

# Evaluating environmental impacts of online shopping

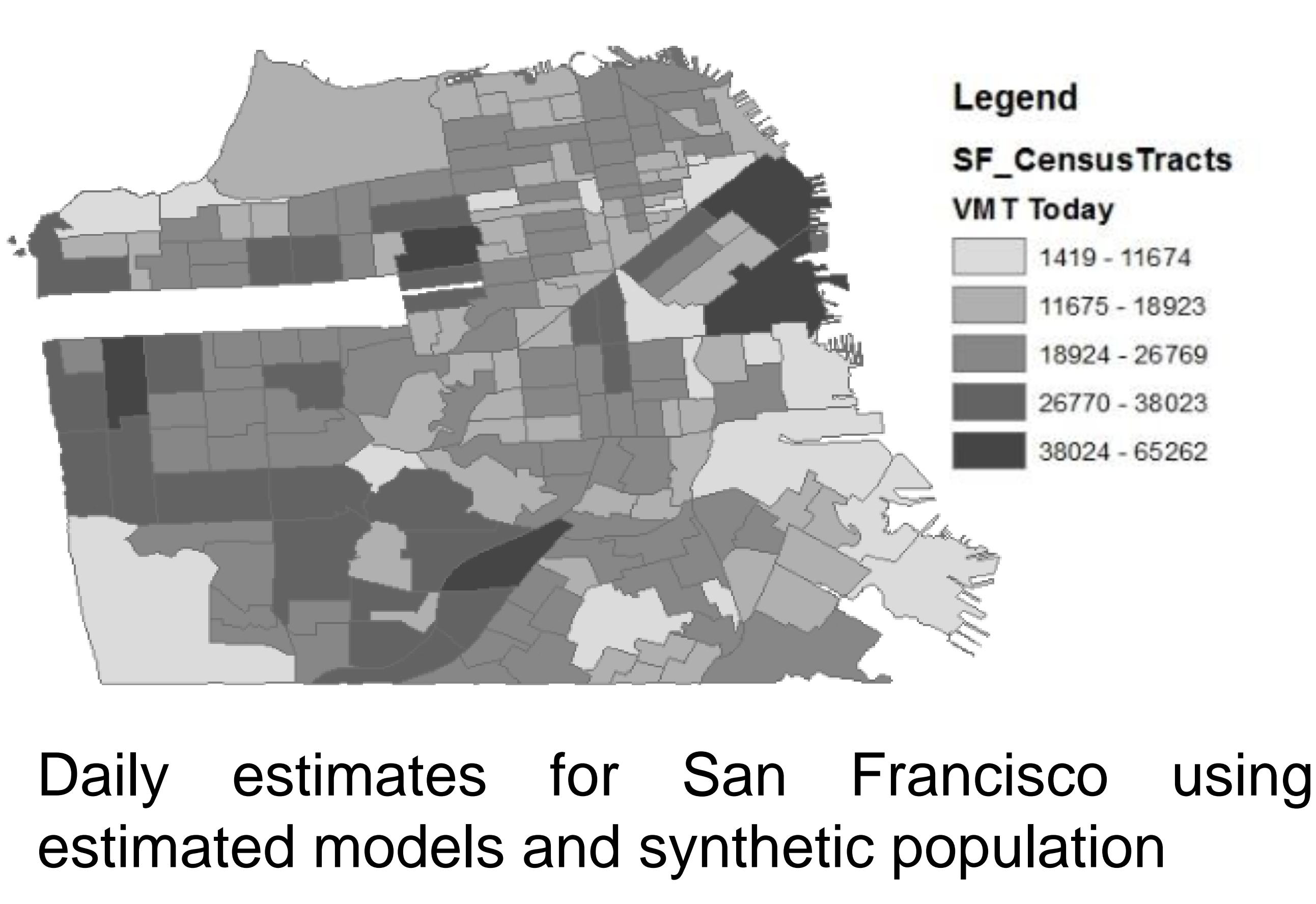
## This Study

1. Estimated econometric models to determine the factors that affect shopping behavior using the American Time Use Survey (ATUS).
2. Evaluated complementarity or substitution effects between in-store and online shopping.
3. Developed a behavioral-based shopping trip and urban delivery aggregate simulator.
4. Estimated vehicle miles traveled and environmental emissions from shopping.
5. Evaluated the impact of rush deliveries.
6. Developed a breakeven analysis to compare in-store versus online shopping.

## Online vs In-store

- In a typical day, about 40% of individuals shop in-store, while 2-3% shop online.
- Heterogeneous shopping behaviors across different segments of the population.
- Generalizing substitution or complementarity effects over the entire shopping behavior leads to aggregation impacts
- The probability of shopping through one channel reduces when the individual had already shopped in the other.
- This effect is different across two genders.

## Estimating Shopping Activity



## Shopping Behavior

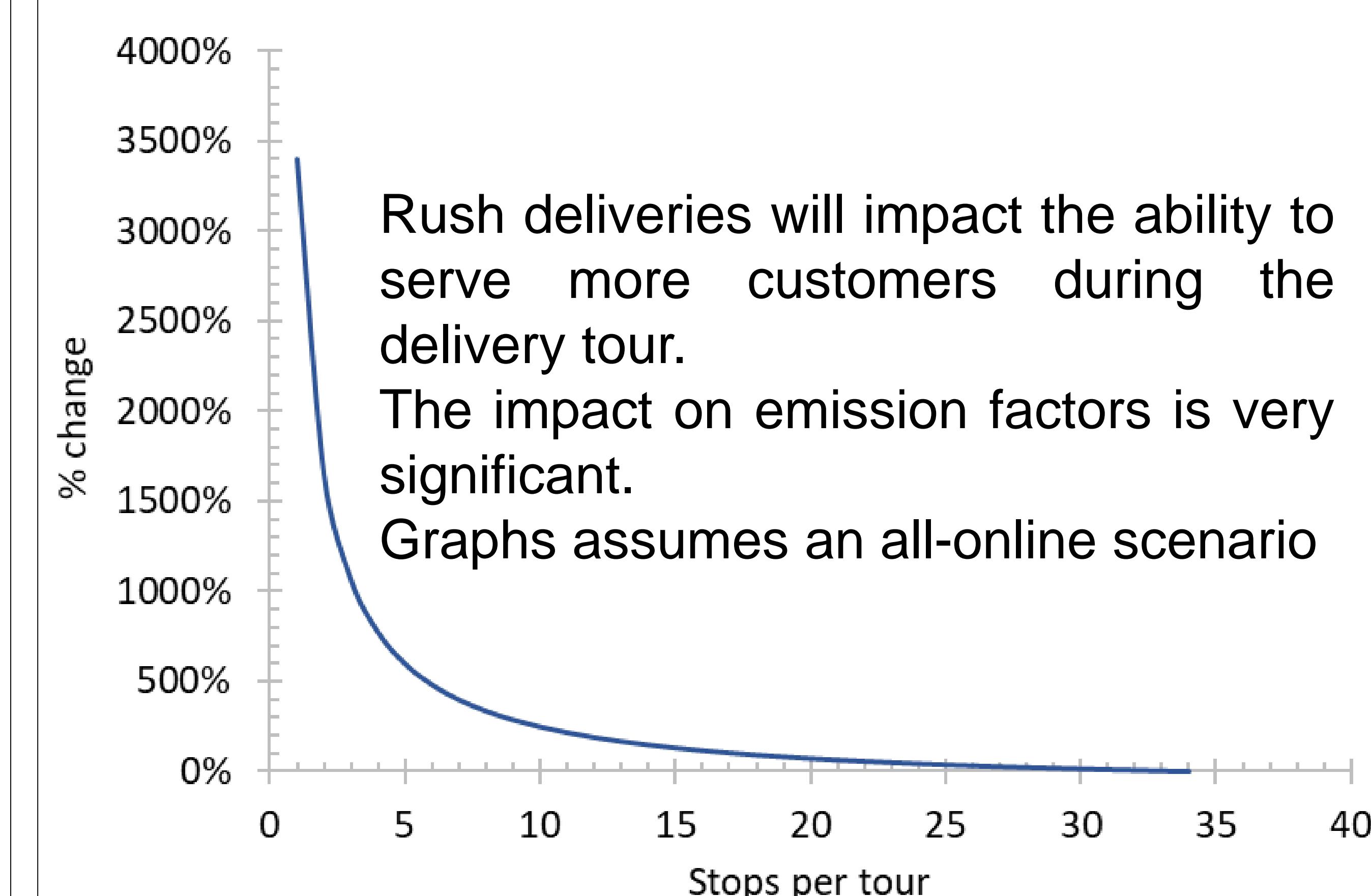
Variable	Shop	In-store	Online
Gender	Female	+	-
Mobility	Diff. in mobility	-	
Employment	Unemployed	+	
Education	Secondary	+	
Level	Graduate	+	
Age group	Millennial	+	
	Generation X	+	
	Baby	+	
	Boomers		
	Silent	+	
Family	Low		+
Income	Lower Middle	+	+
	Median	+	+
	Middle Middle	+	+
	Upper Middle	+	
	High		+
Season	Fall		+
HH variables	Family Structure	-	

Control group - A single male belonging to generation Z, with no mobility issues, no education, not in the labor force, living under poverty level, from Midwest.

## Impacts All In-Store vs. All Online

Parameters	Scenario	%Δ w.r.t. to SC in-store			Omni-channel vs. SC online
		FQC	MQC	TQC	
VMT	Omni Channel	0%	1%	1%	
	SC online	-92%	-88%	-81%	
CO (kg)	Omni Channel	0%	1%	1%	
	SC online	-91%	-88%	-80%	
NO <sub>x</sub> (kg)	Omni Channel	6%	9%	15%	
	SC online	-16%	20%	90%	
CO <sub>2</sub> (Metric ton)	Omni Channel	2%	2%	4%	
	SC online	-75%	-64%	-42%	
PM 10 (kg)	Omni Channel	3%	4%	6%	
	SC online	-62%	-46%	-14%	
PM 2.5 (kg)	Omni Channel	3%	4%	6%	
	SC online	-62%	-46%	-14%	
SO <sub>x</sub> (kg)	Omni Channel	2%	2%	4%	
	SC online	-75%	-64%	-43%	
N <sub>2</sub> O (kg)	Omni Channel	3%	4%	7%	
	SC online	-58%	-40%	-5%	
SC:	Single Channel				
F/M/TQC::	First/Median/Third Quartile Case				

## Rush Deliveries & Consolidation



Rush deliveries will impact the ability to serve more customers during the delivery tour.  
 The impact on emission factors is very significant.  
 Graphs assumes an all-online scenario

## Break-even Consolidation Level

Param.	Delivery tour length case	Stops per delivery tour		Omni-channel vs. SC online
		SC in-store vs. SC online	SC in-store vs. Omni-channel	
VMT	FQC	6	130	6
	MQC	9	187	9
CO	TQC	14	297	14
	FQC	6	134	6
NO <sub>x</sub>	MQC	9	192	9
	TQC	14	305	14
CO <sub>2</sub>	FQC	61	1301	61
	MQC	87	1870	87
PM 10	TQC	138	2966	138
	FQC	18	393	18
PM 2.5	MQC	26	565	26
	TQC	42	896	42
SO <sub>x</sub>	FQC	30	650	30
	MQC	44	935	44
	TQC	69	1483	69
	FQC	30	650	30
	MQC	44	935	44
	TQC	69	1483	69
	FQC	20	434	20
	MQC	29	623	29
	TQC	46	989	46

When comparing in-store vs. omni-channel under complementarity, not enough market share exists