

Evaluating environmental impacts of online shopping

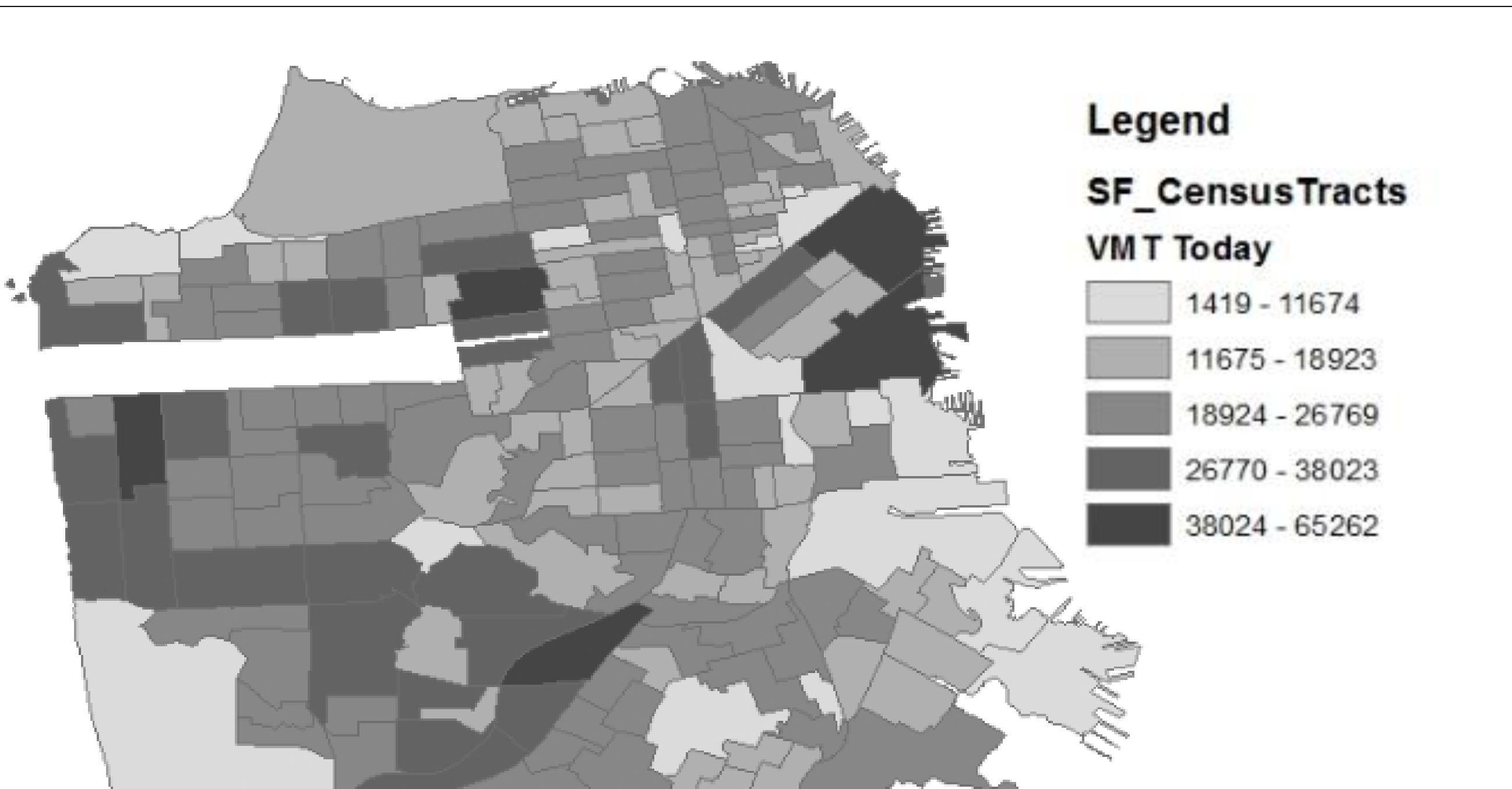
This Study

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



Daily estimates for San Francisco using estimated models and synthetic population

Shopping Behavior

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

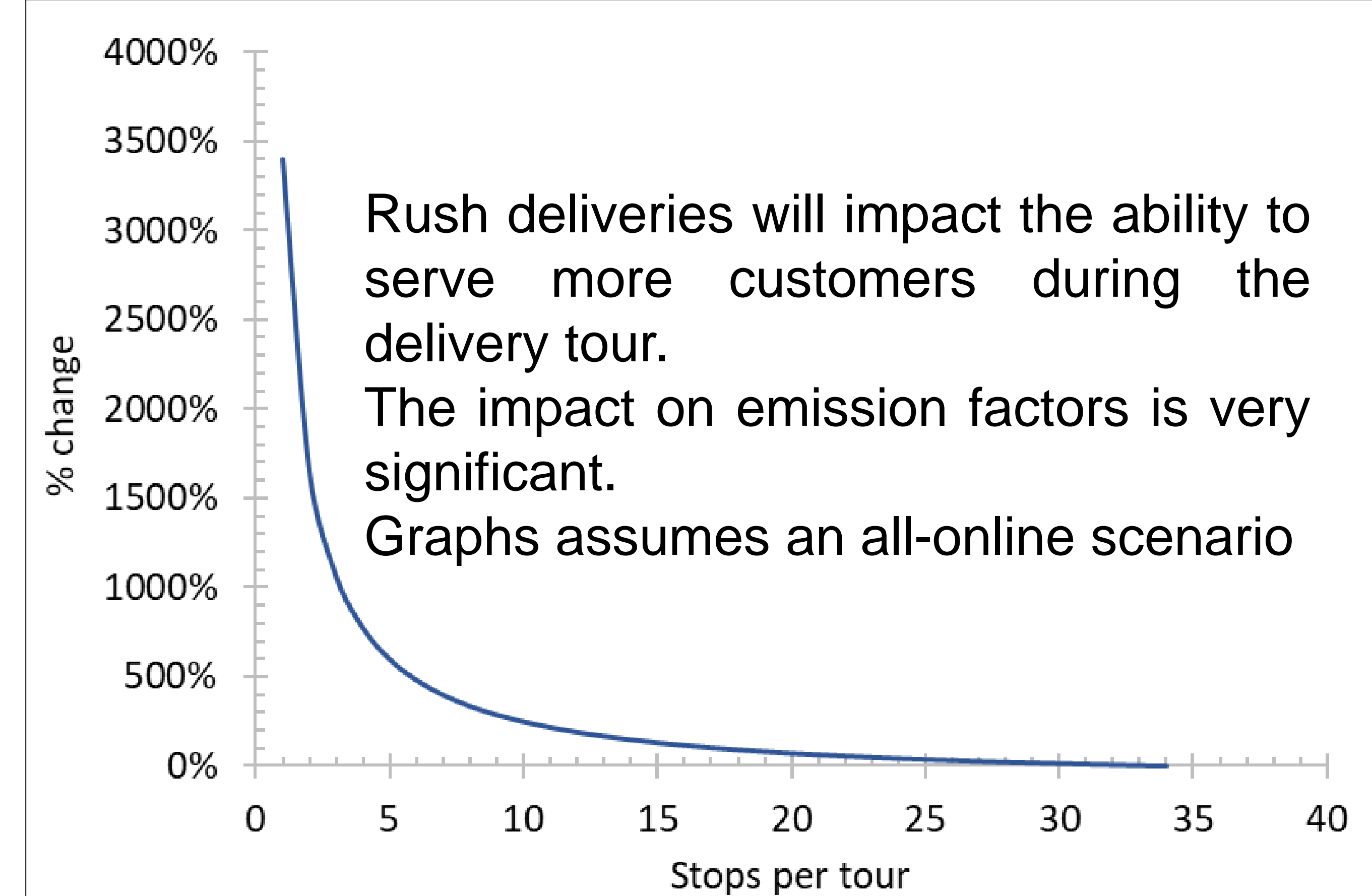
Control group - A single male belonging to generation Z, with no mobility issues, no education, not in the labor force, living under poverty level, from Midwest.

Impacts All In-Store vs. All Online

Parameters	Scenario	%Δ w.r.t. to SC in-store		
		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 _x (kg)	Omni Channel	6%	9%	15%
	SC online	-16%	20%	90%
CO ₂ (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 _x (kg)	Omni Channel	2%	2%	4%
	SC online	-75%	-64%	-43%
N ₂ 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



Breakeven Consolidation Level

Param.	Delivery tour length case	Stops per delivery tour			
		SC in-store vs. SC online	SC in-store vs. Omni-channel	Omni-channel vs. SC online	
		Comp.	No Comp.		
VMT	FQC	6	130	6	6
	MQC	9	187	9	9
	TQC	14	297	14	13
CO	FQC	6	134	6	6
	MQC	9	192	9	9
	TQC	14	305	14	14
NO _x	FQC	61	1301	61	54
	MQC	87	1870	87	74
	TQC	138	2966	138	107
CO ₂	FQC	18	393	18	18
	MQC	26	565	26	25
	TQC	42	896	42	38
PM 10	FQC	30	650	30	29
	MQC	44	935	44	40
	TQC	69	1483	69	60
PM 2.5	FQC	30	650	30	29
	MQC	44	935	44	40
	TQC	69	1483	69	60
SO _x	FQC	20	434	20	19
	MQC	29	623	29	27
	TQC	46	989	46	42

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