At the Frontier of Retail in the 21st Century: Modern Fulfillment and The Case of FlexiWeight

BY OMAR BESBES[*], CARRI CHAN[†], AND C. DANIEL GUETTA[‡]

In the fall of 2020, FlexiWeight co-founders Shanice Williams and David Smith found themselves in a "careful what you wish for" moment. Founded in 2018 with a mission to "revolutionize the way America exercises," FlexiWeight had designed an innovative set of compact, Bluetooth-enabled adjustable weights suitable for at-home use. The concept was an immediate hit and, perhaps fueled by a rise in at-home exercising during the COVID-19 pandemic, the product quickly grew from a niche product to a must-have accessory for workout buffs across the United States. Demand for the product skyrocketed, and Williams and Smith quickly realized the ad-hoc shipping and fulfillment systems they were using would not be able to keep up.

Against the backdrop of a wave of new fulfillment models initiated by large retailers such as Amazon and Target and rapidly changing shopping behavior, businesses large and small had begun investing in more advanced fulfillment methodologies to fulfill customer demand. Faced with exploding demand, multiple sources of inventory, and an ever-growing set of channels to choose from, Williams and Smith set out to replace their mostly manual shipping system with an automated one that would help them to determine how to best deliver their customers' orders and—ultimately—their dream of a revolutionary approach to fitness.

The Challenge of Fulfillment: A Historical Perspective

GOVERNMENT-IMPOSED LIMITS

American retailers have historically been plagued by the challenges presented by the trans-continental delivery of goods. Early retailers like JC Penney, whose doors first opened in 1902, made use of warehouses to store inventory, locating stores close by.[1] As consumers began to move out of city centers into suburban areas, these retailers were faced with the logistical

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challenge of stocking store branches that were increasingly further away from their warehouses. They began to rely on drop-shipping[2]—the practice of shipping inventory from suppliers directly to individual stores, bypassing warehouses altogether. Over time, this system became increasingly unmanageable; the state of technology at the time made it difficult to monitor inventory levels at the branch level, let alone centrally at corporate headquarters. Consequently, managers at headquarters had little oversight into their overall inventory positions.[3] This resulted in much higher stock levels in suburban stores that did not have ready access to centralized warehouses as retailers tried to keep enough inventory to ensure that customers could find what they needed.

Retailers were further weighed down by government policies that required scarce and costly permits for transportation carriers to carry goods across state lines.[4] Most carriers would therefore only operate within a specific locale, and those with a broader reach charged high fees. This highly fragmented network of carriers was another barrier to distribution from a centralized warehouse, and it further encouraged retailers to ship inventories directly from suppliers to stores. As a result, retailers were unable to efficiently exploit scale economies from centralized distribution and most remained regional chains.

Deregulation with the passage of the Motor Carrier Act of 1980 sharply reduced transportation costs by allowing the transportation industry to consolidate. It increased competition among carriers, giving birth to such services as United Parcel Service (UPS) and Federal Express[5] (FedEx). Significantly lower transportation costs made it financially possible for retailers to build national distribution networks and allowed them to reduce the holding costs of carrying inventory.

As a result of these delivery efficiencies, inventories became leaner. In 1981, inventories amounted to 14% of gross national product (GNP); because of improved transportation services traceable to the Motor Carrier Act of 1980, the total fell to 10.8% by 1987, for a savings of about $62 billion.[6]

THE RISE OF EDI . . . AND WALMART

The last piece of the puzzle that made modern fulfillment systems possible was the maturation of electronic data interchange (EDI) and its subsequent adoption by large retailers like Walmart in the 1980s.[7] EDI gave supply chain managers a bird's eye view of inventory throughout their systems and enabled a shift towards hub-and-spoke fulfillment, where a retailer could receive, plan, allocate, and distribute inventory across its store branches along the most efficient pathways (spokes) from a centralized distribution hub.

Walmart quickly leveraged these new advantages into a fulfillment machine that became a sustainable competitive advantage.[8] By capitalizing on the ability to seamlessly transmit data between its suppliers, warehouses, and store networks, Walmart pioneered the adoption of vendor-managed inventory systems where suppliers were responsible for managing their own inventory in Walmart's warehouses. This meant that goods could be produced and distributed

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in the right quantities to the right locations in the right time.[9] Walmart was also able to leverage EDI to take advantage of innovative practices like cross-docking, where goods were transferred directly from incoming trucks to store-bound trucks at warehouses with little holding time.[10] This reduced the need to stockpile inventory at warehouses and therefore the amount of time inventory sat idle before it could be sold.

E-COMMERCE . . . AND AMAZON

Founded in 1994, Amazon would become the gold standard for online fulfillment.[11] The company realized that by operating online, it could focus on fulfillment exclusively and take the practice to levels brick-and-mortar stores could have only dreamed of. It built a vertically integrated fulfillment infrastructure which, by 2010, spanned 11 fulfillment centers in North America, eight centers in Europe, and six in Asia,[12] allowing it to supply a long tail of niche products and position itself as the "everything store." By operating online only, it was able to build fulfillment centers at comparatively low costs outside of prime urban areas and use its scale to negotiate better parcel delivery rates from transportation carriers like UPS.[13]

Amazon also quickly realized that the fulfillment infrastructure it had built—and the client base it had captured—was a valuable asset in its own right. It launched the "Fulfillment by Amazon" program,[14] in which third-party marketplace vendors would entrust their inventory to Amazon and allow the company to fulfill its orders for a fee. Within the firm, its inventory planning and control group optimized inventory placement by researching the company's network and customer orders so that goods could be distributed in anticipation of demand and replenished after the demand was realized.[15] In the first quarter of 2020, Amazon would come to own 26% of the online retail space.[16]

Microfulfillment: The Next Frontier

As e-commerce became widely adopted across the country and business-to-consumer share of the total parcel delivery market grew to 40%, last-mile costs—the cost of transporting items along the last leg of journey between a store or warehouse and a customer—soared and grew to exceed 50% of total parcel delivery costs.[17] Retailers were once again confronted with the challenge of fulfillment across large distances.

In response, national retailers began to experiment with ways to aggregate demand that would allow greater flexibility in inventory allocation and optimize for transportation costs. Rather than having deliveries to both stores and online customers routed from centralized warehouses, retailers tried to create more nodes in their distribution network to reduce transportation costs. In this new paradigm of "microfulfillment," orders were no longer fulfilled exclusively from warehouses; instead, the retailer leveraged every channel available to meet demand more quickly, efficiently, and cheaply. Brick-and-mortar stores also saw this as a way to use their existing infrastructure to gain competitive advantage over the behemoth Amazon had become.

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Companies leveraging this new technique ranged from Walmart, which partnered with FedEx in 2010 to allow customers to order online and pick up their orders in select FedEx locations, to Target, which reportedly reduced its fulfillment costs for same-day shipping by 90% by using its extensive network of brick-and-mortar stores as last-mile fulfillment centers. In autumn 2020, Apple quietly announced it would begin shipping products directly from its 300 US and Canadian stores to consumers. Even Amazon, the doyen of smart fulfillment, made a major foray into the offline world with its acquisition of Whole Foods, which it used to fulfill its online orders. (See Appendix B for more details on each of these examples.)

Microfulfillment: A Global Trend

In adopting microfulfillment, these companies were following a path by other national retailers that had turned to fulfillment as a potential source of strategic advantage in a highly competitive landscape. In fact, the microfulfillment model had also been adopted by an increasing number of retailers outside the United States. For instance, inspired by online grocery delivery, Watsons, a healthcare and beauty care chain store in Asia, partnered with Alibaba to offer a "ship from store" service to its customers through Alibaba's Taobao platform.[18] Customers could see which items were available in the nearby stores and receive those products within a few hours. The ship-from-store service received a further boost in late 2018 when Watsons also partnered with Ele.Me, a major food delivery service in China, to deliver select products from its stores, which cut the fulfillment time from same day to less than an hour.[19]

Whether a retailer chose to use its physical stores to fulfill orders from its own online store or a third-party platform, it needed to optimize its inventories at various fulfillment nodes and choose the best place to fulfill the online orders. While delivering products from the closest physical stores could potentially reduce both costs and fulfillment time, a retailer may risk stock-out at the store and lose the opportunity to sell to in-store customers. For big online platforms like Amazon and Alibaba, there was even greater complexity in fulfillment strategy as they needed to consider inventory levels in both their own fulfillment networks and from third-party retailers on the platforms. Microfulfillment had proved transformational in the way these stores had done business—but it also created a new set of astonishingly complex logistical challenges companies had to wrestle with every time an order came in.

FlexiWeight's Logistical Challenge

As illustrated by the many challenges that confront all retailers world-wide, FlexiWeight was not alone in facing the technical complications of modern fulfillment.

COMPANY BACKSTORY

In 2015, Williams, a successful executive at a major car manufacturer, went on maternity leave to have her first child. After returning to work, she realized her schedule made it increasingly difficult to keep up with her punishing weightlifting routine. Undaunted, she quickly realized

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her biggest hurdle was the time it took her to get to the gym from her suburban Detroit home every day—if she were able to work out at home, she could shave at least an hour from her routine. She started looking into ways to make this a reality and found slim pickings. She had neither the space nor budget to buy a full set of weights, barbells, and dumbbells, and whilst companies like Peloton offered technology-enabled cardio equipment, she found little in the way of more advanced weightlifting equipment.

With her extensive experience in manufacturing, she knew it should be feasible to create the product she was looking for, but her research convinced her the future lay in software-enabled workout equipment. She did not feel she had the software-development experience to pull that off. She was ready to give up when a chance encounter proved to be the breakthrough she needed. By a stroke of luck, Smith's husband worked out at Williams' gym, where he overheard her discussing her idea. He knew Smith was feeling frustrated at his current job and was looking to move somewhere new. He introduced the two of them, and they hit it off immediately. Both decided the idea was worth pursuing, and FlexiWeight was born.

Together, they designed an innovative set of compact, Bluetooth-enabled, adjustable weights. The base allowed the user to select a desired weight from 5 to 100 pounds; the correct weight would them be loaded onto the system, and the user could pick it up to carry out a specific exercise. An accelerometer embedded in the weight tracked the user's progress based on the weight's movements and reported it back via Bluetooth to the FlexiWeight app on the user's phone. Smith leaned on Williams' knowledge of weightlifting to design an AI-based algorithm that was able to correctly sense the weight's movements for a variety of exercises. They marketed their product to the high-end fitness market, and quickly developed a loyal following with fitness fanatics.

BUSINESS AND DISTRIBUTION MODEL

FlexiWeight's headquarters were located in New York City, and the company had two flagship stores—one in New York City and one in San Francisco. There were two main channels through which customers could buy FlexiWeight's products:

- **One of FlexiWeight's flagship stores**, where they could see the product, try it in person, and place an order. This order was then delivered directly to the customer's house, with same-day or next-day delivery guaranteed. (The set of adjustable weights was too heavy to carry, so no option was offered to carry the product directly from the store.)

- **FlexiWeight's website**, where customers could read about the product, watch demo videos, and get the item delivered to their home. Two delivery speeds were available—a guaranteed three-day delivery and a guaranteed seven-day delivery. (FlexiWeight only offered delivery to the contiguous United States.)

In line with the company's high-end branding, all delivery options came with white-glove service. Employees would deliver the weight set directly to the customer's house, set up the

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weights, ensure they were functioning, and take any packaging with them. FlexiWeight arranged the delivery themselves in New York City and San Francisco and contracted with a third-party logistics company for deliveries in the rest of the contiguous United States. For pricing purposes, this logistics company divided the states into five regions—Northeast, Midwest, Southeast, Southwest, and West.

In addition to its two flagship stores, FlexiWeight had two additional warehouses—one in Newark, New Jersey, and one in Phoenix, Arizona. All orders were fulfilled from these warehouses, which were located further away from customers, but in areas with far cheaper rent. Same day orders in New York City and San Francisco had to be fulfilled from a warehouse on the same coast, but others could be fulfilled from anywhere via the third-party logistics provider.

AN EXPLOSION IN DEMAND

As the COVID-19 pandemic hit, FlexiWeight realized that the digital nature of its system, together with Bluetooth connectivity, made it perfect for an additional application—remote personal training. Indeed, because the weights were controlled digitally, it was theoretically possible to have a trainer manage them from a distance. The accelerometer data could also be shared with the trainer to provide real-time performance feedback.

In an astonishingly short amount of time, Smith and his team were able to create a platform that would allow personal trainers to do just that. The platform was an immediate hit—many of FlexiWeight's existing customers started using it, and order volumes soared. In 2019, FlexiWeight's average order volume was 7,000 monthly orders; by the summer of 2020, it had almost doubled to 13,550 orders per month. Williams and Smith quickly realized that what had originally been intended as a beta feature during the pandemic would become a major selling point of their platform.

With this explosion in demand, however, came the headache of having to manufacture and deliver more units than they had ever planned for. Luckily, Williams' manufacturing experience and contacts allowed her to quickly ramp up manufacturing overseas and across the country to meet demand. She quickly ramped up the company's East Coast production to 5,250 units (delivered to the Newark warehouse on the first of the month), and its West Coast production to 8,300 units (delivered to the Phoenix warehouse), thus meeting average demand every month.

THE NEED FOR PRINCIPLED FULFILLMENT

Having overcome the immediate hurdle of producing enough units to meet this new demand, Smith and Williams now turned their attention to the fulfillment process. In the pre-pandemic world, they would fulfill all orders from their two warehouses, whichever was closest and had inventory available. Demand was small enough that stockouts were rare, and Smith and Williams were so focused on growing the company that optimizing fulfillment was not a priority.

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Unfortunately, in this new world of increased demand, this simple approach was stretched to the breaking point. Smith and Williams were increasingly facing sellouts at individual warehouses, and their fulfillment costs were skyrocketing. Something needed to be done.

As a first step, Smith and Williams realized that their most expensive fulfillment costs came from same-day deliveries to New York City and San Francisco. They realized there was a way to drastically reduce these costs—by using their New York City and San Francisco flagship stores as microfulfillment centers, they would be able to fulfill some of these same-day orders (and even some online orders) directly from these stores.

They quickly moved to implement this idea. Due to limited capacity, they were only able to store 250 units in the New York City store and 300 units in the San Francisco store. They modified the start-of-month plan accordingly, to divert some units from the Newark and Phoenix warehouses respectively.

This new fulfillment structure, however, came with new complications. When an order came in from a given channel and with a given shipping speed, FlexiWeight now had four possible locations it could ship it from—the New York City store, the San Francisco store, the Phoenix warehouse, or the Newark warehouse. Which location should they ship it from, to reduce fulfillment cost and prevent stockouts? Appendix A lists all shipping costs from every fulfillment node to every demand location (New York City, San Francisco, Northeast, Midwest, Southeast, Southwest, and West), and for all shipping modes.

Faced with this ocean of numbers, Williams and Smith had a real headache. When a new order arrived, where should they fulfill it from to reduce fulfillment cost and prevent stockouts? Shipping from the cheapest store would no longer do—they had to create a better system.

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Assignment

Put yourself in Williams' and Smith's position, and consider the following questions:

- Do you agree with FlexiWeight's decision to move from a simple single-channel fulfillment system to a more complex microfulfillment strategy? What are some pros and cons of their choice?

- Suppose a new order comes in, and you need to decide where to fulfill it from. How would you make this decision? What considerations should you take into account in designing such a strategy? Can you think of any pitfalls of the strategy you came up with?

- How would you evaluate your strategy before implementing it?

- If their microfulfillment strategy is successful, FlexiWeight might choose to expand and solidify this approach. If they do, there are several parts of the system they might invest in—larger storage capacity, lower shipment costs, etc. How should they go about deciding which parts of the system to invest in first?

- Thinking more broadly about modern, "smart" fulfillment systems, what broader impact on society can these systems have as they are increasingly adopted?

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Appendix A

This appendix lists data pertaining to FlexiWeight's fulfillment system.

The company's East Coast facilities produce 5,250 units per month. At the start of each month, 5,000 of these units are delivered to the Newark warehouse, and 250 to the New York City store as part of Williams' and Smith's microfulfillment strategy. The West Coast facilities produce 8,300 units, of which 8,000 are delivered to the Phoenix warehouse and 300 to the San Francisco store. FlexiWeight has no ability to move units between facilities during the month— once a facility runs out, no new units can be delivered until the start of the next month. If a facility happens to run out of inventory before the month is over, it can no longer fulfill any orders that month.

Average demands at each of the stores (requiring same-day shipping) are 377 units per month in New York City and 411 units in San Francisco. In addition, the following average order demands are observed online every month in each of the five pricing regions defined by FlexiWeight's third-party logistic supplier. Note that New York City and San Francisco are listed separately—online orders for these two cities listed in the table are *in addition* to the in-store orders of 377 units per month and 411 units per month respectively:

	3-day orders	7-day orders
NYC	667	261
SF	660	295
Northeast	1,235	876
Midwest	1,250	870
Southeast	1,313	889
Southwest	1,345	874
West	1,307	920

It is important to remember that each of these orders are averages. Actual orders will be random and might be greater than or smaller than these numbers.

Same-day orders from a flagship store must be shipped from a facility on the same coast to get to their destination on time; this shipping modality is only available for orders to New York City and San Francisco:

- New York City orders can be shipped directly from the New York City store for a marginal cost of $12 per order or from the Newark warehouse for $15 per order.

- San Francisco orders can be shipped directly from the San Francisco store for a marginal cost of $12 per order or from the Phoenix warehouse for $55 per order.

The following table summarizes the marginal cost of shipping a single unit using three-day shipping from each of the warehouses (columns) to each region (rows). Note that New York

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City and San Francisco are listed separately from their respective regions to reflect cheaper routes available when shipping directly to these cities:

	NYC	Newark	SF	Phoenix
NYC	3	4	40	30
SF	40	40	4	10
Northeast	11	12	44	40
Midwest	18	20	18	20
Southeast	14	15	24	25
Southwest	24	25	15	10
West	40	45	10	14

The following table lists corresponding marginal costs for seven-day shipping:

	NYC	Newark	SF	Phoenix
NYC	1.8	2.4	24	18
SF	24	24	2.4	6
Northeast	6.6	7.2	26.4	24
Midwest	10.8	12	10.8	12
Southeast	8.4	9	14.4	15
Southwest	14.4	15	9	6
West	24	27	6	8.4

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Appendix B
Examples of Companies Adopting Microfulfillment

In 2010, Walmart partnered with FedEx so that customers could order online and pick up their orders in select FedEx locations.[20] By 2016, the largest retailer in the United States also began to work with regional parcel carriers like LaserShip to better serve niche customer bases when UPS or FedEx did not have sufficient capacity.[21] During the COVID-19 pandemic, LaserShip added a 40,000-square-foot facility in Durham, North Carolina, which could process 14,000 parcels hourly to meet growing demand.[22]

Beginning in 2017, Minnesota-based Target began to heavily invest in a store-centric fulfillment model where orders across its channels were fulfilled from its fleet of 1,800 brick-and-mortar stores.[23] Recognizing the systemic shift towards online retail and Amazon's competitive advantage in the space, Target sought to parlay its existing stores into a last-mile fulfillment edge by combining advanced inventory allocation software with in-store order fulfillment. In effect, while each store was served by a "spoke" from a centralized hub, stores would themselves also serve as hubs for online customers near them. This enabled Target to fulfill orders closer to consumers without needing to invest in more real estate or warehouses and reportedly made order fulfillment 40% cheaper per unit on average.[24] Target was also able to reduce fulfillment costs by 90% for same-day offerings, which further boosted its online sales.[25] While it had incurred additional costs to convert its stores into microfulfillment centers, the added flexibility allowed the retailer to maintain utilization of its existing assets during the COVID-19 pandemic when stores were forced to close. In April 2020, Target's digital sales increased 282% year over year, and stores fulfilled 80% of digital orders.[26]

With the $13.7 billion acquisition of Whole Foods in June 2017, Amazon made a major foray into the offline world. While the transaction was initially framed as Amazon's attempt to grow its grocery business, its integration with Whole Foods had profound impact on its logistics and fulfillment network. Customers were now able to order both grocery and non-grocery items from Whole Foods on Amazon and get their orders fulfilled by the closest Whole Foods store, usually within the same day.[27] In addition, customers could pick up and return Amazon items at Whole Foods locations, increasing Amazon's physical presence significantly.[28] Subsequent to the Whole Foods acquisition, Amazon further expanded its fulfillment network through Amazon 4-Star, Amazon Pop Ups, Amazon Bookstores, Amazon Go, Amazon Fresh Supermarket, various Amazon Pick-up Locations, and Amazon Lockers.[29]

In autumn 2020, Apple quietly announced that it would begin shipping products directly from its fleet of 300 US and Canadian stores to consumers. The company had piloted the new approach at the beginning of the pandemic and was on track to roll it out to most of its stores.[30] This was a substantial shift in the status quo for Apple who had previously either shipped from regional warehouses or the factory. This change meant faster delivery times for

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customers who lived further from distribution centers and greater flexibility in inventory allocation for the company.

Apple's shift towards microfulfillment and the use of stores as fulfillment centers also ensured that stores that were shuttered or limited due to COVID-19 restrictions would still be operational.[31]

Unlike the big box retailers such as Target and Walmart in the United States, almost all traditional retailers in China engage in e-commerce primarily as third-party sellers on major e-commerce platforms such as Taobao and JD.com. For instance, Walmart and its Sam's Club stores sell products primarily through JD.com in China rather than operate its own platform.[32] Certain retailers like Watsons also operate on multiple platforms including both e-commerce and food-delivery platforms. As a result, retailers' inventory and fulfillment strategies can be further complicated by intense competition from other retailers on the same platforms or competing orders across very different platforms that may also need to be served differently.[i]

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[i] For instance, an order from a food-delivery platform will almost have to be fulfilled from the closest retail stores by a delivery person on the platform within hours, while that from an e-commerce platform can be more flexible.

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