Efficiency and Emissions Impact of Last Mile Online Delivery in the U.S.

Prepared For :

CHAMBER OF PROGRESS

Prepared By:

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FOURTH ECONOMY
A Steer Company

About Chamber of Progress

Chamber of Progress is a tech industry coalition devoted to a progressive society, economy, workforce, and consumer climate. We back public policies that will build a fairer, more inclusive country in which all people benefit from technological leaps.

The following report on online delivery emissions is an independent report commissioned by Chamber of Progress and developed by Steer and Fourth Economy.

About the Consultants
Working across cities, infrastructure, and transportation, Steer is a global transportation consultancy that combines commercial, economic, technical, and planning expertise to find powerful answers to our clients' complex questions. Fourth Economy is a national strategy firm focused on community and economic development. We partner with communities and organizations, public and private, who are ready for change to equip them with tools and innovative solutions to build better communities and stronger economies.

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Report Published July 2024

Report Contents

About the Project

The rise of e-commerce activity over the last decade has significantly influenced the demand for deliveries in the U.S. including takeouts, groceries, and online purchases. There are a range of benefits and challenges associated with the e-commerce market and last mile delivery. Through improved efficiencies, compared to individual consumers traveling to stores, e-commerce has the potential to decrease vehicle miles traveled and carbon emissions. This study evaluates the potential efficiency and carbon emissions savings impact of online delivery services including takeout services, grocery delivery, and online purchases in the U.S. The study helps determine the scale of emissions benefits of last mile delivery services and can assist lawmakers looking to develop ways to facilitate or regulate last mile delivery services, or meet emissions targets.

As a base case, this project considers last mile online delivery vs. in-person trips by car across retail, grocery, and restaurant purchases.

Factors Not Considered in this Study

This study considers vehicle miles traveled and emissions associated with last mile delivery services. It does not account for any emissions associated with other aspects of the supply chain, like first or middle mile transportation. Likewise, it does not consider the emissions impacts of the products or packaging.

Key Findings

The results of this study suggest that online delivery has the potential to be more efficient than in-person shopping trips by car. These findings are consistent with a recent MIT study that found **online shopping to be more sustainable than traditional retail in more than 75% of the scenarios developed by the researchers.**[1]

This study evaluates the potential efficiency and carbon emissions savings impact of online delivery services in the U.S. As a base case, this project considers last mile online delivery vs. in-person trips by car across retail, grocery, and restaurant purchases. Analysis suggests that online delivery is more efficient when the delivery method includes operational efficiencies like making multiple deliveries in a single trip, route optimization, and the use of efficient vehicles.

- **E-Commerce** deliveries are able to capitalize on operational efficiencies like batching and smart routing. These deliveries are 2.3x to 2.7x more efficient than individual consumer trips and can save up to 1,416 miles of travel and 62 gallons of gas per 1,000 items.

- **Batched grocery** deliveries are efficient when they can pool and fulfill multiple orders with a single delivery. These deliveries are 1.1x to 1.5x more efficient than individual consumer trips and can save up to 300 miles of travel and 13 gallons of gas per 1,000 items.

- **Instant delivery** is efficient when deliveries can be made by efficient vehicles, like bicycles and e-bikes. These deliveries are 0.9x to 1.1x more efficient than individual consumer trips and can save up to 53 miles of travel and 13 gallons of gas per 1,000 items.

The emissions savings from online delivery could be significant – for cities, states, and the U.S. as a whole.

- A household that replaces car trips with online fulfillment could experience annual savings of up to **5.9 gallons of gas saved and 133 fewer miles driven per household**.

- If half of U.S. households experienced these reductions, the **potential annual emissions savings for last mile online delivery are equivalent to a day's worth of gasoline usage for the U.S. as a whole.**[2]

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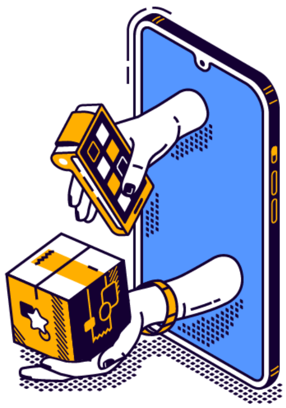
[1] Retail Carbon Footprints: Measuring Impacts from Real Estate and Technology | MIT Real Estate Innovation Lab
[2] Use of gasoline | U.S. Energy Information Administration

When is online delivery more efficient than individual consumer trips?

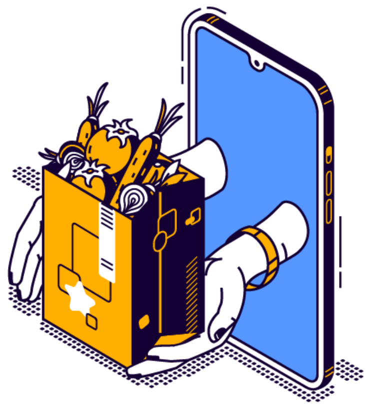
Analysis suggests that online delivery is more efficient when the delivery method includes operational efficiencies like making multiple deliveries in a single trip, route optimization, and the use of efficient vehicles. Deliveries can range from point-to-point (e.g. third-party delivery from a restaurant to an individual household) vs. point-to-many-points (e.g. groceries delivered to multiple households or e-commerce retail delivered to multiple households) with efficiencies varying by delivery service.



E-Commerce

Non-perishable goods are delivered via carrier using a delivery van or fleet vehicle. Multiple deliveries are made per trip as a route consists of multiple households.

E-Commerce deliveries are able to capitalize on operational efficiencies like **batching and smart routing.**



Batched Grocery

Perishable and non-perishable goods are delivered from grocery stores either directly by the grocer or through a third-party app. Both services typically deliver to multiple households per trip.

Delivery horizons can span from same-day to next-day delivery, which allows the store or a third-party to **pool and fulfill multiple orders with a single delivery.**

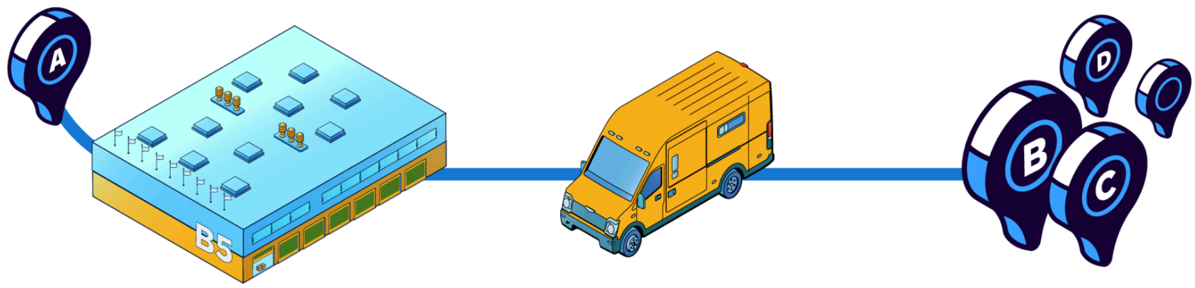
Instant Delivery

This on-demand delivery service provides instant delivery. Prepared foods and convenience items are delivered directly to the consumer typically as an individual order.

Orders are processed quickly, with limited ability to batch or deliver multiple orders at a time. Instant delivery is efficient when deliveries can be made by **efficient vehicles like bicycles and e-bikes.**

Overview of Last Mile Online Delivery Services

E-Commerce



The e-commerce retail category includes deliveries of purchases of non-perishable items. In the U.S., last-mile delivery in this category is handled via carriers like Amazon, UPS, FedEx, and United States Postal Service (USPS). These services operate large distribution and warehousing networks to fulfill retail orders. For last mile delivery, these companies or their subcontractors typically operate delivery vans with a capacity of 200-300 packages delivered in batches, with a single route serving around 180 to 200 customers.

Examples: Amazon, UPS, FedEx, USPS

1-2
Average items per delivery

10+
Average fleet MPG

180 - 200
Average deliveries per trip

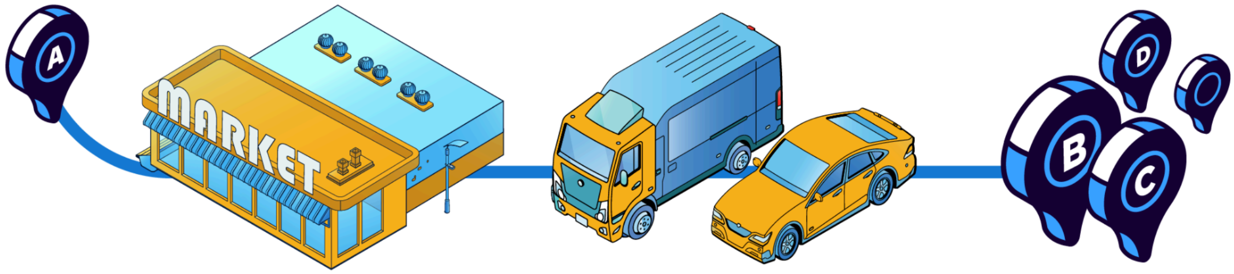
2.3x to 2.7x
more efficient than individual consumer trips

Up to
1,416 mi.
of travel saved per 1,000 items

Up to
62 Gal.
of gas saved per 1,000 items

Data Source: Steer and Fourth Economy Analysis of Last Mile Online Delivery.
See the Appendix for a more detailed discussion of sources and methodology.

Batched Grocery | Third-Party Delivery and Direct from Grocer



Third-Party Delivery: A third-party app like Instacart or Shipt will dispatch contractors to purchase food or other items on behalf of the consumer. Deliveries are made using personal vehicles, with drivers incentivized to use more efficient vehicles that are less expensive to operate. While not offering almost instantaneous delivery like food takeout services, these deliveries can occur during the same day or at a pre-scheduled time, and allow for batching.

Examples: Instacart, Shipt

Direct from Grocer: This delivery type uses refrigerated vans operated by the grocery store or partner vendor to fulfill grocery orders. Delivery horizons can span from same-day to next-day delivery, which allows the store to pool and fulfill multiple orders with a single delivery.

Examples: FreshDirect, Kroger Direct, Peapod

10-20
Average items per delivery

7+ | 22+
Average fleet MPG

3-20
Average deliveries per trip

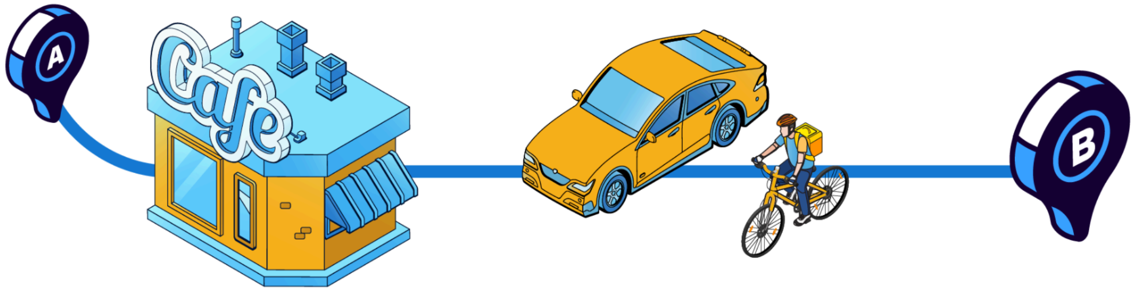
1.1x to 1.5x
more efficient than individual consumer trips

Up to
300 mi.
of travel saved per 1,000 items

Up to
13 Gal.
of gas saved per 1,000 items

Data Source: Steer and Fourth Economy Analysis of Last Mile Online Delivery.
See the Appendix for a more detailed discussion of sources and methodology.

Instant Delivery



Third-party delivery services like Uber Eats, Grubhub, and DoorDash act as intermediaries between restaurants or convenience stores and customers, providing a convenient way for people to order food. This on-demand delivery service provides instant delivery for takeout, food, and other convenience items. Orders are processed quickly, with limited ability to batch or deliver multiple orders at a time. The convenience of instant delivery options may generate food orders that would not otherwise occur, which could result in increased miles traveled and emissions. However, instant deliveries can be more efficient than in-person trips when the mode of transportation used to make the delivery is more efficient than the mode of transportation it replaces. In dense U.S. cities, roughly half of instant deliveries are made by bike or e-bike. In less dense areas, the majority of deliveries are made using personal vehicles, with drivers incentivized to use more efficient vehicles that are less expensive to operate.

Examples: DoorDash, Grubhub, Uber Eats

1-2
Average items per delivery

22+
Average fleet MPG

1-2
Average deliveries per trip

0.9x to 1.1x
more efficient than individual consumer trips

Up to
53 mi.
of travel saved per 1,000 items

Up to
2 Gal.
of gas saved per 1,000 items

Data Source: Steer and Fourth Economy Analysis of Last Mile Online Delivery.
See the Appendix for a more detailed discussion of sources and methodology.

Factors that Influence Efficiency of Online Delivery

Online deliveries have the potential to reduce vehicle miles traveled and emissions compared to individual consumer trips due to several factors. These factors include **operational efficiency, consumer behavior, and market density.**

Operational Efficiency

Across delivery types, operational efficiency will vary depending upon several factors including:

- **Multiple deliveries or batching** - Online deliveries are often grouped together and delivered in batches, with a delivery vehicle making multiple deliveries in a single trip.
- **Routing** - With multiple delivery and/or pickup locations, routing software can direct drivers to take the most efficient routes to fulfill orders.
- **Vehicle fleet** - When last mile delivery companies own or operate their vehicles, they choose more efficient vehicles that are less costly to maintain and operate, with many operators transitioning to electric vehicle fleets.

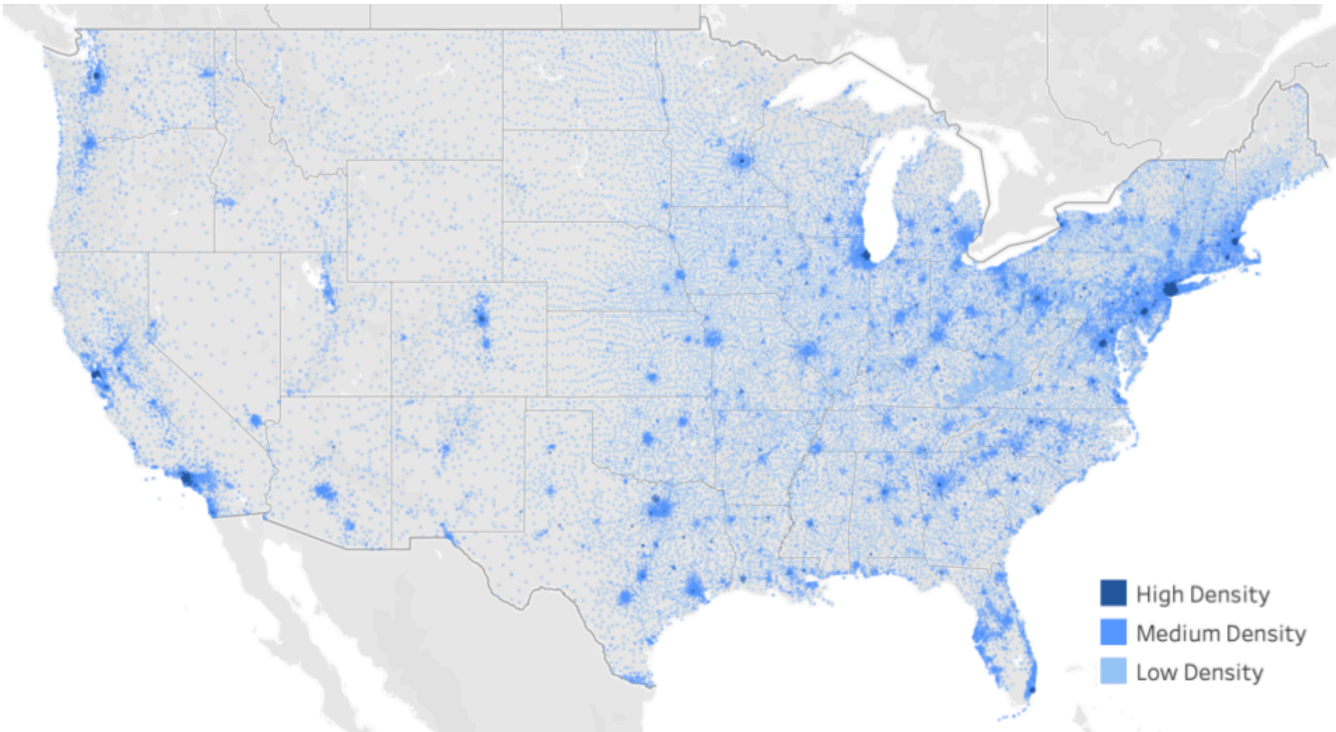
Consumer Behavior

In addition to factors specific to how online delivery companies operate, consumer behavior also influences efficiency. Factors related to consumer behavior include:

- **Basket size** - Consumers may order a different number of items at a time from online compared to in-person shopping.
- **Returns** - Online purchases may have a higher likelihood of being returned than those purchased in-store.
- **Trip chaining or grouping errands** - Consumers often group shopping errands or other activities into one trip, instead of returning home in between each one.
- **Induced demand** - In some circumstances, the convenience of online ordering may increase demand for products or services, also known as induced demand.

Market Density

The final piece of the puzzle is market density. Density of deliveries will affect efficiency in obvious ways (the closer the deliveries are to each other and to distribution points, the fewer miles traveled) and less obvious ways (high density areas open up possibilities for deliveries to be made by bicycle, e-bike, or other personal or shared low-emissions means of transportation).



Data Source: Steer and Fourth Economy Analysis of Household Density (2024)

As illustrated by the map above, the majority of U.S. land area is low density, but the majority of households and delivery points fall within medium density areas. This study adopts an approach to density used by the United States Postal Service Office of Inspector General which classifies areas as high density, medium density, or low density based on population size along a rural-urban spectrum and density of delivery points. Only a handful of areas are considered high density. Examples of areas that fall within each density type are listed below:

Examples of Places within each Density

High Density

- New York, NY
- San Francisco, CA
- Boston, MA
- Miami, FL
- Chicago, IL
- Philadelphia, PA
- Washington, DC

Medium Density

- Los Angeles, CA
- Baltimore, MD
- Atlanta, GA
- Houston, TX
- Phoenix, AZ
- Indianapolis, IN
- Kansas City, MO
- Oklahoma City, OK

Low Density

- Somerset County, ME
- Callaway County, MO
- La Plata County, CO
- Hill County, TX

Delivery Points and Density

	High Density	Medium Density	Low Density
Total Delivery Points	9,193,514	107,751,376	21,224,156
Share of Total Delivery Points	**7%**	**78%**	**15%**
Share of U.S. population	6%	76%	16%
Share of U.S. land area	0.04%	14%	86%

Data Source: Package Delivery in Rural and Dense Urban Areas | USPS Office of the Inspector General (2020)
See the Appendix for a more detailed discussion of Density.

The majority of U.S. online deliveries are made to customers who live in suburbs, towns, and cities that are medium density: **78% of all delivery points fall within medium density areas.**

Online Delivery Coverage and Density

	High Density	Medium Density	Low Density
E-Commerce	Yes	Yes	Limited Coverage
Batched Grocery	Yes	Yes	No
Instant Delivery	Yes	Yes	No

Data Source: Steer and Fourth Economy Analysis of Online Delivery Service Offerings (2024)

While all types of online delivery operate in high density places, some online delivery services do not, at the moment, operate in low density or rural areas. For example, low density areas are typically not serviced by instant delivery and batched grocery deliveries.

Potential Annual Household Emissions Savings and Density

	High Density	Medium Density	Low Density	Blended Rate
Gallons of Gas Saved	3.6	5.9	4.7	5.5
Miles Not Driven	81	133	108	126

Data Source: Steer and Fourth Economy Analysis of Emissions Savings (2024)

A household in a medium density location that replaces car trips with online fulfillment could experience annual household emissions savings of up to 5.9 gallons of gas saved and 133 fewer miles driven. These savings are based on a household that orders retail 48 times per year, takeout 24 times per year, and grocery 12 times per year. For reference, the average Amazon shopper makes 76 purchases per year;[3] 26% of U.S. adults order takeout or delivery at least 52 times per year;[4] 28% grocery shop online at least 12 times per year.[5] Additionally, the rise of subscription services is fueling the appeal and growth of e-commerce delivery.[6]

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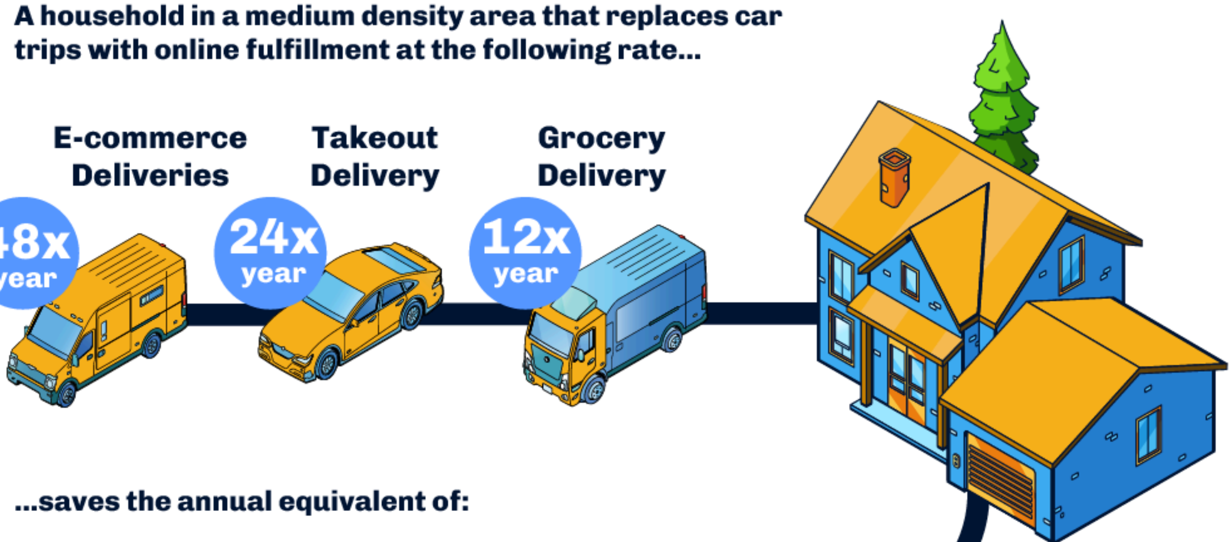
[3] How Many Orders Does Amazon Get & Deliver per Day? | Capital One
[4] Restaurant takeout and delivery are taking a bite out of dine-in traffic | Nation's Restaurant News
[5] Online Grocery Shopping Statistics | Capital One
[6] Everything's becoming a subscription | Washington Post

Potential Emissions Savings

1 A household in a medium density area that replaces car trips with online fulfillment at the following rate...

E-commerce Deliveries	Takeout Delivery	Grocery Delivery
48x year	24x year	12x year



2 ...saves the annual equivalent of:

5.9 Gallons of Gas

133 Miles Not Driven

3 multiplied by 100,000 households...

x100,000

4 this adds up to:

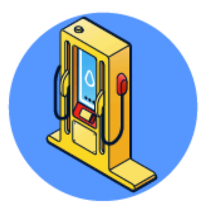
585,000 Gallons of Gas Saved

5 or the emissions equivalent of:

2,850 tons of coal not burned

6,070 acres worth of annual carbon sequestration by U.S. forests

258 garbage trucks worth of waste recycled instead of landfilled



13.3 Million miles not driven in a gas-powered car

Potential Emissions Savings by State

The chart below summarizes the potential statewide and U.S. savings for gallons of gas saved and miles not driven if half of all households replace car trips with online fulfillment for a retail order 48 times a year, takeout 24 times a year, and grocery 12 times a year.

Annual statewide emissions savings from online delivery could be significant. Added together, the **potential annual emissions savings for last mile online delivery are equivalent to a day's worth of gasoline usage for the U.S. as a whole.**[7]

	Households	Gallons of Gas Saved	Miles Not Driven
Alabama	2,297,000	6,317,000	144,706,000
Alaska	326,000	897,000	20,550,000
Arizona	3,098,000	8,519,000	195,159,000
Arkansas	1,372,000	3,772,000	86,418,000
California	14,424,000	39,667,000	908,740,000
Colorado	2,500,000	6,875,000	157,506,000
Connecticut	1,531,000	4,211,000	96,474,000
Delaware	452,000	1,242,000	28,448,000
Florida	9,916,000	27,269,000	624,705,000
Georgia	4,427,000	12,174,000	278,887,000
Hawaii	561,000	1,542,000	35,335,000
Idaho	759,000	2,087,000	47,809,000
Illinois	5,427,000	14,925,000	341,923,000
Indiana	2,932,000	8,062,000	184,698,000
Iowa	1,417,000	3,897,000	89,275,000
Kansas	1,279,000	3,516,000	80,549,000
Kentucky	1,999,000	5,498,000	125,950,000
Louisiana	2,080,000	5,721,000	131,063,000
Maine	742,000	2,040,000	46,734,000
Maryland	2,531,000	6,960,000	159,458,000
Massachusetts	2,999,000	8,248,000	188,957,000
Michigan	4,580,000	12,596,000	288,568,000
Minnesota	2,494,000	6,858,000	157,119,000

[7] Use of gasoline | U.S. Energy Information Administration

Mississippi	1,325,000	3,644,000	83,474,000
Missouri	2,795,000	7,686,000	176,087,000
Montana	517,000	1,423,000	32,598,000
Nebraska	848,000	2,332,000	53,425,000
Nevada	1,288,000	3,543,000	81,166,000
New Hampshire	640,000	1,761,000	40,341,000
New Jersey	3,756,000	10,330,000	236,649,000
New Mexico	943,000	2,594,000	59,418,000
New York	8,494,000	23,360,000	535,150,000
North Carolina	4,740,000	13,035,000	298,613,000
North Dakota	372,000	1,024,000	23,460,000
Ohio	5,251,000	14,441,000	330,826,000
Oklahoma	1,752,000	4,817,000	110,364,000
Oregon	1,819,000	5,001,000	114,572,000
Pennsylvania	5,754,000	15,823,000	362,496,000
Rhode Island	483,000	1,328,000	30,432,000
South Carolina	2,362,000	6,496,000	148,822,000
South Dakota	397,000	1,091,000	24,987,000
Tennessee	3,051,000	8,390,000	192,204,000
Texas	11,655,000	32,051,000	734,263,000
Utah	1,163,000	3,197,000	73,247,000
Vermont	335,000	922,000	21,114,000
Virginia	3,625,000	9,970,000	228,393,000
Washington	3,216,000	8,845,000	202,623,000
West Virginia	859,000	2,363,000	54,126,000
Wisconsin	2,735,000	7,520,000	172,274,000
Wyoming	273,000	752,000	17,217,000
U.S. Total	**140,591,000**	**386,632,000**	**8,857,372,000**

Data Source: Steer and Fourth Economy Analysis of Emissions Savings (2024) and U.S. Census Data (2022)

Conclusion

While many factors across operational efficiency, consumer behaviors, and market density influence the efficiency of online delivery, the results of this study suggest that online delivery can be more efficient than in-person shopping trips by car. These findings are consistent with a recent MIT study that found online shopping to be more sustainable than traditional retail in more than 75% of the scenarios developed by the researchers.[8] These results point to the scale of emissions benefits of e-commerce delivery to lawmakers looking to develop ways to facilitate or regulate last mile delivery services, or meet emissions targets.

Facing declining gas tax revenue and budget shortfalls, many states have been exploring alternative sources for transportation funding. One alternative that has been proposed in a number of states is to impose a fee on retail delivery services–often in the form of a per-package or per-order fee. As of June 2024, only Colorado[9] and Minnesota[10] have actually implemented such fees, but proposals have been considered in Maryland[11] and New York,[12] and Washington and Pennsylvania have commissioned studies to explore the idea. Colorado's fee applies broadly to all categories of delivery, while Minnesota's applies only to qualifying orders over $100. Minnesota's fee exempts deliveries from food and beverage establishments, as well as food, food ingredients, and prepared foods – essentially, for purposes of this study, exempting Instant Deliveries, most Batched Grocery orders, and small E-Commerce orders.[13]

Proponents of delivery fees argue that delivery services, particularly those that use vans or heavy trucks, cause more roadway and environmental damage, and therefore should bear more of the cost of infrastructure funding.[14] All of the states that have either implemented or explored the idea of delivery fees have also adopted emissions reduction goals.[15] However, as this study makes clear, delivery services can play an important role in reducing vehicle miles traveled and emissions for last mile delivery compared to individual trips. While the vehicles used for e-commerce and some batched grocery orders are larger and often, currently, less fuel-efficient than personal cars, the improvement of batching systems and route optimization technology actually make them more energy efficient than individual trips. Lawmakers looking to balance future transportation funding options with emissions reduction targets should look closely at these results and consider the implications of raising the cost of delivery services, which risks incentivizing individual trips rather than more efficient delivery options.

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[8] Retail Carbon Footprints: Measuring Impacts from Real Estate and Technology | MIT Real Estate Innovation Lab
[9] Colorado Revised Statutes (C.R.S.) §43-4-218
[10] Minnesota Statutes Chapter 168E. Retail Delivery Fee
[11] Maryland HB 1215
[12] New York AB 3009
[13] Delivery Fees – A New Wave in State and Local Tax Considerations | CliftonLarsonAllen
[14] As Retail Delivery Grows, Tax Authorities Look for Their Share of the Revenue | Retail Touchpoints
[15] U.S. State Greenhouse Gas Emissions Targets | Center for Climate and Energy Solutions

Appendix

The Appendix documents assumptions and cites data sources used in the analysis across operational efficiency, consumer behavior, density, and emissions factors.

Primary source data for this analysis include U.S. Census Data, U.S. Energy Information Administration, U.S. Environmental Protection Agency, and U.S. Postal Service Office of Inspector General, and Replica, which provides mobility data associated with trip destination type. Additional data associated with operational efficiency, consumer behavior, and density were identified from academic and industry studies, press releases and news articles, and research. These assumptions were validated through a series of interviews of online delivery operators, with some assumptions coming directly from stakeholder interviews.

As a base case, this project considers last mile online delivery vs. in-person trips by car across retail, grocery, and restaurant purchases.

The model developed for this project calculates distance traveled per item by online delivery across e-commerce, batched delivery, and instant delivery and associated emissions. It then calculates distance traveled and emissions per item by in-person trips for retail, grocery, and restaurant purchases. Finally, the model compares in-person output to the corresponding output from online delivery to determine the level of efficiency of online deliveries compared to in-person trips.

To determine distance traveled and emissions per item, the model incorporates metrics across:

- Operational Efficiency
    - Multiple Deliveries or Batching & Routing
    - Vehicle Fleet & Miles per Gallon
- Consumer Behavior
    - Basket Size or Items per Order
    - Returns
    - Trip Chaining or Grouping Errands
    - Induced Demand
- Market Density
    - Distance - Origin to Households
    - Distance - Between Households
    - Market Density also has impacts on Vehicle Fleet & Miles per Gallon and Trip Chaining or Grouping Errands

The calculation for Distance per Item for Online Deliveries is:

- Distance per Item = Total Distance Traveled by Delivery Vehicle ÷ Total Number of Items Delivered, adjusted for Consumer Behavior Factors, where
    - Total Distance Traveled by Delivery Vehicle = Origin to Households x 2 + Distance Between Households x Number of Deliveries
    - Total Number of Items Delivered = Number of Items per Order x Number of Deliveries
    - Consumer Behavior Factors include Returns and Induced Demand

The calculation for Emissions per Item for Online Deliveries is:

- Emissions per Item = Distance per Item x MPG Vehicle Emissions

The calculation for Distance per Item for Personal Trips is:

- Distance per Item = Total Distance Traveled by Personal Vehicle ÷ Total Number of Items, adjusted for Consumer Behavior Factors, where
    - Total Distance Traveled by Personal Vehicle = Distance Between Households to Destination x 2
    - Total Number of Items = Number of Items per Order
    - Consumer Behavior Factors include Returns and Trip Chaining or Grouping Errands

The calculation for Emissions per Item for Personal Trips is:

- Emissions per Item = Distance per Item x MPG Vehicle Emissions

Operational Efficiency

Across delivery type, operational efficiency will vary depending upon several factors including multiple deliveries or batching, routing, and vehicle fleet.

Multiple Deliveries or Batching & Routing

Online deliveries are often grouped together and delivered in batches, with a delivery vehicle making multiple deliveries in a single trip. With multiple delivery and/or pickup locations, routing software can direct drivers to take efficient routes to fulfill orders.

- **E-Commerce**
    - Though numerous e-commerce platforms operate in the U.S. the vast majority of packages are delivered by one of four carriers: Amazon, FedEx, UPS, or USPS.

Delivery is typically made by vans with a capacity of around 200 packages.[16] A typical suburban or semi-urban Amazon Delivery Service Partner driver makes 180 stops and delivers 250-300 packages in a day.[17]

- **Batched Grocery**
  - Third-Party Delivery: For the batch grocery delivery service Instacart, up to three customer orders may be included.[18]
  - Direct from Grocer: A typical refrigerated delivery van can store up to 20 orders.[19]
- **Instant Delivery**
  - These deliveries typically involve the delivery of a single order at a time.
- **Individual Consumers**
  - Individual consumer trips can include trip chaining or grouping errands, which is discussed in more detail below.

Vehicle Fleet & Miles per Gallon

When last mile delivery companies own or operate their vehicles, they choose more efficient vehicles that are less costly to maintain and operate. Drivers using personal vehicles for batched grocery delivery and instant delivery are economically incentivized to drive more efficient vehicles that are less expensive to operate (like sedans) than the mix of personal vehicles across the population as a whole (which includes SUVs, trucks, and sedans).

- **E-Commerce**
  - UPS: Diesel vans average 10.6 mpg.[20] The UPS fleet includes over 18,300 alternate fuel and advanced technology vehicles, including more than 1,000 electric and plug-in hybrid electric vehicles.[21]
  - Amazon: Amazon's fleet has 10,000 electric Rivian vans, and a goal of 100,000 electric Rivian vans by 2030.[22] Presently, the majority of Amazon's branded delivery fleet in the U.S., which at last count stood at more than 70,000, have internal combustion engines.[23] These vehicles include the Ram ProMaster[24] (21

[16] Estimating the Traffic Congestion Footprint of Retail E-Commerce | MIT Center for Transportation Logistics
[17] How Many Orders Does Amazon Get & Deliver per Day? | Capital One
[18] How accessing batches works at Instacart | Instacart
[19] Kroger strengthens home delivery network | Fleet Owner
[20] Thirty-Six Month Evaluation of UPS Diesel Hybrid-Electric Delivery Vans | National Renewable Energy Lab
[21] Electrifying our future | UPS
[22] Amazon's electric delivery vehicles from Rivian roll out across the U.S. | Amazon
[23] Amazon to bolster delivery fleet with all-electric Ram ProMaster vans | TechCrunch
[24] A Day in the Life of an Amazon Delivery Agent | Automotive Fleet

mpg city)[25], Ford Transit[26] (15 mpg city)[27], and Mercedes Sprinter Van[28] (16.8 mpg city)[29]. Amazon is attempting to transition to an all-electric fleet, making electric delivery vehicles a quickly growing part of the overall fleet.
    - USPS: The United States Postal Service has started electric delivery vehicles.[30]
    - FedEx: The FedEx fleet includes 200,000 vehicles, with a pilot program for 150 electric delivery vehicles.[31]
- **Batched Grocery**
    - Direct from Grocer: Emissions from a refrigerated van are 15% to 18% higher than for a standard van.[32] Smaller delivery trucks and vans average 6.8 miles per gallon.[33]
    - Third-Party Delivery: 24.4 miles per gallon for cars.[34]
- **Instant Delivery**
    - Medium Density and High Density: 24.4 miles per gallon for cars.[35]
    - High Density: Bikes and e-bikes are a key part of the vehicle fleet for instant deliveries, with around half of all instant deliveries in high density areas being fulfilled by bike and e-bike. High density areas are served by a mix of cars, bikes, e-bikes, mopeds, and other low-emission vehicles. San Francisco: 21% Electric bike; 27% Bicycle; 48% Car; 4% Walk.[36] New York: 59% use their car, 41% use an e-bike or moped.[37]
- **Individual Consumers**
    - 22.9 miles per gallon blended rate, accounting for share of cars and SUVs.[38]

Consumer Behavior

In addition to factors specific to how online delivery companies operate, consumer behavior also influences efficiency. Factors related to consumer behavior include basket size, returns, trip chaining or grouping errands, and induced demand.

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[25] 2021 Ram Promaster City | FuelEconomy.gov
[26] A Day in the Life of an Amazon Delivery Agent | Automotive Fleet
[27] 2021 Ford Transit T150 Wagon 2WD FFV | FuelEconomy.gov
[28] Amazon orders 20,000 vans for small businesses | Amazon
[29] 2018 Mercedes-Benz Sprinter 2500 MPG | Fuelly
[30] U.S. Postal Service Unveils First Postal Electric Vehicle Charging Stations and Electric Delivery Vehicles | USPS
[31] Charged up about electric vehicles | FedEx
[32] Real-world CO2 and NOX emissions from refrigerated vans | National Institutes of Health
[33] Average Fuel Economy by Major Vehicle Category | Federal Highway Administration
[34] Average Fuel Economy by Major Vehicle Category | Federal Highway Administration
[35] Average Fuel Economy by Major Vehicle Category | Federal Highway Administration
[36] Emerging Mobility Labor Study | San Francisco Local Agency Formation Commission
[37] Journal of Urban Health
[38] Average Fuel Economy by Major Vehicle Category | Federal Highway Administration

Basket Size or Items per Order

Consumers may order a different number of items at a time from online compared to in-person shopping.

- **E-Commerce**
  - Typical e-commerce orders contain one or two products or items. 89% of Amazon orders include 1-2 items.[39]
- **Batched Grocery**
  - A typical online supermarket transaction totals $109; 148% more than the average in-store transaction of $44.[40]
- **Instant Delivery**
  - These deliveries typically involve the delivery of a single order at a time.
- **Individual Consumers**
  - Retail: The average basket size for the traditional retail consumer is 2.6 items.[41]
  - Grocery: A typical online supermarket transaction totals $109; 148% more than the average in-store transaction of $44[42]
  - Restaurant: These typically involve a single order at a time.

Returns

Online purchases may have a higher likelihood of being returned than those purchased in store.

- **E-Commerce and Individual Consumers**
  - According to credit card data, the average retail return rate is 16.6% for E-Commerce and 16.4% for in-store purchases.[43] According to the National Retail Federation, the retail return rate is 17.6% for E-Commerce and 10% for in-store purchases.[44]
- **Batched Grocery and Instant Deliver**
  - Items returned not applicable. An assumption of the model is that Batched Grocery and Instant Delivery items are returned at similar frequency as in-store purchases.

Trip Chaining or Grouping Errands

Consumers often group shopping errands or other activities into one trip, instead of returning home in between each one.

- **E-Commerce, Batched Grocery, Instant Delivery**

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[39] How Many Orders Does Amazon Get & Deliver per Day? | Capital One
[40] Online Grocery Shopping Statistics | Capital One
[41] Retail Carbon Footprints: Measuring Impacts from Real Estate and Technology | MIT Real Estate Innovation Lab
[42] Online Grocery Shopping Statistics | Capital One
[43] Retail Return Rate Statistics | Capital One
[44] 2023 Consumer Returns in the Retail Industry | National Retail Federation

    - Trip chaining is not applicable for online fulfillment of E-Commerce, Batched Grocery, and Instant Delivery.
- **Individual Consumers**
    - Retail and Grocery: Trip chaining provides an estimate of marginal shopping travel, e.g. how much travel is directly attributable to shopping rather than trips on the same tour. To estimate baseline trip chaining, a factor may be suitable but should vary by location. Brown and Guffrida (2014) multiply round-trip travel estimates by a factor to account for trip chaining. They estimate this factor as 0.64.[45] High Density areas experience less trip chaining (by a factor of 0.98) and Low Density areas experience more trip chaining (by a factor of 1.01).[46]
    - Restaurant: These typically involve a single order at a time. No trip chaining is typically present.

Induced Demand

In some circumstances the convenience of online ordering may increase demand for products or services, also known as induced demand.

- E-Commerce and Batched Grocery
    - The model does not assume induced demand for E-Commerce or Batched Grocery. There is some evidence of substitution (a purchase online removes a purchase in-person or vice versa), neutrality (no impact on inducing demand), and some mixed evidence:
        - "Many studies indicate that e-commerce has a potential for increasing sustainability of personal travel through replacing trips to physical stores. Other studies show no impact or a complementary impact of e-commerce on personal travel behavior."[47]
        - "Online grocery shopping had no significant effect on in-store grocery shopping (i.e., neutrality), but those who shopped frequently in-store tended to shop less frequently online (i.e., substitution)."[48]
- Instant Delivery
    - Induced demand for Instant Delivery Apps could be between 10% and 20%, based on sales data comparing pre-and post-implementing mobile app delivery options. Working with a third-party delivery service has been found to raise restaurant sales volume by 10% to 20%.[49]

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[45] A Better Understanding of Shopping Travel in the United States | National Transportation Library, Bureau of Transportation Statistics
[46] Multivariate analysis of trip-chaining behavior | Environment and Planning B: Planning and Design
[47] E-groceries: Sustainable last mile distribution in city planning | Research in Transportation Economics
[48] Investigating e-grocery shopping behavior and its travel effect | International Journal of Transportation Science and Technology
[49] Restaurant takeout and delivery are taking a bite out of dine-in traffic | National Restaurant News

Market Density

Density of deliveries affects efficiency in obvious ways (the closer the deliveries are to each other and to distribution points, the fewer miles traveled) and less obvious ways (high density areas open up possibilities for deliveries to be made by bicycle, e-bike, or other low-emissions means of transportation).

Density

This study adopts an approach to density classification by the United States Postal Service Office of Inspector General (USPS OIG). The USPS OIG created a density classification system to study package delivery in urban, suburban, and rural areas. They classified all ZIP Codes as High, Medium, or Low Density based on multiple criteria, including population size along a rural-urban spectrum and density of delivery points:

> "The Departments of Transportation and Agriculture often use a system called the Rural-Urban Commuting Area (RUCA) code. This system provides 10 codes that determine an area's rurality or urbanity on the size and direction of the largest commuting flow. For this study, the OIG combined RUCA codes with delivery point density are used to classify geographic areas. We opted to categorize geographic areas as High Density, Medium Density, or Low Density rather than urban or rural. The use of High, Medium, and Low Density better conveys the operational challenges faced by delivery companies in certain geographic areas. Although the High Density classification is a rough proxy for urban cores and Low Density is a rough proxy for rural areas, the USPS OIG chose not to use the terms "urban" and "rural" in order to distinguish our definitions from that of other government agencies or general public perceptions.
>
> The classification of ZIP Codes as High Density, Medium Density, and Low Density is as follows:
>
> - ZIPs with a RUCA code of 6 through 10 → Low Density
> - ZIPs with a RUCA code of 1 through 5:
>   - Delivery density ≥ 5000 delivery points per square mile → High Density
>   - Delivery density ≥ 50 but < 5000 delivery points per square mile → Medium Density
>   - Delivery density > 0 and < 50 delivery points per square mile → Low Density"

Distance, Origin to Households

- **E-Commerce**
  - Last mile distribution hubs now extend no farther than six to nine miles away from 15 major metropolitan statistical areas.[50]
- **Batched Grocery**
  - 3.5 miles (High Density), 5.33 miles (Medium Density), 5.68 miles (Low Density).[51] Note that Batched Grocery is most likely not available in Low Density areas.
- **Instant Delivery**
  - 2.77 miles (High Density), 3.80 miles (Medium Density), 5.46 miles (Low Density).[52] Note that Instant Delivery is most likely not available in Low Density areas.
- **Individual Consumers**
  - Retail: 3.10 miles (High Density), 4.0 miles (Medium Density), 3.5 miles (Low Density).[53]
  - Grocery: 3.5 miles (High Density), 5.33 miles (Medium Density), 5.68 miles (Low Density).[54]
  - Restaurant: 2.77 miles (High Density), 3.80 miles (Medium Density), 5.46 miles (Low Density).[55]

Distances for each density type (Low, Medium, and High Density) were determined by an analysis of Replica data for trips made by destination type and trip purpose (Retail, Grocery, Restaurant). Data from the Seasonal Trip Table was used in the analysis. Median distance traveled was the metric used to determine typical trip distances. For more information, reference Replica Data Documentation.

A blended rate of distances from following representative areas were used for these estimates:

- High Density (New York, NY; San Francisco, CA; Boston, MA; Miami, FL; Chicago, IL; Philadelphia, PA; Washington, DC);
- Medium Density (Los Angeles, CA; Baltimore, MD; Atlanta, GA; Houston, TX; Phoenix, AZ; Indianapolis, IN; Kansas City, MO; Oklahoma City, OK);
- Low Density (Somerset County, ME; Callaway County, MO; La Plata County, CO; Hill County, TX).

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[50] How Close Is Too Close? E-Commerce Pushing Last Mile Hubs Closer To Population Centers | Forbes
[51] Steer and Fourth Economy Analysis of Replica Data.
[52] Steer and Fourth Economy Analysis of Replica Data.
[53] Steer and Fourth Economy Analysis of Replica Data.
[54] Steer and Fourth Economy Analysis of Replica Data.
[55] Steer and Fourth Economy Analysis of Replica Data.

Distance, Between Households

- **E-Commerce**
    - Amazon: Amazon Rivian vans travel an average of 58 miles per trip. From 2021 to 2022, Rivian vans delivered over 430,000 packages and accumulated over 90,000 miles; 0.21 miles per package. If delivering 250 packages, those vans would travel 52 miles; 300 packages, 63 miles — an average of 58 miles per van trip.[56]
    - UPS: The conventional vans averaged 64 miles a day.[57]
- **Batched Grocery**
    - Direct from Grocer: A van with 20 orders may travel up to 90 miles with orders from facilities to make deliveries.[58]
- **Instant Delivery**
    - Distance between households not applicable. These deliveries typically involve the delivery of a single order at a time.

Emissions Savings

The Environmental Protection Agency Greenhouse Gas Equivalencies calculator converts emissions or energy data to the equivalent amount of carbon dioxide (CO2) emissions from using that amount. The calculator helps translate abstract measurements into familiar terms, such as the annual emissions from cars, households, or power plants.

[56] Amazon's electric delivery vehicles from Rivian roll out across the U.S. | Amazon
[57] Measured Laboratory and In-Use Fuel Economy over Targeted Drive Cycles for Comparable Hybrid and Conventional Package Delivery Vehicles | SAE International
[58] Kroger strengthens home delivery network | Fleet Owner