The Emissions Implications of Modern Retailing: Omnichannel vs. Stores and Online Pure-Plays

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Environmental Defense Fund
Massachusetts Institute of Technology

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Today's retail landscape continues to evolve, with innovations in retail formats and delivery methods. These changes raise important questions about how our impact on the environment will also evolve and change. How does our environmental footprint vary across delivery channels? How will customer shopping behaviors impact emissions? And what can we at Walmart do to reach our 2025 sustainability goals?

As we work to answer these questions, we have seen that a retail model offering a mix of channels (omnichannel) is optimal. An omnichannel model brings together physical assets that are close to the customer and digital assets that provide 24/7 access. The result is an offering that provide customers significantly more flexibility and convenience across their full set of shopping occasions and at a lower emissions footprint than e-commerce alone when options are used efficiently.

Across channels, we will continue to explore opportunities for Walmart and other retailers to reduce emissions. Among other efforts, we have been working to reduce emissions in our retail facilities and fleet for years. This work highlights additional sources of emissions such as the customer trip to the store, and e-commerce packaging and shipping. We benefit, relative to other retailers, from the proximity of our stores to customers, large basket size (which amortizes fixed emissions over many items), and the breadth of our assortment. Continuing to establish our stores as destinations for multiple errands and occasions will provide our customers superior convenience and limit one-off trips and additional stops that drive emissions. And despite rising expectations for assortment selection and delivery windows, we can find ways to consolidate shipments and reduce packaging.

The pages that follow expand on these thoughts, providing the detail of our findings as well as our approach. We hope that by sharing these insights, we will prompt a dialogue within Walmart and at other retailers on how we can collectively reduce our environmental impact in this rapidly changing world.

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INTRODUCTION

We at Walmart are working to understand and mitigate the impact our business has on the environment. To that end, we have embedded sustainability initiatives into our core business strategies and seek to continually evaluate and reduce the impact of our operations through robust analysis and determined action.

This paper shares the findings of an analysis we undertook to understand the carbon footprint of various retail channels. Specifically, our primary objectives were to understand:

- **What are the key sources of emissions across channels** (including pure brick and mortar and e-commerce, as well as flexible delivery paths like buy online and pickup in store)
- **How does this profile vary by type of purchase** (including but not limited to type of trip, size of basket, type of products, and speed of delivery)
- **How will sustainability trends impact this profile in the future** (e.g., more efficient vehicles, renewables usage, and rates of recycling)

We based this analysis on Walmart stores and Walmart.com operations in the United States. However, we believe the insights and conclusions drawn from that data may apply broadly to the retail industry.

WHAT WE FOUND

Which channel is most efficient in terms of carbon emissions? There is no single answer to that question, because our customers' lives and purchase patterns are dynamic. Sometimes they sprint to the store to purchase a last-minute toy for a birthday party, and sometimes they stock up on groceries. Sometimes they need it now, and other times next week will do.

The better question is: *When is each channel most efficient in terms of emissions?*

We start by looking at small baskets: Consider a customer who wants to purchase a single general merchandise item, like a toy or t-shirt.

Analyzing emissions from customer vehicles

Our analysis uses the **average fuel efficiency** of cars on US roads today (21 MPG). The majority of cars being made today (about 70%) fall within 5 MPG of this range. Fuel efficiency will continue to improve as we adopt better technology, including hybrid and electric cars.

Source: US Dept. of Energy 2015 Fuel Economy Guide

When we add up the individual sources of emissions[1], the first clear observation is that the last mile of a purchase's journey to the customer's home is an important contributor to emissions, regardless of whether the customer makes her purchase in the store or has it delivered to her home (see **Figure 1**).

For store purchases, we must differentiate between the type of trip and whether it was a dedicated trip to and from the store or if it was made on the way to or from work, school, or another errand (what is called a chained trip).

We see that if a customer shops on a chained trip, a store purchase is preferable to home delivery. However, if the customer must make a dedicated trip, delivery to the home is more emissions efficient to purchase a single item. Chained trips are the most common type of trip, so store purchases are most often the lowest

[1] This analysis includes all direct and indirect emissions from Walmart's own US operations, as well as emissions from customer and parcel carrier travel. We measure emissions in carbon dioxide equivalents (CO_2e) to convert different sources of emissions into a single measure. More detail can be found in the appendix.

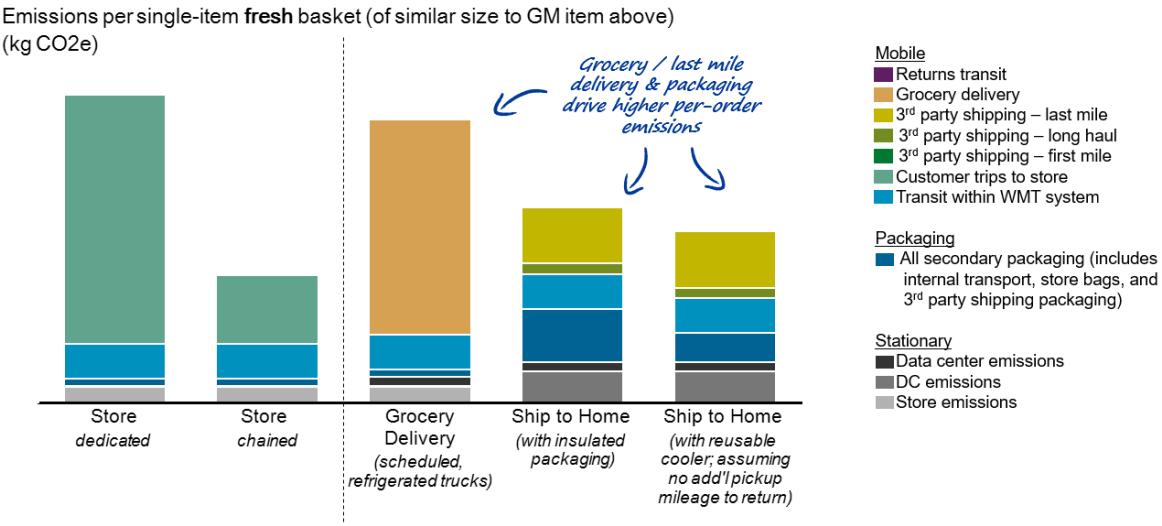
carbon option for a single-item purchase.

Figure 1: Comparison of footprint for a single-item basket

If our customer wants a single fresh item, like a gallon of milk, e-commerce incurs additional emissions that narrow the gap to dedicated trips.

Shipping fresh or frozen items produces higher emissions, as seen in **Figure 2**. This is because shipping fresh items typically involves one of three options. Items can be delivered by refrigerated trucks (shown as Grocery Delivery below). Or items can be shipped to home in insulated packaging by parcel delivery. The third option is parcel delivery in a reusable cooler. This option has the potential to be the most sustainable of the three, but assumes coolers are always returned with pickups and introduces complex return logistics. Because customers report that most store trips are chained, shopping in stores is typically most emissions efficient for the purchase of a single fresh item.

Figure 2: Comparison of footprint for a single-item 'fresh' basket across channels



Note that these comparisons differ for oversized items. Oversized items are much less efficient in terms of emissions when shipped to home due to the increased amount of secondary packaging and last-mile transit space required, whereas the emissions of a customer trip to the store is independent of the size of the items being purchased. For these items, ship to home emissions for a

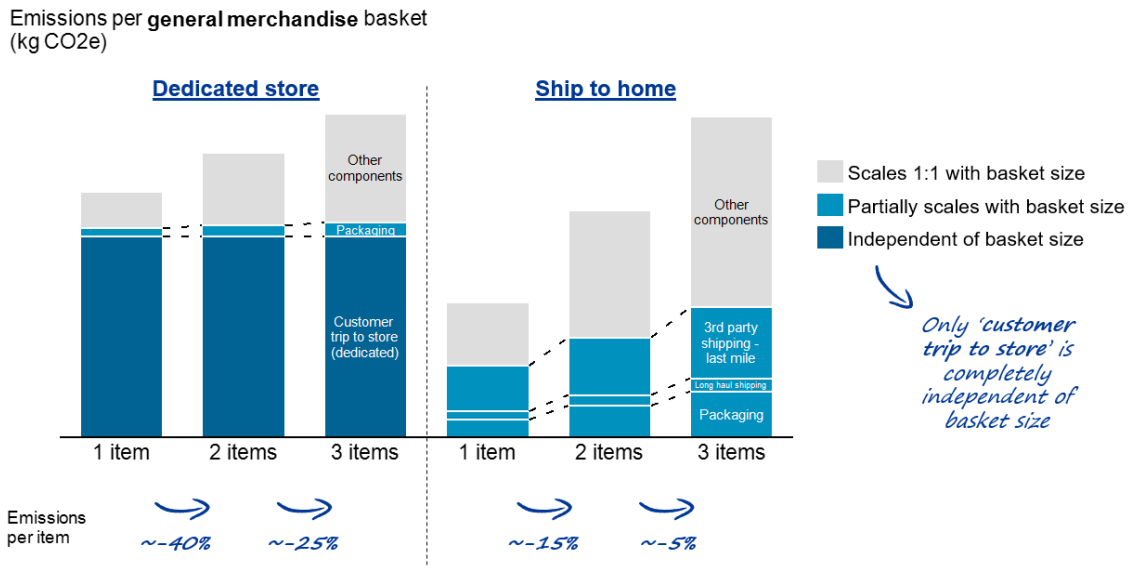
single item are higher and comparable to making a dedicated trip to the store.

With larger baskets, purchases become more emissions efficient, particularly for dedicated store trips. When customers purchase four or more items, these trips are more emissions efficient than home delivery.

As we move from considering the emissions of a single item to those of a basket, emissions components can behave in one of three ways (see **Figure 3**). Some emissions, like those from a customer's trip to the store, are completely independent of basket size – so as baskets grow, the per-item emissions fall. Others, like the emissions allocation of supply chain movements scale mostly one-to-one with basket size. Finally, some fall somewhere in the middle, increasing as basket size grows, but not at a rate of one-to-one.

Growing basket sizes benefit per-item emissions more for dedicated store trips than e-commerce. This is because the independent store trip acts like a 'fixed carbon cost' that scales as the basket grows. Buying two items instead of one reduces per-item emissions of the dedicated store trip by about 40%. Ship to home benefits from larger baskets as well, though per-item emissions don't drop quite as quickly: buying two items instead of one reduces per-item emissions by about 15%.

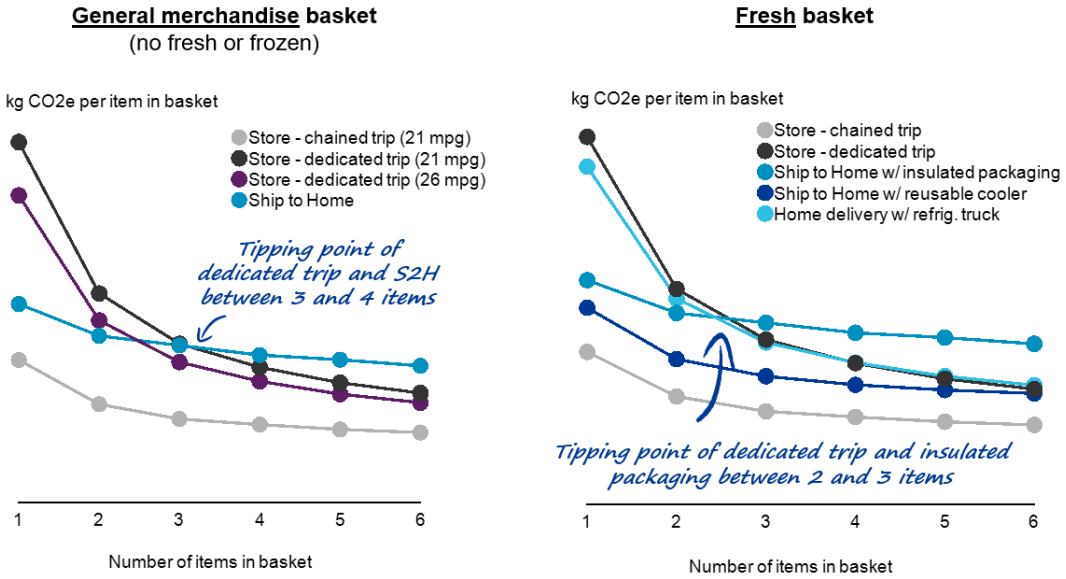
Figure 3: How emissions are impacted by basket size



The prevalence of split shipments is one of the reasons that increasing basket size doesn't drop per-item emissions as quickly for ship to home as for a dedicated store trip. With every additional item added to a basket, the likelihood of a split shipment increases. When items are shipped separately, potential packaging and shipping efficiencies disappear. Our analysis accounts for the fact that for e-commerce companies, multi-item baskets are sometimes, but not always, shipped separately. This means that larger baskets do see some efficiencies (see "emissions per item" in **Figure 3**), but less than if orders were never split.

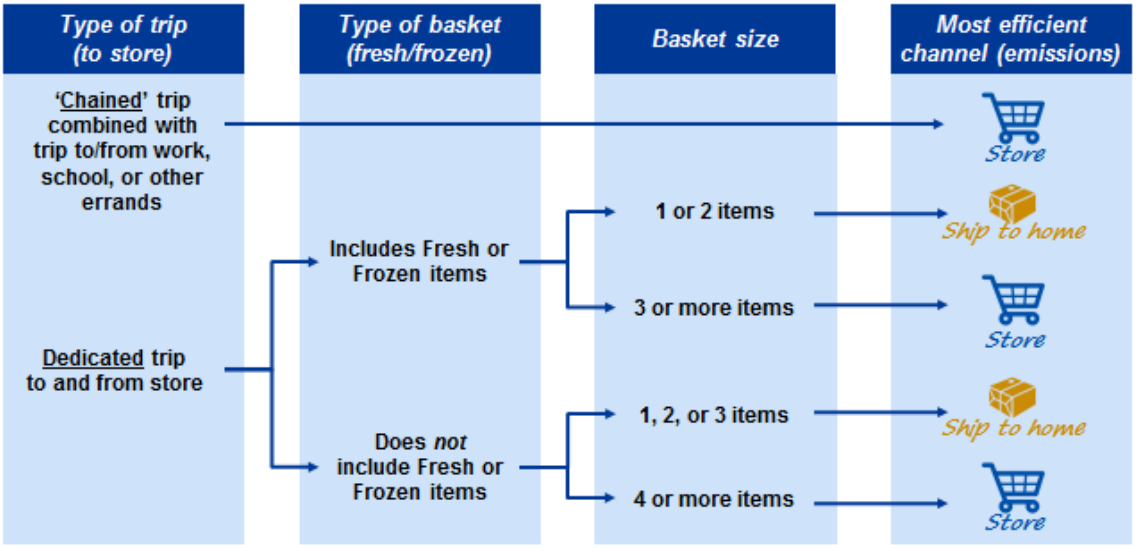
A dedicated trip to store for non-refrigerated items becomes more emissions efficient than shipping to home when four or more items are being purchased (see **Figure 4**), based on today's industry averages for split shipments. When we consider cars with better fuel efficiency (the purple line in **Figure 4**), this tipping point drops to three or more items.

Figure 4: "Tipping points" of lower emissions channel by basket size



The combination of these three factors—the type of trip, the inclusion of fresh or frozen items, and basket size—shape the answer to our original question: *When is each retail channel most efficient in terms of emissions?* **Figure 5** summarizes these conditions.

Figure 5: Pure store and e-commerce comparison by combination of factors



It is also important to note that **these outcomes generally hold regardless of whether a customer is in a rural or more urban area.** Urban customers require less incremental mileage for last-mile delivery (one tenth of a rural customer), but these customers' trips to stores are also shorter (one fifth of a rural customer). Urban store purchases would be even more emissions efficient if we included the benefits of public transportation, not incorporated in the scope of this analysis.

As a result, it holds generally true, regardless of where customers live, that store trips are more emissions efficient if the trip is chained or the basket is large, and ship to home is more emissions efficient for small baskets when the customer would otherwise make a dedicated trip.

Some purchase occasions are more emissions efficient and convenient through e-commerce. But overall, looking across a customer's occasions, shopping only in stores is much more emissions efficient than only through e-commerce.

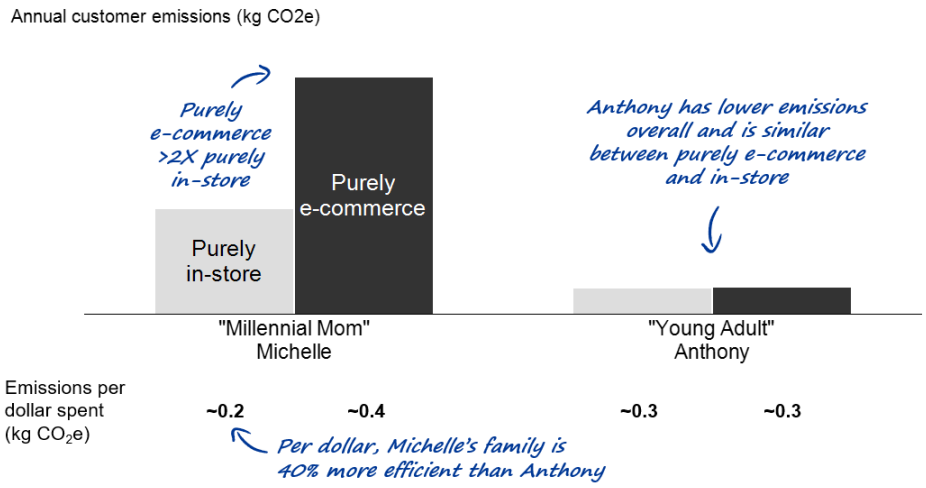
To understand the impact of a pure brick and mortar versus a pure e-commerce purchase pattern, consider two customers:

First, **meet Michelle**, a millennial mom who shops for a family of four. Michelle's behavior is representative of how most families in America shop. She makes a trip to the store each week for a big stock-up of diapers, formula, and groceries, purchasing about 20 items. Most weeks she also makes a purchase of just one item, either something forgotten or to fill an unexpected need. She makes an extra store trip every other month for less frequent or special occasion purchases, like holiday shopping. Michelle usually makes her shopping trip on the way home for work or while she is out at the bank or getting gas, so most of her trips are chained.

Second, **meet Anthony**, a young adult who is living alone, buys primarily for himself, and eats out a lot. Anthony is a niche low-spend consumer, representative of a shopper whose most emissions efficient channel is often ship to home. He will do a stock-up trip every couple months, but Anthony is not a big cook, so he rarely buys groceries that are fresh or frozen. Every couple weeks he tends to make another purchase, either a new shirt for work or a new video game. These tend to be small, mission-specific purchases, so he will either buy online or make a dedicated trip to the store. Most of his store trips are dedicated.

Our analysis shows that serving Michelle purely through stores is more than twice as efficient in terms of emissions as purely through e-commerce because she makes so many stock-up trips. Contrast that with Anthony for whom the tradeoff is much closer. Note that Michelle's family consumes much more—about six times Anthony's total spending—but does so more efficiently, with only about three times Anthony's emissions (see **Figure 6**).

Figure 6: Customer archetypes by purely store and purely e-commerce



However, there are options beyond pure brick and mortar and pure e-commerce that can offer customers greater convenience with similar or even lower emissions.

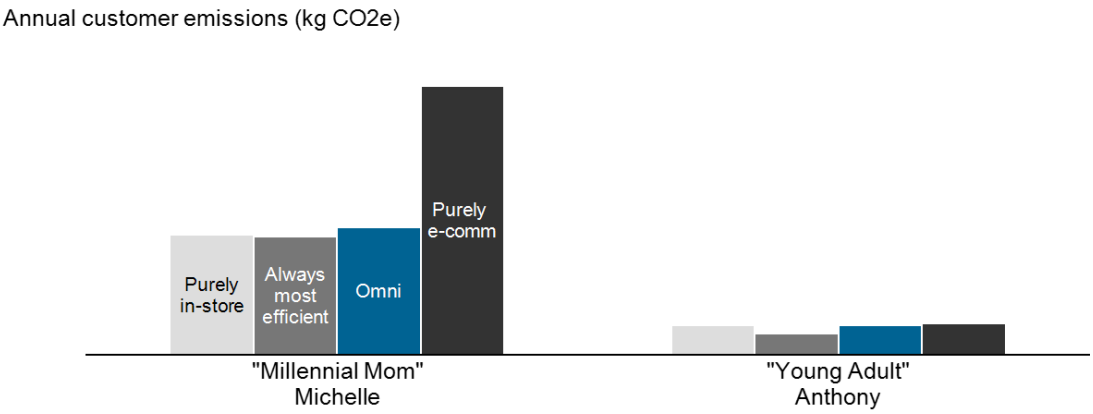
Let's paint the hypothetical picture of customers always choosing the most efficient channel for their purchase in terms of emissions. For instance, take Anthony. If he *always* chose the most efficient channel, making his small non-grocery purchases on Walmart.com and his stock-up purchases at a

Walmart store, his total emissions would instead be lower than if he purchased only from one channel (see “always most efficient” in **Figure 7** below). The same is true for Michelle.

But always choosing the lowest carbon shopping option may compromise convenience. What if Anthony does not have time today to stock up on groceries in-store, or Michelle does not have time to pop by for that item she forgot over the weekend? Options like home grocery delivery and in-store pickup offer more flexibility.

So envision that about once a month Michelle has her big weekly grocery stock-up delivered to her home. She also starts ordering about half of her one-off purchases to her home so she does not have to make a special trip to the store. In other cases, she can choose in-store pickup options to ensure the item is available before making the trip. With these choices, Michelle is receiving about 20% of her purchases to her home but with only a 5 to 10% increase in her total carbon footprint (see “omni” in **Figure 7** below). Michelle is experiencing **omnichannel optionality** that is significantly more convenient but with only slightly higher emissions. When Anthony modifies his shopping behavior to take advantage of omnichannel optionality, his increase in total carbon footprint is negligible.

Figure 7: Customer archetypes including omnichannel convenience



Considering these many variables, omnichannel retailing provides the best opportunity to serve the customer efficiently today and looking forward when it comes to emissions.

We acknowledge that emissions profiles will change over time, and we believe these improvements will impact both brick and mortar and e-commerce channels. Vehicles are becoming more efficient, and more of the energy we use at Walmart is coming from renewable sources. These two factors alone could lower average per-item brick and mortar emissions by nearly 10% in the next 5 to 10 years. For e-commerce, delivery vehicles are also getting more efficient and distribution networks are reaching scale. The impact of these changes could reduce average e-commerce emissions by nearly 15% in the same window of time. As a result, we would expect the “tipping points” may move slightly on basket size but our structural conclusions will still hold: Stores will remain a more efficient channel when trips are chained and baskets are built, and e-commerce will remain more efficient for small baskets otherwise purchased on dedicated trips when it comes to emissions.

Both today and with these changes in the future, omnichannel behavior offers comparable emissions but with superior customer experience. As customers continue to seek out unprecedented levels of convenience and flexibility, we believe it is the omnichannel retailers who will be best positioned to develop lower carbon operations.

IMPLICATIONS

What do these observations mean for retailers and customers? There are two important conclusions:

- **An omnichannel model offers the greatest potential for emissions efficient retailing** because it provides the flexibility to serve the customer in an efficient way. An omnichannel approach combines more carbon efficient operations with customer convenience. This will become increasingly important as customer preferences change.

- **Retailers have many opportunities to make their operations even more sustainable, across channels.** They can encourage customers to adopt lower-carbon shopping behaviors and make internal operations as emissions efficient as possible.

We can encourage our customers to behave in a more sustainable way…

Let's **make our stores hubs of convenience**. We have a large network of stores nearby most American families. Customers today can effectively 'chain' multiple errands at a Walmart store. By continuing to make our stores ecosystems where customers can stock-up on groceries, pick up an online order, cash a check, and cross other items off the to-do list, we can deliver our customers unprecedented convenience all while helping them consolidate trips and miles.

Let's encourage **larger in-store baskets and smarter online baskets**. We can aim to remind customers of their staples, so they won't forget items and make dedicated trips for them later on. We can leverage technology like Jet's "smart cart", which adjusts pricing in real-time, to encourage baskets that will ship from a single location. Or we can alert customers when separate deliveries will be required for their basket, and suggest similar products that could ship together.

Let's also continue to innovate the delivery model for **refrigerated items and large baskets**. We can aim to use the most sustainable packaging options available for shipping fresh or frozen items, and we can point customers to in-store pickup for large orders.

…and we can optimize our operations to serve the customer.

Let's **minimize packaging and last-mile delivery**. We can mirror inventory, ensuring we have our most popular items in every distribution center, so that split shipments are rare. We can aim to choose shipping locations dynamically to minimize distances travelled. We can aim to minimize packaging by optimizing box sizing or even investing in custom boxing technology. We can even try to avoid traditional parcel delivery altogether: models such as drone delivery are low-carbon, and models like crowd-sourced delivery (such as Uber and Lyft) don't require shipping packaging.

What if the entire retail industry increased the use of carbon-efficient options like these? We are excited to imagine the possibilities and to do our part in making them a reality.

APPENDIX: Methodology overview

Our analysis is based on a combination of internal Walmart US and Walmart.com US data, external data, primary research, and estimates or assumptions.

Our emissions analysis includes all direct and indirect emissions from Walmart's own US operations (often referred to as Scope 1 and 2 emissions), as well as emissions from customer and parcel carrier travel (components of Scope 3 emissions).

Timing: Unless otherwise indicated, our findings reflect industry and Walmart US data from Walmart's fiscal year 2016.

Scope: Our analysis considers Walmart and Walmart.com in the US. Sam's Club is not included.

Unit of measure: We measure emissions in carbon dioxide equivalents, or CO_2e, a standard that allows us to convert different sources of emissions into a single measure of equivalent climate change[2] impact (for example, making a kilogram of cardboard or burning a gallon of gasoline).

The flow path: We include emissions incurred from the point an item leaves the supplier (for domestic suppliers) or from the US point-of-entry (for international suppliers). We include getting the item to the customer's home, calculating the customer's trip to the store and back. In addition, we include returns to the point of a returns center.

Sources of emissions:

- **Facilities:** Facility emissions include electricity, on-site fuel sources (e.g., propane, natural gas), and refrigerants for our network of stores, distribution centers, and data centers.

- **Packaging:** We include the carbon footprint from producing packaging (e.g., raw material acquisition, manufacturing, transportation). We do not include the impact of deforestation or carbon sequestration. We include packaging used for transport (e.g., pallets), in-store packaging (e.g., shopping bags), and shipping packaging used to ship to a customer's home. We do not include an item's 'primary packaging', the box it comes in, as this is provided by the supplier and is the same regardless of delivery method or channel. We assumed the current US industry mix of virgin vs. recycled fiber in raw material to account for the benefit of recycling.

- **Mobile:** Mobile emissions are the result of fuel burned during the transport of goods. We estimate these emissions based on the distance traveled, capacity, and fuel economy of the vehicle (e.g., air, rail, freight truck, parcel delivery truck). We used actual locations, distances, and capacity utilization to estimate these mobile emissions.

  Importantly, we also include the emissions from the customer driving their personal vehicle to and from the store. These trips are either dedicated (directly to and from Walmart, with no other stops) or chained (part of a trip that involves at least one other stop). Our research suggests that the majority of customers report that trips are chained. However, it is also important to consider the emissions of dedicated trips, because customer trip emissions can be three times higher in this case.

[2] Our analysis uses Environmental Protection Agency (EPA) emissions conversion factors to convert different sources of emissions into carbon dioxide equivalents (CO_2e)

Approach for estimating emissions: To calculate the emissions created by delivering an order through a given channel, we start by calculating emissions created to deliver a single unit through that channel. From there, we identify which emissions sources scale over a basket (e.g., the customer drive to the store should be applied only once) versus those that accrued for each item (e.g., the electricity on the building to support that item).

Some emissions components scale in part. For instance, an e-commerce delivery to your home with three items will have more packaging than a single-item purchase, but not three times as much. For the last mile of that same purchase, a parcel delivery service may deliver it in a single delivery or in two or three separate shipments depending on the nature of the items and where they were stored. As a result, split shipments become a key lever affecting e-commerce emissions.

How we group items: We evaluated different category groups based on similar characteristics in terms of size, price point, returns rate, and whether they require refrigeration. The six categories we identified were: fresh, frozen, dry grocery and consumables, apparel, electronics, and other general merchandise. We often cite general merchandise in our analysis, as it is representative of the shelf-stable categories, and we use fresh for those that require refrigeration.

How we refer to channels: We cite a number of ways customers might shop and receive purchases. Specifically, we include six current Walmart channels:

- **Store:** Customer drives to a store, shops, and drives home with purchases
- **In-store pickup:** Customer shops online for items that are in store inventory; store associates gather the items; she drives to the store to claim purchases
- **Shipped from store:** She shops online; a store associate gathers items from her local store; items are delivered to her home
- **Ship to home (owned inventory):** She shops online; Walmart ships item from its online inventory; UPS, FedEx, USPS, or other parcel carrier delivers to home