maximize the efficiency of the supply chain for these more expensive items. As a pilot item, Cargo chose a phone charger that retails for \$10 in vehicles. When the company took into account shipping costs for returns from drivers, unsold chargers at the end of the month could be sold for a salvage value between \$0 and \$1, depending on the unsold volume.

Cargo first considered a basic *wholesale price* contracting strategy. Under this contract, the supplier would charge a fixed wholesale price for each unit delivered to Cargo, and, given this wholesale price and historical data, Cargo would decide how many units to order to maximize

its profit. The supplier, of course, would choose the wholesale price that maximized its profit. The supply chain in this setting is illustrated in **Exhibit 4**.

However, Cargo had a strong suspicion that this contracting strategy was not optimal. The discomfort mostly stemmed from the fact that even though Cargo's decision and the supplier's decision were strongly interrelated, they were made completely independent of each other. As Cargo had seen in the studies with drivers, this could lead to a large profit left on the table. The company also worried about demand uncertainty risk (which could be significant for some products) and would have preferred a strategy in which this risk was also partly borne by the supplier.

After extensive research and discussions with supply chain experts, Cargo identified several common supply chain contracts that would alleviate the problems, including revenue sharing contracts and buyback contracts (both discussed more comprehensively in Appendix A). The company eventually decided to focus on *revenue sharing contracts*. In these contracts, the supplier charges a cheaper wholesale price for each unit provided to Cargo, and Cargo agrees to share some of the revenue realized on each unit with the supplier. The supplier decides both the wholesale price (which we denote w) and the fraction of the revenue that is shared with the supplier (denoted y). In some cases, suppliers will set the wholesale price at cost (or even below cost) to incentivize the retailer to order larger quantities that will result in higher sales. It is, of course, essential for the retailer's expected earnings to be at least as large in a revenue sharing contract as in a wholesale price contract, to incentivize the retailer to accept such a contract.

In our example of the phone charger that retails for \$10, each sale would net $\$10y$ for the supplier, and Cargo would receive $\$10(1 - y)$.

Attractive as this contracting strategy appeared, Cargo still wanted to test it to ensure it would lead to the expected financial gains. As the company did with drivers, it created a simulated study to evaluate the revenue it could earn from using both kinds of contracts.

THE PHONE CHARGER TEST

To test the performance of this supply chain contract, Cargo carried out simulations with the aforementioned phone charger. The data associated with this test can be found in two tables in the spreadsheet associated with this case—"Part 2 (wholesale)" and "Part 2 (revenue sharing)." The simulations spanned 300 months, and demand realizations for these 300 months are also included in the file.

Exhibits

Exhibit 1

A graph of Cargo's driver signups since the official launch

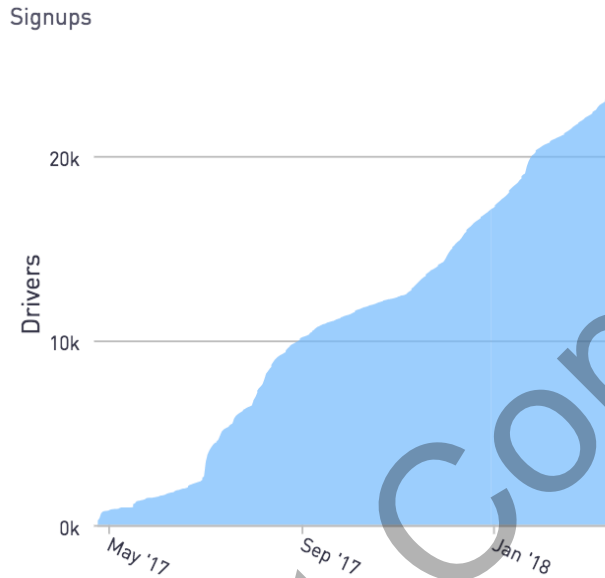


Exhibit 2

Cargo's display box with four-digit code and QR code to access the web store



Exhibit 3
Screenshot of Cargo’s mobile web store

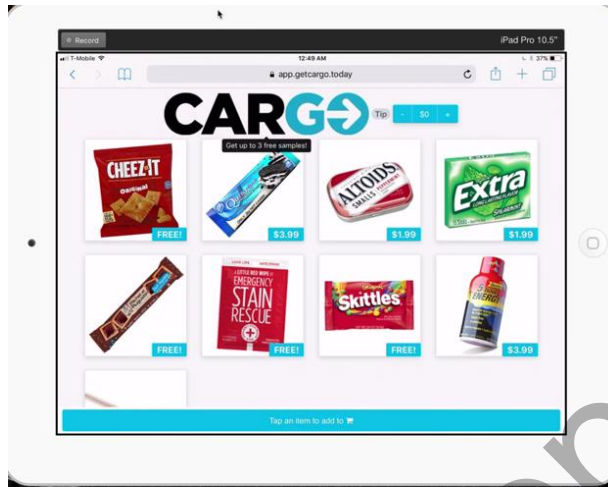


Exhibit 4
Traditional supply chain setting with a single supplier and a single retailer



Questions

Part 1: Cargo and its Drivers

The data associated with this part of the case can be found in the tab “Part 1 (summarized)” of the spreadsheet associated with this case. Carefully examine the data provided with the first part of the case and answer the following questions:

1. What strategy do you think the drivers used to decide what orders to place? Comment on this choice of strategy.
2. On average, what is the sum of the profit made by the drivers and by Cargo over each two-month replenishment period?
3. Suppose we were still using the first strategy (i.e., decentralized decisions), but that drivers now correctly optimized the quantity to order in each period. What would be the sum of the profit made by Cargo and its drivers over each two-month replenishment period?
4. Suppose we are now using the second strategy (i.e., centralized decisions) so that Cargo makes decisions for each driver in each period to optimize the total revenue earned by the drivers. What would be the sum of the profit earned by Cargo and its drivers over each two-month replenishment period?
5. Based on your answers above, write a paragraph summarizing the pros and cons of the centralized and decentralized strategies.
6. **(Optional)** The tab “Part 1 (forecast model)” in the same spreadsheet contains the sales data used to calibrate the demand model from the simulated trial. This data was provided by Herbacetamol’s manufacturer, and catalogues past Herbacetamol sales over a single year with hourly granularity. Look at these data and answer the following questions:
 - Investigate the data contained in this tab. Is there a time of year that Herbacetamol is more popular? A day of the week? A time of the day? Is there a trend in sales over time? Do these factors depend on one another? Can you come up with explanations for the patterns you observe in these data?
 - How would you build a demand model based on these data that Cargo could use to predict future Herbacetamol sales?

Part 2: Cargo and its Suppliers

The data associated with this part of the case can be found in two tabs, “Part 2 (wholesale)” and “Part 2 (revenue sharing),” of the spreadsheet associated with this case. It refers to the simulations carried out on the phone charger described in the case, which costs \$2.50 to produce and retails for \$10 (both prices are included in the spreadsheet). The file also contains simulated demand realizations for 300 months. First, assume that there is no salvage value for the phone chargers at the end of each month.

1. We consider and simulate the supply chain under a wholesale price contract. As mentioned, we use a retail price of \$10, a unit production cost of \$2.50, and a (monthly) demand that is normally distributed with mean 1,000 and standard deviation 200. The demand realizations are given in the spreadsheet.
 - a. Under a wholesale price of \$5, what is the retailer’s optimal order quantity?
 - b. Under a wholesale price of \$5, compute the expected profit of the retailer and of the supplier.
 - c. Vary the value of the wholesale price between \$2.50 and \$10 and find the value that yields the highest possible profit for the supplier. What is this wholesale price value?
 - d. For the wholesale price value obtained in Part 1c, what is the total expected profit of the supply chain (i.e., the sum of the retailer’s profit and the supplier’s profit)?
2. The supply chain’s *First-Best* profit is defined as the profit under the ideal situation where the entire supply chain is owned by one party, i.e., the centralized supply chain.
 - a. What is the supply chain’s optimal order quantity?
 - b. What is the First-Best expected profit?
 - c. How does the retailer’s order quantity (from Part 1a) compare to the First-Best’s optimal order quantity (from Part 2a)? Why is it the case? Carefully justify your answer.
 - d. How does the total expected profit (from Part 1d) compare to the First-Best expected profit (from Part 2b)? What is the relative difference between these two values?
3. (**Optional**) Re-solve questions 1 and 2 using a salvage value of \$1. How does it affect the results? Please elaborate.
4. We now consider using a revenue sharing contract. We start with a wholesale price w of \$0.75 and a revenue share percentage γ of 0.7.
 - a. What is the retailer’s optimal order quantity? What can you say on this value?
 - b. Compute the retailer’s expected profit and the supplier’s expected profit under the above revenue sharing contract. What can you conclude?
 - c. When comparing the wholesale price contract to the revenue sharing contract, who benefits? Justify your answer.

5. **(Optional)** In Part 4b, you calculated the expected profit earned by the supplier and by the retailer. In some settings, to incentivize the retailer to sign on, the supplier needs to guarantee a minimum expected profit level to the retailer. Find the wholesale price w and the revenue share percentage y that maximize the supplier's expected profit while ensuring the retailer makes at least as much as under the wholesale price contract (see Part 1b).
6. **(Optional)** In a buyback contract, the supplier does not receive a share of the retailer's revenue. Instead, the supplier offers to buy back any unsold unit from the retailer (at a discount) at the end of the selling period. Implement such a contract in this context. What is the optimal buyback price? How does this contract perform relative to the wholesale price contract and relative to the revenue sharing contract?

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Appendix A

Supply chain contracts are ubiquitously used in a wide range of industries to remedy these inefficiencies. When designed properly, these contracts allow both retailers and suppliers to coordinate their decisions even in a setting where the supply chain is fragmented. Traditionally, supply chain contracts have been used in the pharmaceutical industry, the rental business (e.g., DVD rentals), and for large medical and manufacturing machines. This case study provides an example of supply chain contracts in the sharing economy, and this appendix lists some other common supply chain contracts and their applications.³

Wholesale Price Contract

Under the wholesale price contract, an upstream firm (e.g., a supplier) sells to a downstream partner (e.g., a retailer) at a constant wholesale price for each unit ordered by the retailer. Then, the retailer resells the goods and keeps all the realized sales revenue. Note that in such a contract, the retailer is solely responsible for salvaging unsold items, and bears the risk of over-ordering. The wholesale price contract is the most basic supply chain contract and is widely used in many industries, including franchises, groceries, and automobiles.

Revenue Sharing Contract

Under the revenue sharing contract, the retailer pays a wholesale price to the supplier for each unit purchased and earns a percentage of the sales revenue that the retailer generates from selling to end consumers. This contract was historically popular in the video rental and streaming industries, where it was estimated to increase both upstream and downstream profits by approximately 10–20% (Mortimer 2008).

Buyback Contract

Under the buyback contract, the supplier sells to the retailer at a constant wholesale price for each unit ordered by the retailer. However, the retailer is no longer solely responsible for salvaging unsold items. Instead, the retailer can return unsold items to the supplier in exchange of a refund. The buyback contract is popular for products with a limited shelf life—for example, pharmaceuticals, computer hardware and software, magazines, newspapers, and books.

Endnotes

¹ Cargo, “Earn \$300+ Extra Each Month” (advertisement), <https://www.getcargo.today>.

² Caitlin Huston, “Ride-hailing industry expected to grow eightfold to \$285 billion by 2030,” MarketWatch.com (May 27, 2017), <https://www.marketwatch.com/story/ride-hailing-industry-expected-to-grow-eightfold-to-285-billion-by-2030-2017-05-24>.

³ For more details on supply chain contracts, including mathematical models and analyses, see e.g., Cachon (2003).

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